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The effectiveness of back belts as a control measure for occupational low back pain in a retail hardware chain

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The Effectiveness of Back Belts as a Control Measure for Occupational Low Back Pain in a Retail Hardware Chain

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ABSTRACT

The objective of this study was to examine the effect of the mandatory introduction of back belts on the incidence, days lost and cost of occupational low back injuries resulting from manual handling in a retail hardware chain. The study was of a non-experimental before-and-after design with all retail employees in Western Australia being included in a retrospective cohort. The pre-intervention period extended for 21 months and included 2,265,933 work hours with 647 full-time equivalent positions, while the intervention period was 32 months for 4,411,352 hours worked and 827 full-time equivalent positions. Workers' compensation claims for all occupational injuries occurring during the study period were analysed. During the intervention period there was a 14% reduction in the incidence frequency rate for all low back pain claims and a 33% reduction in those low back pain claims resulting in lost time, but neither reduction was statistically significant. During the intervention period there was a significant 69% reduction in the average days lost per low back pain claim and a 79% reduction in the days lost to low back pain per hours worked. The average direct cost was reduced by 77% for all low back pain claims and 74% for low back claims resulting in lost time, and 80% and 83% respectively when analysed per hours worked. The author concluded that the mandatory use of back belts significantly reduces the days lost due to, and the cost of occupational low back pain resulting from manual handling in the workplace and provides a cost effective control measure if high compliance is maintained.

DECLARATION

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INTRODUCTION

The Background of the Study

Back belts have been used for many years in competitive weight lifting on the assumption that they prevent lower back injuries. More recently their use has spread to the workplace as a control measure to reduce the risk of manual handling injury to the lower back.

There appears to be a good deal of anecdotal evidence that back belts do prevent manual handling injury to the lower back, their widespread use by weight lifters and growing popularity in the workplace gives testimony to this, and there are some biomechanical indications to support their use. However, the evidence from laboratory and clinical trials on their effectiveness in an industrial setting is, on the whole, often regarded as inconclusive.

The hardware retail arm of Bunnings Building Supplies, which in Western Australia had 21 metropolitan branches employing workers for over 1,700,000 work hours a year by the end of 1999, has required all employees to wear a back belt in the workplace since April 1997. The decision to introduce the back belts into the workplace was based largely on the positive results reported following the introduction of mandatory back belt use in a similar hardware chain in the USA (Kraus et al., 1996). Analysis of workplace injuries over an extended period of time spanning the introduction of the back belts provided a large database to assess the effectiveness of back belts as a control measure for reducing the risk of manual handling injury related low back pain.

The Significance of the Study

Manual handling injuries to the lower back are a major cost to industry and the community. In Western Australia manual handling injuries to the trunk, which includes the lower back, account for 64.4% of all manual handling injuries in male workers and 50.7% in female workers (Straker, 1999). Between 1988 and 1995 in Western Australia there was a steady decrease in overall workplace injury although the 15% decrease in manual handling injuries compared unfavourably with the 27% decrease for all other injuries (Straker, 1999), possibly attesting to the difficulty in controlling manual handling injuries compared to other injuries. However, between 1995 and 2000 there appears to have been an overall increase in the number of manual handling injuries in Western Australia (Lurie, 2000). In 1997 the average direct or insurable cost of low back injury resulting in lost time from work was $22,191 (in 2001 dollars) (WorkCover Western Australia, 2004). In the USA occupational low back pain accounts for almost 20% of all injuries and illnesses in the workplace, with an estimated cost of 20-50 billion US dollars a year (NIOSH, 1997a).

Back belts have been seen as a simple, reliable and cost effective control measure for low back pain in the workplace and they are being introduced in growing numbers. However, their continued use requires evidence of their effectiveness, which has yet to be established. Previous epidemiological studies of back belts in the workplace have focused largely on low back pain incidence rates. This study goes further by additionally examining the effect back belts have on the duration and the direct dollar costs of injury. The dependant variables are also compared to data obtained for workplace injuries other than low back pain resulting from manual handling injury to provide an indication of internal validity, a process which, again, has not been attempted in earlier studies in this field.

Establishing whether back belts affect the cost of low back pain is of significant commercial importance. Various measures of incidence have been examined in the past as they are readily available and are a common means of comparing safety performance. However, it will generally be the effect that any

intervention has on the bottom line in dollar savings per dollars spent, that is the cost effectiveness of the intervention, that will be of concern to management when considering the overall benefit of the intervention.

Further, this study was performed in a workplace where back belt use was mandated which provides for a far more bias free examination than many previous attempts which have relied on voluntary participation.

The Purpose of the Study

The aim of this study is to measure and evaluate the effect of the introduction of mandatory back belt use on the incidence, severity and cost of low back pain resulting from manual handling injury within the Bunnings Building Supplies home improvement stores across Western Australia. On the basis of this study relevant recommendations will be formulated for the use of back belts throughout the Bunnings organization and industry as a whole. The results of this study will provide information that will help reduce the societal and economic costs of occupational low back pain.

Hypotheses

1. The mandatory use of the back belts has decreased the incidence of manual handling injuries to the lower back.
2. The mandatory use of the back belts has decreased the days lost due to manual handling injuries to the lower back.
3. The mandatory use of back belts has reduced the cost of manual handling injuries to the lower back.

Definitions

Back Belt: In general usage describes leather weight lifting belts, elastic abdominal belts and therapeutic devices such as spinal braces, corsets and orthoses. In the context of this study back belts refers to those now seen commonly in the industrial setting which are light weight, flexible and adjustable belts with or without shoulder braces.

Surgical Corsets: Therapeutic supports used post-operatively or to manage an existing low back pain complaint.

Low Back Pain: All disorders, injuries or pain to the lumbar and lumbosacral region due to either a single traumatic event or cumulative trauma. In the context of this study occupational low back pain (LBP) is a manual handling injury and therefore excludes injuries resulting from falls and direct blows, unless otherwise stated. In an occupational health setting the terms low back pain, low back injury and low back disorder are often used interchangeably in the literature. For clarity the one term, low back pain, will be used throughout this discussion, unless citing directly from the literature.

Manual Handling: "Any activity requiring the use of force exerted by a person to lift, lower, push, pull, carry or to move hold or restrain a person, animal or thing" (Worksafe Western Australia Commission, 2000). In the context of this study manual handling injuries refers to injuries to the lower back through manual handling unless otherwise stated.

Abbreviations

BB	Back belt
BP	Blood pressure
bpm	beats per minute
CI	Confidence interval
EMG	Electromyography
FTE	Full time equivalent
HR	Heart rate
IAP	Intra-abdominal pressure
IFR	Incidence frequency rate
LBP	Low back pain
LTI	Lost time injury
MAWL	Maximum acceptable weight of lift
MHI	Manual handling injury
MSD	Musculoskeletal disorder
NIOSH	National Institute of Occupational Safety and Health
OR	Odds ratio
PPE	Personal protective equipment
RCT	Randomised controlled trials
RM	Repetition maximum
ROM	Range of motion
RPE	Rating of perceived exertion
RR	Relative risk / risk ratio
χ^2	Chi squared

LITERATURE REVIEW

Epidemiology of Occupational Low Back Pain

Definition of Occupational Low Back Pain

Occupational low back pain can be defined as "...any back pain originating in the context of work and considered clinically to have been probably caused, at least in part, or exacerbated by the claimants job" (Frank et al., 1996p. 2908)

Although most acute low back pain is thought to arise from a mechanical injury to the spine (Jayson, 2000) in the majority of cases it is not possible to make a specific diagnosis or to identify an anatomical structure as the source of the complaint (Bernard & Fine, 1997; Garg & Moore, 1992a; Gerr & Mani, 2000; Haldeman, 1990; Jayson, 2000; Kraus, Gardner, Collins, Sorock & Volinn, 1997; Riihimaki, 1998). Even though occupational low back pain is often assumed to arise from work tasks the injury mechanism itself may be multi-causal (Bernard & Fine, 1997; Westgaard & Winkel, 1997) and a complaint resulting in symptoms or disability reported in the workplace may have causes completely outside the individuals job.

Ferguson and Marras (1997) describe a progression of events through time for occupational low back pain which commences with a physical load and ends with disability (see Figure 1). Each one of the stages following the introduction of the physical load described by Ferguson and Marras (1997) can and are used as outcome measures to define an occupational low back pain occurrence in the epidemiological literature. This can make a discussion of incidence and prevalence difficult and

probably accounts for much of the wide variation reported that will become apparent through this discussion. The different definitions have also been shown to be associated with different risk factors (Ozguler, Leclerc, Landre, Pietri-Taleb & Niedhammer, 2000), further confusing the issue.

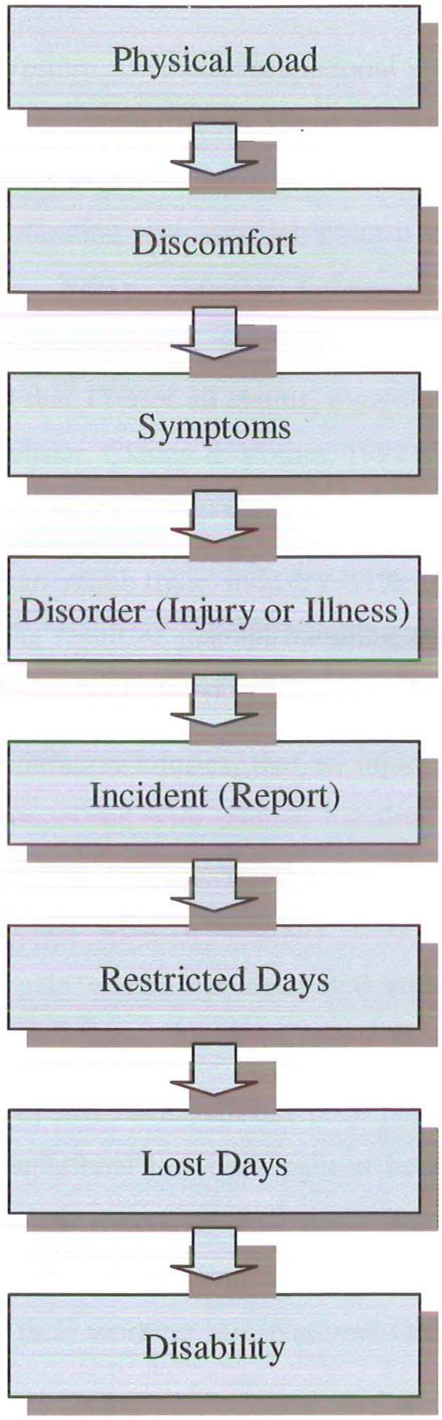

Figure 1. Sequence of events associated with occupational low back pain (Ferguson & Marras, 1997)

Incidence and Prevalence

In the year 1998/99 in Western Australia occupational injuries categorized as 'sprains and strains' to the back[1] accounted for 19.5% of all workers' compensation claims with one or more days lost time (WorkCover Western Australia, 2000) but this increased to 21.3% in the following year at which point it stabilised for 3 years (WorkCover Western Australia, 2003). Similar figures were reported in an examination of workers' compensation data for approximately 10% of the US workforce in 1992, which found that 17% of all claims, regardless of lost time, were for low back pain (Hashemi, Webster, Clancy & Volinn, 1997), changing little from the 16% reported a decade earlier (Snook, 1982. Cited in: Bernard & Fine, 1997).

In the Western Australian retail trade industry 41% of lost time injuries between 1995 and 2000 were the result of manual handling and of these 33% (or 13.5% of the total) were to the lower back (Worksafe Western Australia, 2002b).

The proportion of long duration injuries, that is, injuries resulting in more than 60 days lost from work, associated with manual handling have been steadily increasing in Western Australia since 1982, accounting for 43.2% of the total long duration injuries by 1998 (Worksafe Western Australia, 1999), although the actual average duration of low back pain claims has decreased somewhat (WorkCover Western Australia, 2004).

The lifetime prevalence of low back pain has been put at greater than 70% and a 1 year prevalence of occupational low back pain at between 25% and 45% (Andersson, 1997; Jayson, 2000; Shelerud, 1998). Australian data indicates that workers have a 40% chance of experiencing a manual handling injury resulting in 5 or more days off work through their working life (National Occupational Health & Safety Commission, 1996).

In a survey of 31,000 material handlers working in a home improvement retail chain in the USA between 1990 and 1994 low back pain was reported at an incidence frequency rate of 20.2 per million hours worked and low back pain

[1] In Western Australia workers' compensation statistics record the bodily locations either 'trunk or 'back' so that the true figures for the lower back are difficult to determine. For the year 2000/2001 long duration claims to the trunk were made up of 66.4 lower back, 17.6 back (unspecified), 6.2% abdominal muscles 2.5% upper back and 7.3% other. (WorkCover Western Australia, 2002)

resulting in a lost time injury (LTI) rate of 12.3 per million hours worked (J. Kraus, Schaffer, McArthur & Peek-Asa, 1997). A similarly sized cohort of retail merchandise material handlers followed for 21 months found an incidence frequency rate of 14 per million hours worked for reported low back pain and 4.1 per million hours worked for lost time injuries (Gardner, Landsittel & Nelson, 1999). Some of the difference in results between these 2 studies of similar cohorts can be explained by the fact that Gardner et al. (1999) only reported back injuries resulting from manual handling whereas Kraus et al. (1997) included low back injuries of all causes although they do describe that 79.2% of the total cases resulted from manual handling, bringing the incidence frequency rates into closer agreement.

Stevenson et al. (Stevenson, Weber, Smith, Dumas & Albert, 2001) followed 149 spinning mill workers who were not suffering chronic low back pain for a 2 year period. The workers lifted nylon bobbins weighing 4.5 to 12.7 kg for approximately 5,000 kg per shift. Over the course of the study 55% of the subjects reported experiencing low back pain.

However, workers' compensation data may only represent the proverbial 'tip of the iceberg'. A survey of all employees at an aircraft engine factory found that the one year prevalence of self-reported low back pain was 69.3% with 41% of these cases interfering with daily activities. Over the same 1 year period occupational health records show only 27% of the workforce reporting low back pain with 2.3% requiring time off work (Jefferson & McGrath, 1996). A survey performed by the Australian Bureau of Statistics (Australian Bureau of Statistics, 2001) suggests that only 46% of work related injuries and disease are actually recorded as workers' compensation claims.

Cost

In Western Australia, for the 2000/2001 financial year, lower back injuries resulting in lost time accounted for 20% of the total cost of injuries, or $65.3 million (WorkCover Western Australia, 2004). In 1997/98 the average direct insurable cost of low back pain lost time injuries was $22,191 (in 2001 dollars). This cost decreased over the next 2 years, only to increase again to $20,485 by 2000/01 (see Figure 2) (WorkCover Western Australia, 2004). In the USA the cost is reported as

somewhat higher, with 29.5 to 33% of the total cost of workers' compensation claims accounted for by low back pain (Dempsey & Hashemi, 1999; Hashemi et al., 1997; Webster & Snook, 1994).

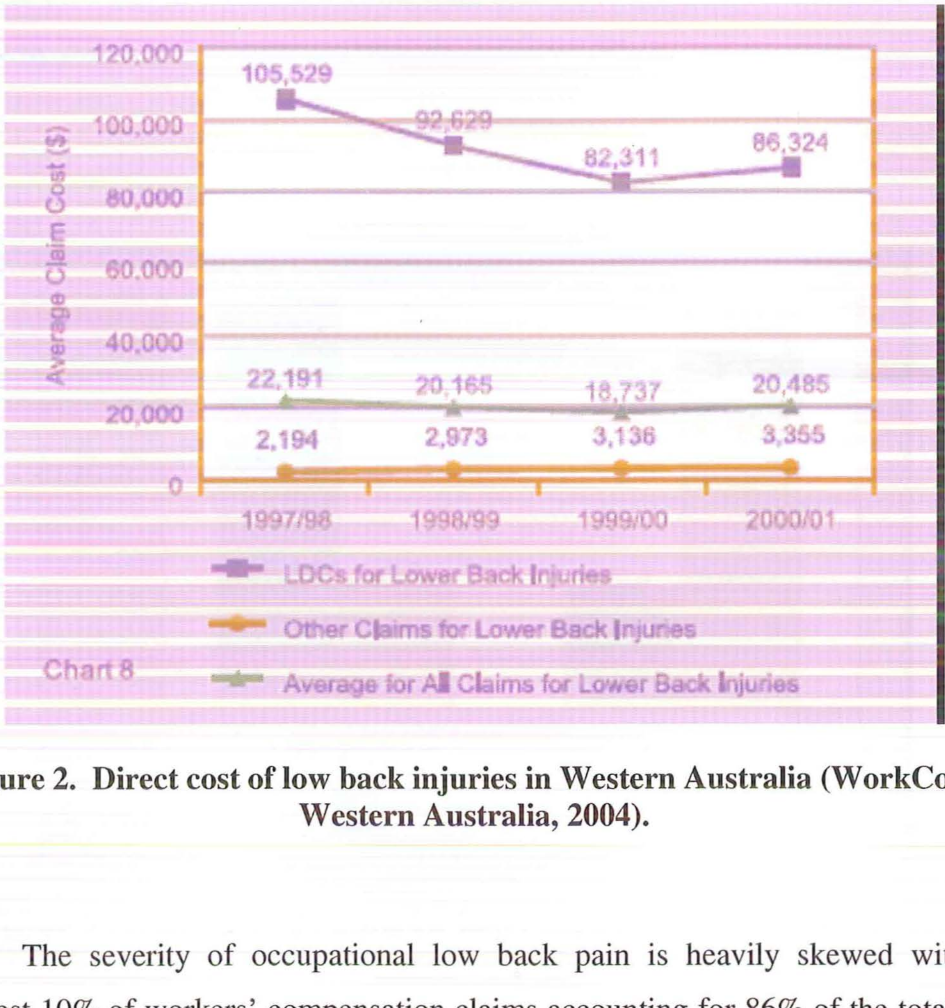

Figure 2. Direct cost of low back injuries in Western Australia (WorkCover Western Australia, 2004).

The severity of occupational low back pain is heavily skewed with the costliest 10% of workers' compensation claims accounting for 86% of the total cost, and the lengthiest 10% accounting for 92% of total days lost (Hashemi et al., 1997). Dempsey and Hashemi (1999), examining the same database as above, found that although low back pain claims accounted for only 29.5% of total manual handling injuries they resulted in 41.6% of the total manual handling injury cost. An examination of injury data for 31,200 employees of the Boeing Company over a 15 year period (Spengler et al., 1986) found that low back pain accounted for 19% of all workers' compensation claims but 41% of the total cost and, like the results of

Hashemi et al. (1997), the costliest 10% of low back pain claims accounted for 79% of the total cost.

A similar skewed pattern appears in workers' compensation claims in Western Australia where, in the financial year 2001/02 low back pain claims resulting in 60 or more lost time days accounted for only 22.4% of the total low back pain lost time claims but 75.6% of the total cost (see Figure 3.) (WorkCover Western Australia, 2004)

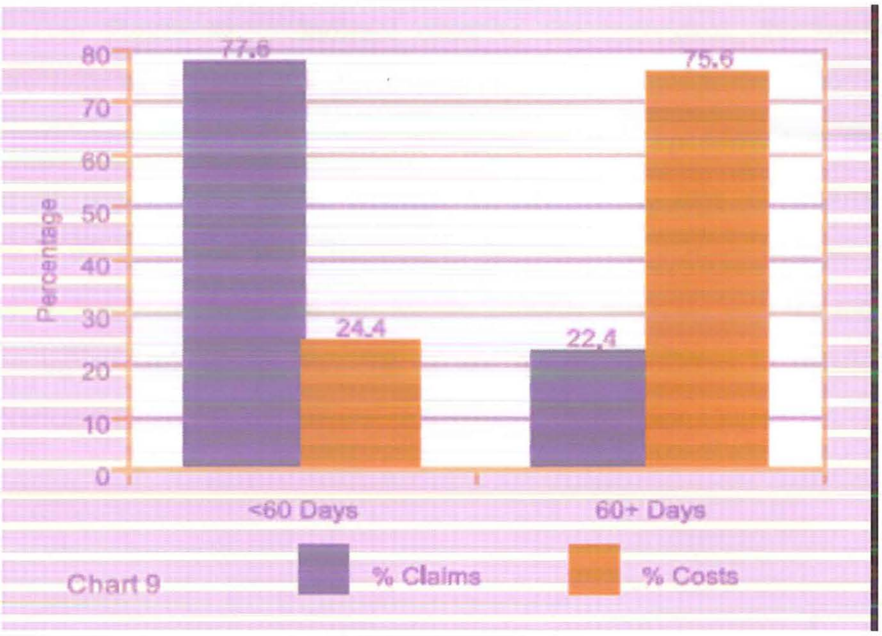

Figure 3. Proportion of claims for lower back injuries and cost by claim duration for 2001/02 (WorkCover Western Australia, 2004).

Ideally these high cost injuries should be the target of control measures but it would appear that "it may not be feasible to target high-cost injuries selectively because for the most part they are indistinguishable in their genesis from low cost injuries." (Clemmer, Mohr & Mercer, 1991).

An actuarial analysis of workers' compensation claims in Western Australia from 1995 to 2000 found that the medical costs of manual handling injuries had increased by 43% (Knowles, Glass & Lord, 2000; Lurie, 2000), a trend that has been

observed in the United States and other industrialised countries (Frymoyer, 1997). Overall, despite a decrease in the incidence of workers' compensation claims in Western Australia the average cost and number of long duration claims has increased in the 5 years up to 2000 (WorkCover Western Australia, 2000).

It should be noted that workers' compensation costs only record the direct costs associated with the injury. In Western Australia these direct costs would typically include the injured worker's general practitioner's accounts, physiotherapy costs, specialist consultations, investigations including X-rays, CT (computerised tomography) scans and MRI (magnetic resonance imaging) scans, vocational rehabilitation services (if required) and the injured parties income replacement while off work (see Figure 4). Indirect costs to the individual, the business and community may be 3 times the direct cost (Industry Commission, 1995). Indirect costs include such things as incident investigation and reporting, lost production, retraining of replacement staff, damage to equipment, loss of reputation and reductions in the quality of life. The cost to the community as a whole is, therefore, enormous. It has been estimated that for the 2000/01 financial year the total cost of workplace injury and illness was 5% of the Australian Gross Domestic Product (GDP) (National Occupational Health and Safety Commission, 2004).

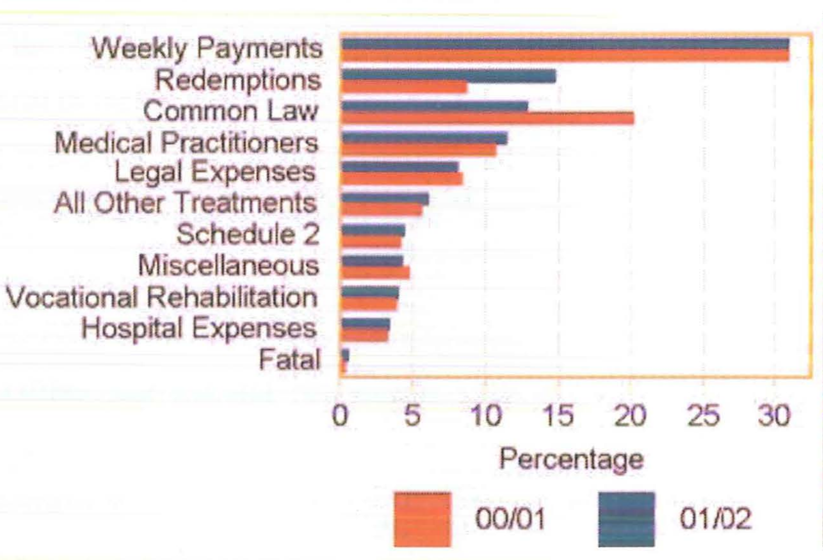

Figure 4. Distribution of direct costs. (WorkCover Western Australia, 2003)

Risk Factors

"Prevention of a disorder is contingent on an understanding of its causative mechanisms." (Leboeuf-Yde, Lauritsen & Lauritzen, 1997, p.877) Unfortunately, establishing these causative mechanisms or risk factors has proved difficult. Many of the popularly held risk factors lack convincing evidence of a causal relationship with low back pain and Battie and Videman (1997) go as far as replacing the term 'risk factor' with 'risk indicator'. Poor consensus in the literature may be due to variations in both the measurement methods and definitions (Ferguson & Marras, 1997; Ozguler et al., 2000). Frank et al. (1996) state that "it often is impossible to distinguish back pain 'caused' by work from pain of uncertain origin that makes the patient's work impossible to carry out." (p 2908)

Work task factors

Heavy physical work can be defined as "as work that has high energy demands or requires some measure of physical strength" (Bernard & Fine, 1997, p. 6-4) and has regularly been identified as a risk factor for occupational low back pain (Andersson, 1981, 1997; G. Andersson, 1998; Bernard & Fine, 1997; Burdorf & Sorock, 1997; Cohen, Gjessing, Fine, Bernard & McGlothlin, 1997; Kuiper et al., 1999; Leboeuf-Yde et al., 1997; Luttmann et al., 2003; Marras, 2000; Riihimaki, 1998; Shelerud, 1998; Xu, Bach & Orhede, 1997). In a critical review of 40 recent studies examining the relationship between low back pain and physical workplace factors the National Institute of Occupational Safety and Health (NIOSH), a department of the US Centres for Disease Control and Prevention, found evidence to support a positive relationship between low back pain and heavy physical work although the risk estimates were not as strong as some other workplace factors which they suggested "was perhaps due to subjective and imprecise characterization of the exposure." (Bernard & Fine, 1997, p.6-1)

Lifting and forceful movements such as pushing and pulling have also consistently been shown to be associated with low back pain (Andersson, 1981, 1997; Bernard & Fine, 1997; Burdorf & Sorock, 1997; Clemmer et al., 1991; Cohen et al., 1997; Kuiper et al., 1999; Luttmann et al., 2003; Marras, 2000; Shelerud, 1998). The NIOSH panel found strong evidence of an association, with odds ratios

(ORs) ranging from 1.2 to 11, with some evidence of a dose-response relationship and plausible biomechanical links (Bernard & Fine, 1997).

Kraus et al. (1997), in their study of a home improvement retail chain, found a strong relationship between high lifting intensity job and low back pain incidence with an relative risk/risk ratio (RR) of 5.77 (95% confidence interval (CI) = 4.55-7.31) and with lost time injury incidence with an relative risk of 6.12 (95% CI = 4.48-8.38). Similarly Gardner et al. (1999), when comparing retail stockers/receivers (high lifting intensity) with managers (low lifting intensity) found an relative risk from lifting adjusted for other risk factors of 1.62 (95% CI = 1.38-1.91).

Macfarlane et al. (1997) performed a 12 month longitudinal study of 1,412 employed adults with no low back pain at enrolment in the study. Increased risk of low back pain was associated with jobs involving lifting, pushing or pulling objects greater than 11.3 kg.

In an extensive review of the literature Andersson (1997) found that lifting, pulling and pushing were associated with between 3 and 8 times the risk of developing low back pain compared to sedentary work. In a systematic review of 25 studies Kiuper (1999) found that manual materials handling was linked to lower back disorders with the risk being highest with lifting, although evidence of a dose-response relationship was not strong. In a similar review of 35 publications Burdorf and Sorock (1996) found a strong and consistent association between lifting and carrying, whole body vibration and frequent bending and twisting and the occurrence of low back pain. They felt that this consistent relationship and the existence of biomechanical and physiological evidence was enough to support the biological plausibility of lifting as a risk factor for low back pain, a view supported by Frank et al. (1996).

An analysis of a large insurance database containing 2,442 worksite reports collected between 1981 and 1993 with information on 10,101 lifts, 7,461 lowers, 1,879 pushes, 1,866 pulls and 3,984 carries suggested low back pain could be reduced by decreasing the distance away from the trunk that lifts were performed, decreasing the load, frequency and length of the manual handling and increasing the starting height of lifts (Ciriello, Snook, Hashemi & Cotnam, 1999).

Tubach, Leclerc, Landre and Pietri-Taleb (2002) enlisted subjects from an initial cohort commenced in 1989 of 20,624 workers in the French national electricity and gas company who completed an annual self-administered questionnaire. In 1992 a subgroup of 4,018 workers who were exposed to higher levels of physical stress at work were selected to complete low back pain questionnaires from which 3,123 (77.7%) responded. 2,236 of this subgroup completed further low back pain questionnaires in both 1994 and 1996. Lifting loads greater than 10 kg every day at work was positively associated with 30 days or more of low back pain and 8 days or more of sick leave due to low back pain in the previous year (RR = 4.1, 95% CI = 2.2-7.5). However, the low back pain measures used in this study were based on subjects recall, introducing the potential for bias, and the average age of the cohort at 49.6 years did not represent a typical workforce.

A community survey was performed of 22,194 males and females of working age in the United Kingdom. 58% responded and the resulted demonstrated a statically significant association with the 1 year prevalence of low back pain and lifting 10 kg or more at work (Palmer et al., 2003).

Twisting and bending is also associated with low back pain, especially when combined with a load, although there is some difficulty separating these activities from that of lifting (Andersson, 1981, 1997; Andersson, 1998; Bernard & Fine, 1997; Burdorf & Sorock, 1997; Cohen et al., 1997; Garg & Moore, 1992a; Gerr & Mani, 2000; Luttmann et al., 2003; Marras, 2000; Shelerud, 1998).

Magnusson et al. (1990) estimated the compressive load at the L3/4 intervertebral disc during assembly line work and found that the highest compression occurred not when lifting heavy objects but when having to reach excessively with a relatively small (1.2 kg) load.

Tubach et al. (2002) found that bending was significantly associated with extended periods of low back pain and sick leave, occasional bending giving a relative risk of 3.4 (95% CI = 1.6-7.3), bending often a relative risk of 4.7 (95% CI = 2.2-10.1) and repetitive or every day bending a relative risk of 8.2 (95% CI = 3.7-17.9). For low back pain of shorter duration the relative risk for the same dependant variables were 1.7 (95% CI = 1.3-2.1), 1.7 (95% CI = 1.3-2.2) and 1.9 (95% CI = 1.4-2.6). Twisting demonstrated a similar relationship with longer duration low back

pain being associated with twisting often (RR = 2.9, 95% CI = 1.5-5.5) and twisting repetitively every day (RR = 3.7, 95% CI = 1.8-7.5).

In a study of the relationship between three-dimensional lifting dynamics of 403 repetitive industrial lifting jobs and membership in a high risk of occupational low back pain group a combination of 5 factors were strongly associated with low back pain (OR=10.7, 95% CI=4.9-23.6); (1) lifting frequency; (2) load moment (weight of the load multiplied by the horizontal distance from the L5/S1 intervertebral disc); (3) trunk lateral velocity; (4) trunk twisting velocity and; (5) trunk sagittal angle (Marras et al., 1995; Marras et al., 1993). These results suggest that the risk of developing low back pain can be reduced by reducing any one of these factors and that there may be some opportunity for a 'trade-off' between factors. A similar study (Fathallah, Marras & Parnianpour, 1998b) found that medium and high risk jobs were associated with complex and simultaneous combinations of lateral and twisting velocities and positional data alone was not a consistent predictor of risk. When kinematics and modelled spinal loading were examined through an entire shift a combination of peak shear force, cumulative load moment, peak trunk flexion velocity and average hand force were found to be associated with a six fold increase in the risk for reporting low back pain (Norman et al., 1998). It must be noted that Norman et al. did not measure kinematics outside the sagittal plane as distinct from the other studies of combined kinematics in the workplace. Garanata and Marras (1999) suggest that knowledge of multidimensional dynamic spinal biomechanics should improve hazard identification and in an extensive literature review Davis and Marras (2000b) found that trunk velocity and acceleration measurements were better predictors of low back pain risk than trunk range of motion data alone.

The relationship between work factors and low back pain may be weakened as a result of workers with a past history of low back pain being placed in more sedentary work, increasing the prevalence and rate of low back pain in these lighter roles and thus reducing the true difference between heavy and light manual work (Andersson, 1997).

The significance of workload factors is reflected in the revised NIOSH lifting equation (Waters, Putz-Anderson & Garg, 1994; Waters, Putz-Anderson, Garg &

Fine, 1993) for calculating the recommended weight limit (RWL) for a given lifting task which is:

RWL = LC x HM x VM x DM x AM x FM x CM

Where:

LC = Load constant

HM = Horizontal multiplier

VM = Vertical multiplier

DM = Distance multiplier

AM = Asymmetric multiplier

FM = Frequency multiplier

CM = Coupling multiplier

For the purposes of this discussion the most significant component of the revised NIOSH lifting equation are the horizontal multiplier, which proportionally reduces the recommended weight limit when the grip point on the load is more than 25 cm horizontally in front of the ankle, the vertical multiplier, which proportionally reduces the recommended weight limit when the grip point on the load is above or below knuckle height, and asymmetric multiplier, which reduces the recommended weight limit in proportion to the degree of trunk rotation.

Regardless of the strength of the association between physical work factors and the incidence of low back pain this does not prove a causal relationship. Jayson (2000) points out that it is difficult to determine whether low back pain "is a consequence of repeated physical stresses or the subject has a constitutional back problem in which symptoms are experienced on undertaking forceful activities." (p. 480) However, since it is the symptoms that are of concern to the individual worker and generate a recorded incidence, in what ever form, this distinction will have little impact on the workplace control of low back pain. In fact, it could be argued that altering the physical work load is simpler than attempting to address an underlying complaint such as degenerative disc disease.

Past history

Although difficult to control a recent past history of low back pain has consistently been found to be a risk factor for future episodes of low back pain (Battie & Videman, 1997; Biering-Sorensen, 1983; Bigos & Battie, 1992; Bigos et al., 1992; Dempsey, Burdorf & Webster, 1997; Ferguson & Marras, 1997; Frank et al., 1996; Garg & Moore, 1992a, 1992b; Jayson, 2000; Marras, 2000; Shelerud, 1998; Tubach et al., 2002; van Poppel, Koes, Deville, Smid & Bouter, 1998) and no doubt has a bearing in intervention studies.

Psychosocial factors

"Psychosocial stressors are conditions that are likely to be perceived as harmful, threatening or bothersome or that place a demand on employees that results in a physiological adaptational response." (Davis & Heaney, 2000, p.390) Positive associations have been suggested between psychosocial factors and low back pain (Andersson, 1981, 1997; Atlas, Singer, Keller, Patrick & Deyo, 1996; Battie & Videman, 1997; Bernard & Fine, 1997; Bigos & Battie, 1992; Bigos et al., 1992; A. Burton, Tillotson, Main & Hollis, 1995; Devereux, Buckle & Vlachonikolis, 1999; Ferguson & Marras, 1997; Hadler, 1997; Shelerud, 1998; Symonds, Burton, Tillotson & Main, 1995, 1996; Thorbjornsson et al., 2000; van Poppel, Koes, Deville et al., 1998; Weiser, 1997) although the possibility remains that these variables are dependant on the physical variables themselves or develop as a consequence of the injury (Bernard & Fine, 1997; Marras, 2000). Positive associations between psychosocial factors and low back pain are more likely when self reporting of injuries is used over more objective measures (Davis & Heaney, 2000; Ferguson & Marras, 1997).

Tubach et al. (2002) found that psychosocial variables recorded on questionnaire were positively associated with low back pain, in particular poor social support at work, although, as discussed earlier, the low back pain measures were based on recall.

In an extensive review of the literature Davis and Heaney (2000) found that jobs with high biomechanical demands were more likely to be associated with increased psychosocial stressors, thus introducing potential confounding when

examining the relationship between these stressors and the incidence of low back pain. The relationship between psychosocial stressors and low back pain was also found to be influenced by the type of independent variable and outcome measures used. Davis and Heaney conclude that, although there is evidence of a relationship between psychosocial stressors and the incidence of occupational low back pain there is no strong evidence of a causal relationship.

Andersson (1997, p.120) goes as far as saying that psychosocial factors are "probably more related to disability claims than to occurrence of a specific organic pathology." Clemmer and Mohr (1991) found that injury claims in the offshore petroleum industry decreased during times of economic downturn and increased lay-offs, supporting the suggestion by Andersson.

Atlas et al. (1996), in a study of 507 low back pain cases, found that workers' compensation insurance was associated with significantly poorer outcomes at 6 month follow-up than for uninsured cases. Similarly, Andersson (1997), in a review of the literature, found that workers' compensation insurance was reported as consistently increasing the time off work and length of disability compared to non-compensable low back pain and this effect should be considered when examining work place epidemiological studies. In a review performed for Workcover Western Australia (2001) a negative relationship between outcomes and workers' compensation insurance was reported for all injury types although the authors suggested that factors other than psychosocial aspects, such as the system itself, must be considered.

In summary, the generally accepted risk factors associated with occupational low back pain are:

- Heavy Physical Work
    - Increased load
    - Increased pushing force
    - Increased pulling force
    - Frequency of activity
    - Duration of activity

- **Kinematics**
    - **Increased twisting**
    - **Increased bending**
    - **Increased load moment**
    - **Increased velocities**
- **Past history**
- **Psychosocial**

Etiology of Low Back Pain

Just as an understanding of the risk factors associated with occupational low back pain is essential when examining control measures so is an understanding of the underlying etiology / traumatolgy of low back pain essential when establishing the biological plausibility of both risk factors and control measures. However, a full description of this field is beyond the scope of this discussion and only those areas that may have some bearing on the prophylactic use of a back belt in the workplace will be examined.

There are a multitude of models (Andersson, 1998; Feyer & Williamson, 1998; Hale, 1998; Jorgensen, 1998; Raouf, 1998) that are used to understand workplace incidents/accidents. However, occupational low back pain does not easily fit these general models.

As stated earlier, in the majority of low back pain cases it is not possible to make a specific diagnosis or to identify an anatomical structure as the source of the complaint (Bernard & Fine, 1997; Garg & Moore, 1992a; Gerr & Mani, 2000; Haldeman, 1990; Jayson, 2000; Kraus, Gardner et al., 1997; Riihimaki, 1998) and there is a poor correlation between gross pathology, such as that identifiable on radiology, and low back pain (Haldeman, 1990). The causes of low back pain have been described as being "dynamic, multifaceted and multidimensional." (Granata & Marras, 1999)

McGill (1997) states that "injury must result from excessive mechanical loading of a particular tissue, thereafter psychosocial aspects affect injury reporting, pain perception, etc." (p. 465) This load-tolerance model is also described by Marras (1998) where manual handling tasks that result in loads that remain within the tissue tolerance limits are 'safe'. Damage to tissues occurs either when an applied load is greater than the failure tolerance of the tissues or where repeated sub-failure loads lead a slow degradation in tissue strength and, therefore, decreased failure tolerance. This repeated sub-failure load mode is supported by Shelerud (1998) who, following a review of the literature, concluded that cumulative trauma best explains the cause of occupational low back pain.

Similarly, Riihimaki (1999) describes the overloading of either tissue endurance or tolerance from sudden over exertion, sustained exertion and repetition exertion.

Panjabi (1992) describes a spinal stability system comprising three interactive subsystems; the passive and active musculoskeletal systems and the neural control system (see figure 5). One source of low back pain is an error in the neural control system resulting in excessive muscular force development with subsequent tissue damage and symptoms. Panjabi gives an example of such an injury where acute pain is experienced during a complex manoeuvre under negligible load. A similar mechanism of motor control error has been proposed by Cholewicki and McGill (1996) who mathematically modelled lumbar spinal stability and found that stability increased under conditions of high compressive load/increased muscle activity. Their model suggested that under lighter loads where lower muscle activity is required the spine can buckle following a minor motor error. They suggested that this may explain why injuries often occur during activities requiring little effort and propose two mechanisms of injury; a momentary loss of stability resulting in injury due to strain of pain sensitive tissues or; a sudden muscular response to regain lost stability resulting in muscle spasm or strain. The model did not consider the effect of intra-abdominal pressure (intra-abdominal pressure), nor the action of the transversus abdominis and rotatores muscles.

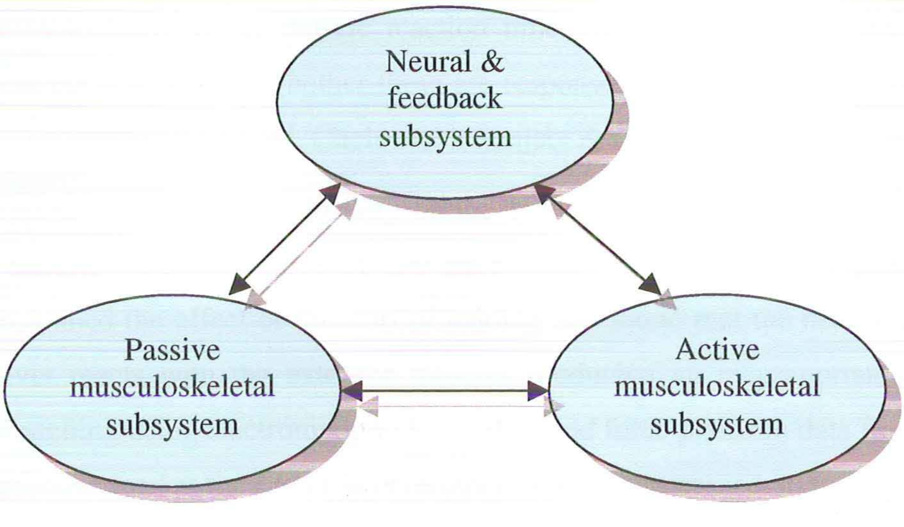

Figure 5. Spinal stability system. (Adapted from Panjabi (1992))

Pope, Goh and Magnusson (2002) also emphasise the importance of proprioception and its role in injury, particularly as a result of failures in the neural feedback system during apparently simple tasks.

Errors in the spinal stability system have been demonstrated experimentally. Parnianpour, Nordin, Kahanovitz and Frankel (1988) examined subjects performing repeated trunk flexion and extension exertions at 70% of their maximum isometric strength. As the subjects fatigued a loss of muscle coordination led to an increase in spinal motion outside of the sagittal plane and it was proposed that these coupled motions would lead to an increased risk of low back pain. This loss of coordination would also expose the individual to increased risk of injury should there be an unforeseen change in the load or task demands.

Solomonow, Zhou, Harris, Lu and Barratta (1998) examined the reflex contraction of the multifidus muscle resulting from mechanical and electrical stimulation of the lumbar supraspinous ligament. They suggested that rapidly applied external forces may not allow sufficient time for the reflux to generate muscular force, thus resulting in destabilisation and subsequent injury. They further suggest that prolonged activity may result in fatigue, a reduction in the reflex efficiency and significant increase in the risk of injury.

In response to sudden trunk loading chronic low back pain sufferers have been shown to have slower muscle reaction times and increased antagonistic co-contraction but it is unclear whether these are responses to the low back pain or are predisposing factors (Radebold, Cholewicki, Panjabi & Patel, 2000).

Sudden or unexpected loading of the lower back during manual handling tasks is another potential source of low back pain. Mannion, Adams and Dolan (2000) examined the effect of this sort of loading and found that the neuromuscular system over reacts with the extensor muscles producing an inappropriately large force. Modelling using electromyography (EMG) and force platform data found that the compressive load at the L5/S1 intervertebral disc was increased 30 to 70% on the application of a sudden and unexpected load, while only a 6% increase in compression could be attributed to the load itself. A similar over compensation was reported by Magnusson et al. (1996) who propose that injury may result where an

individual has poor co-ordination or postural control. In contrast to the suddenly applied load, unexpectedly heavy loads do not appear to lead to increased spinal load (van der Burg & van Dieen, 2001; van der Burg, van Dieen & Toussaint, 2000) although a burst of electromyographic activity in all the abdominal muscles was reported, possibly functioning to maintain stability of the lower back.

Spinal stability can be enhanced by co-activation of antagonists (Pope et al., 2002). However, there is a limit to the degree of protection that can be provided as increasing antagonistic activity leads to increased spinal compression, finally reaching a level where there is further advantage in increasing co-activation.

In an extensive review of the literature van Dieen, Hoozemans and Toussaint (1999) could find no evidence suggesting that the squat lift, which is widely described as the 'correct' lift, was any better, from a biomechanical standpoint, than the stoop lift at preventing low back injury.

Winkel and Mathiassen (1994) describe an exposure-effect model of workplace injury based on mechanical exposure (see Figure 6). External exposure results from factors which result in a mechanical exposure to the body but are independent of the individual. These include the actual load, the frequency of the required task and the duration of the required task. Internal exposure is those forces acting on and in the body, and include the compressive forces developed in the intra-vertebral discs, the lifting frequency adopted by the worker and the duration that the worker performs the activity. The active internal exposure is that exposure that then results in a biological response. Feedback may occur at each level and effect modifiers, such as individual factors and the environment, may modify the exposure at any level.

Marras (1998) simplifies the concept of forces acting on the body during a manual handling task, dividing them into either external loads, which result from the force of gravity acting on the load, and the internal load that is produced by the muscles of the body to deal with the external load.

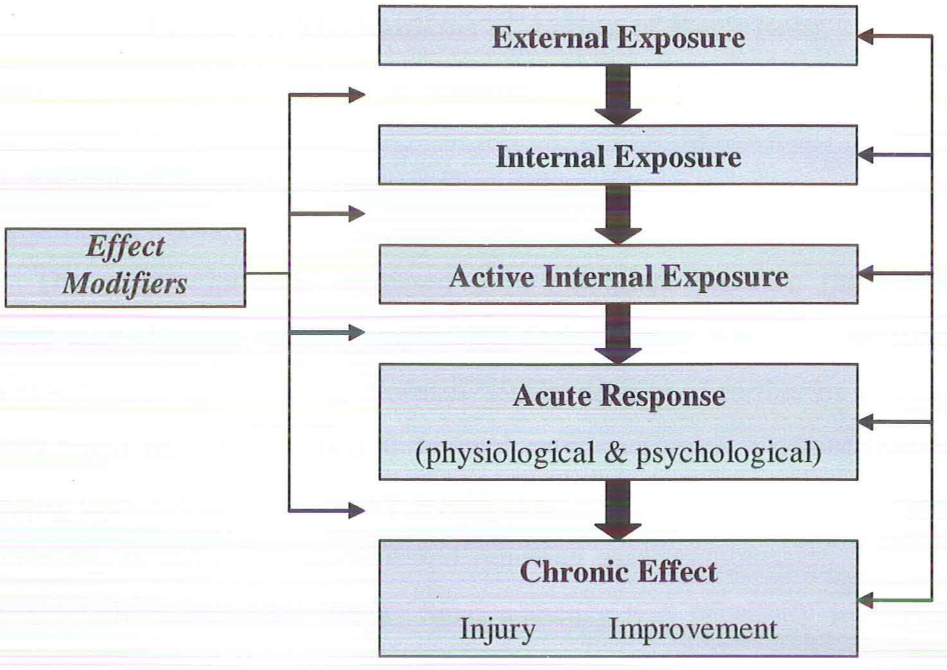

Figure 6. Exposure-Effect Injury Model (Winkel & Mathiassen, 1994)

Proposed Mechanisms of Action of Back Belts

Intra-abdominal Pressure

The proposition that increased intra-abdominal pressure (intra-abdominal pressure) may alleviate spinal compression during lifting was first put forward by Keith (1923, cited in: McGill & Norman, 1987), developed further by Davis (1959), and was based on the contained abdominal cavity acting as a pressurized balloon; increasing intra-abdominal pressure would exert an upward force on the diaphragm, thus creating an extension moment and relieving axial compression on the lumbar spine. (McGill & Norman, 1987) Such a theory was necessary to explain how biomechanically modelled spinal compression often exceeded the experimentally established tissue tolerances and accounted for the raised intra-abdominal pressure observed during lifting (Anderson, Chaffin, Herrin & Matthews, 1985; Daggfeldt & Thorstensson, 1997; P. Davis, 1959; Gracovetsky, Farfan & Lamy, 1981; Hemborg, Moritz, Manburg, Lowing & Akesson, 1983; Marras & Mirka, 1996; McGill & Norman, 1987; Morris, Lucas & Bresler, 1961). Due to the way back belts encompass and apparently compress the abdomen increased intra-abdominal pressure has been a popular mechanism of action put forward in the literature (Barron & Feuerstein, 1994; Cholewicki, Juluru, Radebold, Panjabi & McGill, 1999; Genaidy, Simmons & Christensen, 1995; Granata, Marras & Davis, 1997; Grew & Deane, 1982; Harman, Rosenstein, Frykman & Nigro, 1989; Hemborg, Moritz & Akesson, 1985; Kumar & Godfrey, 1986; Lander, Hundley & Simonton, 1992; Lander, Simonton & Giacobbe, 1990; Levine, 1984; SM McGill, Norman & Sharrat, 1990; Miyamoto, Iinuma, Maeda, Wada & Shimizu, 1999; Morris, 1974; Nachemson, Schultz & Andersson, 1983; Perkins & Bloswick, 1995; van Poppel, de Looze, Koes, Smid & Bouter, 2000; Woodhouse, McCoy, Redondo & Shall, 1995) which will be discussed in the following section.

Thomson (1988) mathematically modelled the bending moment of the pressurised column of the abdomen and suggested that spinal loading can be reduced substantially with increased intra-abdominal pressure, a reduction of about 20% in

one example, although this model assumes that the intra-abdominal pressure is produced without any flexor moment cost from the abdominal musculature. Thomson suggested that injury may occur if the load is beyond a critical level that the pressurised abdominal cavity can withstand, leading to local buckling of the previously rigid abdominal cavity and subsequent increased compression and injury of the lumbar spine.

However, McGill and Norman (1987) reviewed the intra-abdominal pressure model and suggested that the co-contraction of the rectus abdominis and oblique abdominals resulted in an increase in spinal compression, due to the long flexion moment arm they operate through, which was not off-set by the de-loading effect produced by the increased intra-abdominal pressure. They felt that earlier models had over estimated both the area of the diaphragm and the moment arm of intra-abdominal pressure. McGill and Norman suggested that the observed increase in intra-abdominal pressure during lifting may function to stiffen or stabilize the spine, at the expense of a small net increase in compression. An alternative or additional function may be maintaining intervertebral alignment and controlling shearing forces. Cholewicki, Juluru and McGill (1999) further support this contention and state that the ability to increase intra-abdominal pressure and therefore stiffen the spine without having to co-contract the erector spinae muscles for stabilisation frees these muscles to perform their primary task, that is, developing extensor torques. Such a stabilising function of increased intra-abdominal pressure has been demonstrated experimentally (Cholewicki, Juluru, Radebold et al., 1999; Cresswell, Oddsson & Thorstensson, 1994; Marras & Mirka, 1996) and is discussed in more detail in a later section.

Spinal unloading due to increased intra-abdominal pressure may still be possible if the increased intra-abdominal pressure is developed by means other than contraction of the rectus abdominis and obliques abdominals. Daggdfeldt and Thorstensson (1997) have demonstrated mathematically that intra-abdominal pressure can be increased through contraction of the transversus abdominis, without the cost of a flexor moment, thereby developing a net extensor torque and relieving spinal compression. These investigators questioned the assumptions of McGill and Norman (1987) that the intra-abdominal pressure force vector always acts normal to

the diaphragm. Their findings suggest that as long as the centre of pressure of the pressurised column representing the abdominal cavity lies in front of any given lumbar disc centre an extensor torque about that disc will result.

Hodges, Cresswell, Daggfeldt and Thorstensson (2001) demonstrated an extensor moment from intra-abdominal pressure by electrically stimulating the diaphragm via the phrenic nerve. Increasing intra-abdominal pressure to approximately 15% of the maximum voluntary level produced an extensor moment of 6 Nm.

Aspen (1987; 1989) provides an alternative function for intra-abdominal pressure that requires the lumbar spine to be in a lordotic or concave posture. The intra-abdominal pressure acts on the anterior surface of the lumbar spine, that is, the convex surface of the lordotic arch. Loading the arch in such a way increases its stiffness and allows the spine and allows the spine to resist externally (to the spine) extensor moments.

Marras and Mirka (1996) examined 94 male and 20 female healthy subjects performing concentric and eccentric, symmetrical and asymmetrical movements utilizing a KIN/COM isokinetic dynamometer. Intra-abdominal pressure was monitored with a rectally inserted radio pill. Significant increases in intra-abdominal pressure were found to be associated with trunk asymmetry, measured torque and trunk velocity, although the effect of torque was only observed above 54 Nm. The lowest levels of intra-abdominal pressure were recorded under isometric conditions. From an analysis of the data Marras and Mirka concluded also that increased intra-abdominal pressure functioned to stiffen the spine.

Daggfeldt and Thorstensson (1997) proposed a reviewed model of intra-abdominal pressure spinal unloading and suggest that this can be achieved by contraction of abdominal muscles with fibre orientations greater than 55^0 from the vertical, that is, the transversus abdominis. The role of the transversus abdominis in intra-abdominal pressure production is also described by Hodges (1999) who suggests that the transversus abdominis is controlled independently of other trunk muscles and that this separate neural control is to provide trunk stability.

Genaidy, Simmons and Christensen (1995), citing data collected earlier by Morris, Lucas and Bresler, developed a linear regression equation relating intra-

abdominal pressure, static loading of the lumbar spine in various angles of flexion and the effect of an inflatable abdominal corset. They found that an external support, that is, a back belt, should allow development of raised intra-abdominal pressure without the need to contract the abdominal musculature, thereby reducing the compressive forces on the spine.

Morris, Lucas and Bresler (1961) examined 6 male subjects in a surgical corset with an inflatable bladder over the abdomen and measured intra-abdominal pressure via a nasal catheter during static loading up to a maximum of 91 kg in a stooped lift posture with varying degrees of trunk flexion. Although the corset significantly raised resting intra-abdominal pressure they suggested that there was little difference between braced and unbraced intra-abdominal pressure under static load, acknowledging the difficulties of interpreting the results with so few subjects.

Grew and Deane (1982) examined the effects of 5 different surgical corsets on intra-abdominal pressure in 10 healthy male and 8 low back pain male subjects. Despite the large range of supports only one resembled the back belts used in the workplace today. Using a rectal catheter they measured intra-abdominal pressure during 15 kg stoop and squat lifts. When grouped as a whole the supports significantly raised intra-abdominal pressure during sitting and standing compared to no support. During the lifting tasks the supports had no significant effect on peak intra-abdominal pressure in healthy subjects, but the trend was consistently towards lower intra-abdominal pressure, while the low back pain group demonstrated a trend to increased intra-abdominal pressure. They concluded that this may indicate that the corset were decreasing spinal load and therefore the reflex that triggers increased intra-abdominal pressure.

Nachemson, Shultz and Andersson (1983), studying one male and three female subjects, attempted a similar examination of surgical corsets to that performed by Grew and Dean (1982) using a pressure sensitive radio tablet but equipment failure resulted in only two subjects being examined and the results were inconsistent.

Hemborg, Moritz, Holmstrom and Akesson (1985) examined 20 construction workers with a history of chronic low back pain and 10 healthy weight lifters performing different lifts and wearing either no belt, a semi-rigid thermoplastic

support or a leather weight lifters belt. Low back pain subjects performed stoop and squat lifts at 10 and 25 kg while the weight lifters performed a 55 kg squat lift. Intra-abdominal pressure was recorded via a nasal catheter. Intra-abdominal pressure was consistently increased when wearing either support over the no support condition, by 1.0 to 2.5 kPa for the semi-rigid support and 2.3 to 3.0 kPa, but this increase was only significant during lighter lifts when the absolute value of the intra-abdominal pressure was lower.

Kumar and Godfrey (1986) examined the effect of 6 different surgical corsets on intra-abdominal pressure during symmetrical and asymmetrical lifts of 7 to 9 kg in 11 male and 9 female subjects. Intra-abdominal pressure data was recorded via an ingestible radio pill. They reported a significant increase in both peak and average intra-abdominal pressure with all the corsets over the unbraced condition, with no significant differences between corsets. None of the corsets examined in this study resemble an industrial back belt. The loads utilised in this study were lighter than those of all other intra-abdominal pressure studies and well below the 16 kg load, above which the risk of manual handling injury may be considered to increase significantly (Worksafe Western Australia Commission, 2000).

Harman, Rosenstein, Frykman and Nigro (1989), using a nasally inserted pressure transducer, measured intra-abdominal pressure in 8 male and 1 female subjects performing a squat lift at 90% of 1 repetition maximum (RM), that is, a load such that only one lift can be performed, with and without a leather weight lifting belt. Intra-abdominal pressure was found to increase significantly earlier in the lift and was significantly higher throughout the lift while wearing the belt.

Lander, Simonton and Giacobbe (1990) utilized rectal catheters to measure intra-abdominal pressure while 6 competitive weight lifters performed a squat lift at 90% of their 1 repetition maximum while wearing 2 sizes of leather weight lifters belt compared to a no belt condition. A significant increase in both peak and mean intra-abdominal pressure was reported when subjects wore the belt compared to a no-belt condition, the increase in mean intra-abdominal pressure in the order of approximately 17%. In a similar study Lander, Hundley and Simonton (1992) 5 competitive weight lifters performed 8 repetitions of the squat lift at their 8 repetition

maximum. A leather weight lifting belt lead to a 25-40% increase in intra-abdominal pressure over the no-belt condition.

McGill, Norman and Sharratt (1990) studied 6 subjects performing a subjectively heavy but safe squat lift on a lifting machine with and without a leather weight lifting belt. Intra-abdominal pressure was recorded via a nasal catheter. A significant increase in peak intra-abdominal pressure was recorded during the belt condition, the average increase being 21%. However, the increase in intra-abdominal pressure was played down by the authors as they found that this increase was not statistically different from that achieved through breath holding via a Valsalva manoeuvre. The authors concluded that the intra-abdominal pressure data combined with electromyographic data collected, discussed in a later section, suggested that the belt most likely acts to stiffen the trunk. Based on biomechanical modelling, the extensor moments did not alter appreciably, so it was also concluded that the belt resulted in no significant de-loading of the lumbar spine.

Shah (1993a; 1993b; 1994) describes the use by Nepalese heavy workers and mountain porters of a patuka, which is a 5 m long and 1 m wide piece of cloth traditionally wrapped tightly around the waist in the belief that it provides support for the lower back. Shah (1994) randomly selected 10 Gurkha soldiers serving with the British Army and measured intra-abdominal pressure with a radio pill while performing 10 common physical activities with and without a patuka. Overall, the patuka resulted in a significant increase in intra-abdominal pressure with an increase in intra-abdominal pressure reported in 9 out of the 10 activities.

In contrast to the above studies Woodhouse, McCoy, Redondo and Shall (1995) examined 9 male subjects performing a near identical procedure to Harman et al. (1989), but using both a leather weight lifting belt, a leather weight lifting belt with a rigid abdominal pad and a back belt, and reported no significant difference in intra-abdominal pressure between belt conditions.

Miyamoto, Iinuma, Maeda, Wada and Shimizu (1999) examined the effects of a leather weight lifting belt on 7 male subjects performing symmetrical and maximal isometric lifts, with intra-abdominal pressure recorded rectally. They found no significant difference in intra-abdominal pressure although it must be noted that this study was distinct from previous studies in that it was performed under isometric

conditions. The only other study performed under isometric conditions (Morris et al., 1961) likewise demonstrated no change in intra-abdominal pressure.

Miyamoto, Shimizu, and Masuda (2002) utilised fast magnetic resonance imaging to assess the effect of a leather weight lifting belt, with a width at the front of 6 cm and at the back of 10 cm, on the sagittal section of the abdomen at rest and during a Valsalva manoeuvre, which voluntarily increases intra-abdominal pressure through breath holding. Eleven healthy male subjects were examined. The belt resulted in a significant increase in the anterior-posterior diameter of the upper abdomen and a significant increase in the distance from the centre of the diaphragm to the eleventh thoracic vertebra (T11), regardless of the Valsalva manoeuvre. This second measure was assumed to reasonably represent an increase in the lever length of intra-abdominal pressure, which should enhance the spinal unloading effect of increased intra-abdominal pressure. Miyamato et al. acknowledge that difficulties arise when attempting to relate these changes to real world lifting situations for two reasons; the exertions involved in performing a Valsalva manoeuvre differ from those involved in a lifting exertion and the changes were measured in a supine position. In addition to these limitations the dimensions of the weight lifting belt used, although common for a belt of this type, were far narrower than the typical 20 cm width of an industrial back belt, such as that issued to Bunnings' employees.

Barron and Feuerstein (1994) in an extensive review of the literature concerning the mechanisms and outcomes of Back belts stated the effect of corsets, weight lifting belts and back belts on intra-abdominal pressure was variable, despite the consistency presented in their review. Genaidy, Simmons and Christensen (1995), on reviewing the back belt literature, concluded that, although the spinal unloading effect of intra-abdominal pressure is yet to be clarified, the consistent increased intra-abdominal pressure observed with corsets and belts may enhance the proposed stabilizing effect of intra-abdominal pressure. In a review on the use of back belts to increase intra-abdominal pressure Perkins and Bloswick (1995) examine in detail the literature regarding intra-abdominal pressure as a whole but draw no conclusions regarding the relationship between back belts and intra-abdominal pressure.

In a meta-analysis of the mechanisms of action of back belts van Poppell, de Looze, Koes, Smid and Bouter (2000) found no evidence that back belts increase intra-abdominal pressure. The reviewers conceded that the analysis required comparisons of two means rather than paired analysis due to lack of data presented and this had the effect of decreasing the significance of individual studies and possibly increasing the confidence interval of the overall effect, reported as 0.26, and a 95% confidence interval of 0.07 - 0.59.

On the whole the literature would suggest that weight lifting belts and other supports do lead to an increase in intra-abdominal pressure (see Table 1). If this is accompanied by a decrease in abdominal muscle activity, or at least no increase in abdominal activity (discussed in a later section), then it would seem that a de-loading of the lumbar spine and/or enhanced stability may be achieved by wearing a back belt without the added compression cost from abdominal muscle flexion moments usually associated with volitional or reflex increases in intra-abdominal pressure. It should be noted that only one study (Woodhouse et al., 1995) utilised a back belt similar to that seen in today's industrial setting and, in general, subject numbers were small, no doubt due in some part to the nature of the intra-abdominal pressure recording devices.

Table 1. The effect of back belts on intra-abdominal pressure (intra-abdominal pressure).

Legend: = No change. ↑ Increased intra-abdominal pressure. ↓ Decreased intra-abdominal pressure

Author	Subjects	Type of support	Activity	intra-abdominal pressure	Comments
Morris et al. (1961)	6 male	Inflatable corset	Isometric load to 91 kg in varying degrees of trunk flexion	=	Noted increased intra-abdominal pressure at rest with the corset. Acknowledged larger sample may have resulted in different result.
Grew & Dean (1982)	1) 10 healthy male 2) 8 LBP male	Variety of Surgical corsets	Stoop and squat lifts at 15 kg	1) ↓ trend 2) ↑ trend	None of the supports tested resembled a back belt
Nachemson et al. (1983)	1 male 3 female	Variety of Surgical corsets	6 activities with the pelvis fixed	Inconclusive	Equipment failures and small study numbers resulted in inconclusive results

Author	Subjects	Type of support	Activity	Intra-abdominal pressure	Comments
Hemborg et al. (1985)	1) 20 male construction workers with a past history of LBP . 2) 10 male weight lifters	Semi-rigid thermoplastic and leather weight lifting belt	1) Stoop and squat lifts at 10 and 25 kg. 2) Squat lift at 55 kg	1) ↑ 2) ↑	intra-abdominal pressure was consistently raised but only significantly for lighter lifts
Kumar & Godfrey (1986)	11 male 9 female	Surgical corsets	Symmetrical and asymmetrical lifts at 7 – 9 kg	↑	The lifts involved lighter loads than those utilised in other studies
Harman et al. (1989)	8 male 1 female	Leather weight lifting belt	Squat lift at 90% of 1 RM	↑	
Lander et al. (1990)	6 male weight lifters	Leather weight lifting belt	Squat lift at 90% of 1 RM	↑	
McGill et al. (1990)	6 male	Leather weight lifting belt	Heavy squat lift on lifting machine	↑	
Lander et al. (1992)	5 male weight lifters	Leather weight lifting belt	8 squat lifts at 8 RM	↑	
Shah (1994)	10 male soldiers	Traditional Nepalese patuka	Common daily activities	↑	Patuka is a 5 x 1 m cloth wrapped tightly around the waist.

Author	Subjects	Type of support	Activity	intra-abdominal pressure	Comments
Woodhouse et al. (1995)	9 male	Leather weight lifting belt and back belt	Squat lift at 90% of 1 RM	=	
Miyamoto et al. (1999)	7 male	Leather weight lifting belt	Maximal isometric lifts	=	
Miyamoto et al (2002)	11 male	Leather weight lifting belt	Valsalva manoeuvre	Not measured	The back belt resulted in changes in the abdominal dimensions which would result in an increase in the spinal unloading provided by increased intra-abdominal pressure

Spinal Shrinkage

Bourne and Reilly (1991) assessed spinal shrinkage, that is, the loss of spinal length due to compression of the intervertebral discs, via a stadiometer in 8 male subjects performing a weight training circuit with and without a weight lifting belt. Although average spinal shrinkage was less with the belt, 2.9 mm compared to 3.6 mm, the change failed to reach a level of significance ($P>0.05$).

Reilly and Davies (1995) had 10 male weight lifters perform 3 sets of 20 dead-lifts with a 30 kg load. They found that a leather weight lifting belt significantly reduced spinal shrinkage by 49%.

Magnusson, Pope and Hansson (1996) examined 5 male and 7 female subjects performing a 10 kg lift from floor to table at 2 lifts per minute for 5 minutes. Wearing an industrial back belt significantly reduced spinal shrinkage, compared to a no belt condition. Additionally, when the back belt was first put on there was no change in height but on removing the back belt there was an immediate and significant reduction.

Rabinowitz, Bridger and Lambert (1998) examined 10 male subjects performing a floor to table lift of a crate adjusted to 20% of their body weight. The lifts were performed 5 times a minute for 15 minutes. 4 conditions were examined; stoop or squat lift, with and without a back belt. All 4 conditions resulted in a significant amount of spinal shrinkage and there was no significant difference between conditions. However, these authors point out that the length of time that the lifts were performed over may have 'saturated' any differences between conditions that may have existed earlier in the task.

Conclusions regarding the effect of back belts on spinal shrinkage are difficult to make due to the small number of studies and differences in methodology, particularly in the temporal relationship of the measures. The limited evidence would suggest that back belts may decrease spinal shrinkage, the assumption being that a decrease in spinal shrinkage is an indirect measure of decreased spinal compressive loading.

Kinematics

Compared to the biomechanical measures discussed above, the literature demonstrates far more consistency on the effect of back belts and other supports on range of motion (ROM). In fact, the original purpose of back braces and supports was to immobilise the spine (Norton & Brown, 1957).

Grew and Dean (1982) placed 10 healthy male and 8 low back pain male subjects in a pelvic constraint frame to isolate active trunk range of motion and measure total lumbar flexion/extension and lateral flexion range as well as the total area covered by a trunk circumduction movement. All 5 surgical corsets studied demonstrated a consistent decrease in the range of motion measures over the no support condition, in the majority of cases to a statistically significant level.

Fidler and Plasmans (1983) radiologically examined the effect of 4 surgical supports, one a canvas corset and the remaining three rigid jackets, on lumbar intersegmental sagittal range of motion in 5 healthy male subjects. They found that all the supports significantly reduced range, the canvas corset reducing the range to 60% of the unsupported condition with larger restrictions for the rigid supports.

Lantz and Schultz (1986a), in the first part of the study cited previously, investigated the effect of surgical corsets and a moulded thermoplastic brace on active trunk flexion, extension, lateral flexion and rotation. 5 male subjects took part and range of motion was measured in sitting and standing positions with the pelvis fixed. All 3 corsets restricted at least some motions while in no case was there an increase in range, with the restriction in flexion being up to 20% and up to a 48% decrease for the other motions. The most restriction for all the supports was on lateral flexion in sitting. The authors concluded that the restricted motion was very likely to relieve the load on the lumbar spine during activity by reducing the net flexion moment.

Buchalter, Kahanovitz, Viola, Dorsky and Nordin (1989) examined the immobilising effectiveness on the active range of lumbar and thoracic motion of four types of lumbar braces: the Raney Jacket; Camp lace-up corset, a moulded polypropylene thoracolumbar-sacral orthosis; and an elastic corset. 33 healthy subjects took part but gender was not specified. All four supports significantly

reduced active flexion/extension and lateral flexion range of motion in both the lumbar and thoracic spine, the latter being by greater than 60%. No significant restriction to rotation was found, possibly due to the small baseline range.

In a pilot study of the traditional Nepalese patuka Shah (1993b) found a significant reduction in the range of trunk side flexion but no difference in trunk rotation.

Marley and Duggasani (1996) examined 8 healthy males performing a symmetrical floor to table lift of 7 and 14 kg at three different lifting frequencies. The effect of a back belt on lower limb kinematics in the sagittal plane were measured using video motion analysis. Although no significant main effect was demonstrated for the back belt the 3-way interaction of support, lifting frequency and load demonstrated a significantly smaller hip angle, and a significantly greater peak knee and hip acceleration. The authors concluded that, overall, the back belt did not alter the lower limb or lifting mechanics in the sagittal plane any more than could be achieved through training or experience. Nor did they find that the back belt resulted in a 'safer' lift, presumably meaning a lift with a more upright trunk posture, and assumed this indicated that the back belt did not remind the subject to lift correctly.

Granata, Marras and Davis (1997), examined 15 male subjects performing 14 and 23 kg symmetrical and asymmetrical lifts while wearing a back belt, a weight lifter's belt and a corset, and found that all 3 supports reduced the average range of motion in at least one plane over a no support condition but only the back belt significantly reduced peak trunk angles in all 3 planes. Reductions were in the order of 3-4^0 for trunk flexion and side flexion and 2.5^0 for trunk rotation. In symmetrical lifts significant decreases in extension velocities were reported for all supports. During asymmetrical lifts extension velocities were again consistently and significantly reduced and the back belt resulted in a significant reduction in twisting velocities. All 3 supports significantly reduced both sagittal and twisting accelerations. It is important to note that many of the reductions in trunk motions were offset by an increase in pelvic motion.

Jonai, Villanueva, Sotoyama, Hisanaga and Saito (1997) examined trunk motion in 12 workers on an express package delivery line. The belt assessed was a commercially available pelvic belt. They noted no significant change in range of

motion although a significant decrease in maximum flexion velocity was observed. However, the belt and no belt condition were measured through a 30 minute section of a normal work day and no account is taken for the variations in the work task. The belt examined is also worn in a different manner and presumably for a different purpose to the back belts commonly used in the workplace so it is difficult to draw any conclusions or make any comparisons with this study.

Thoumie, Drape, Aymard and Bedoiseau (1998) used electrogoniometers to asses the effect of a back belt on the sagittal range of motion of 15 physiotherapist and nurses performing a single, full range sagittal movement and during normal work duties. Total sagittal range of motion was reduced by 17% for the single movement and by 22% (13^0) during normal work tasks. Lumbar lordosis was noted to decrease with the back belt but the amount depended on the initial degree of lordosis; the greater the lordosis the greater the effect of the back belt. As in the study by Jonai (1997) it appears that the authors assume that the work duties between belt conditions will remain identical.

Sparto, Parnianpour, Reinsel and Simon (1998) investigated 2 groups of 13 male subjects using a back belt performing tasks on a lifting machine. The first group performed symmetrical lifts to fatigue while the second group performed asymmetrical lifts with an 11kg load. The back belt resulted in a significant decrease in sagittal range of motion, of 8^0 and 6^0 respectively, and peak angular velocity in both lifts but no significant effect was found on lateral or twisting motions for the asymmetrical lift.

Woldstad and Sherman (1998) investigated the effect of a back belt on 8 male and 8 female subjects performing maximal isometric lifts at calf and elbow height in both a symmetrical and asymmetrical posture. The only significant relationship between the belt and range of motion occurred in the asymmetrical lift at calf height where a significant decrease in rotation of about 4^0 was reported. The authors applied this decrease in range to the *1991 NIOSH Revised Work Practices Guide for Manual Lifting* (T. Waters et al., 1993) and found that it increased the recommended weight of lift by 1 to 1.5% and therefore concluded that the back belt was unlikely to significantly reduce the risk of injury. However, this conclusion appears to underplay the importance of axial twisting as a risk factor for occupational low back

pain (Fathallah et al., 1998b; Marras et al., 1995; Marras et al., 1993). It is important to note that this was a static test so the true relationship to the NIOSH guidelines, which were formulated for dynamic workplace lifting, is not possible to determine.

McGorry and Hsiang (1999) examined 6 male subjects performing a symmetrical 23 kg lift/lower task from floor to knuckle height and observed a significant decrease in sagittal range of motion of approximately 4^0 with either a rigid or elastic back support over the no support condition. The actual supports used is not clear, other than that they were representative of those commonly found in the workplace. No significant change occurred in pelvic range of motion.

Thomas, Lavender, Corcos and Andersson (1999) examined the effect of a sudden load applied symmetrically and asymmetrically in 10 male and 10 female healthy subjects. The subjects were instrumented with electromyography and an electrogoniometer exoskeleton. The pelvis was fixed and the load applied to the chest through a harness. Back belts were found to significantly reduce both the side flexion range of motion and velocity but had no significant effect on the kinematics in the sagittal or coronal planes.

Utilising a back belt similar to that issued to Bunnings' staff Marras, Jorgensen and Davis (2000) examined its effect on symmetrical and asymmetrical lifts where the subjects were able to adopt their own lifting style and move their feet. 20 healthy males lifted 13.6 and 22.7 kg boxes from either knee or 10 cm above knee height to elbow height. An electrogoniometer exoskeleton recorded trunk kinematics. The back belt resulted in a significant decrease in sagittal (up to 3.8^0) and transverse plane (up to 1.5^0) range of motion and velocity and in sagittal (extension) acceleration.

In a somewhat different approach McGill, Seguin and Bennett (1994) utilized two types of frictionless jig to measure the passive stiffness of the trunk in 22 male and 15 female subjects. The belt examined was a leather weight lifters belt. The belt resulted in a significant increase in passive stiffness in lateral flexion and rotation but not flexion/extension. The authors acknowledge that lateral flexion and rotation were measured in a non-weight bearing, that is reclined, position while flexion/extension were measured upright where the compressive effect of gravity may have affected the results. They also noted that some female subjects found it

difficult to adequately tighten the leather belt which is of a far stiffer and therefore less conforming construction than the back belt commonly used in the workplace.

Lavender, Shakeel, Andersson and Thomas (2000) subjected 10 male and 8 female volunteers to sudden and unexpected loads applied both symmetrically and asymmetrically, with and without a preload and with and without a back belt. Flexion range of motion was significantly reduced by the back belt in symmetric loading conditions, more so with a preload, with a similar but not significant trend under asymmetric loading conditions. In asymmetric loading lateral flexion range was significantly reduced in males when preloaded and in females under both load conditions. No significant change in rotation range was recorded although the authors noted that the small ranges involved would have made detecting an effect difficult. Like the earlier study of McGill et al. (1994) this study varied from previous studies of range of motion in that it was measuring the combined effects of the back belt on the passive stiffness of the trunk and the reflex muscle response to sudden loading.

Giorcelli, Hughes, Wassell and Hsiao (2001) had 17 male and 11 female subjects lift large and small boxes weighing 9.4 kg from 10 cm off the floor to a height of 79 cm and 60^0 to the right. Kinematic measurements were made using video analysis. Wearing a back belt resulted in a significant decrease in trunk flexion range, flexion angular velocity, extension angular velocity and left lateral flexion angular velocity for both box sizes and right lateral flexion and left rotation range.

Willey (2001) enlisted 18 female subjects experienced in patient handling to examine the effect of two different sized back belts on a simulated patient transfer of a 13.6 and 22.7 kg manikin from sitting to standing on various kinematic measures. The narrower belt had a width of 15.2 cm and the wider 22.9 cm. The kinematic variables examined were maximum trunk, knee and elbow flexion, centre of gravity displacement and velocity, and time of lift. Analysis of variance demonstrated a significant difference between the two belts and a no belt condition for trunk flexion during the lighter lifting task. When comparing means only the wider belt resulted in a significant decease in trunk flexion range, by 7.23%, when lifting the smaller manikin. No other back belt effect was found for the remaining kinematic variables.

Zink, Whiting, Vincent, and McLaine (2001) examined 14 healthy male weight lifters performing a single squat lift at 90% of their 1 repetition maximum, with and without a leather weight lifting belt. Video revealed no significant difference in kinematics of individual body parts although overall the lift was performed at a faster rate during the belt condition. The barbell also travelled further anteriorly and vertically during the belt lifts.

Barron and Feuerstein (1994) in a review of the literature examined the results of a very early study on the immobilising effectiveness of rigid surgical braces (Norton & Brown, 1957) which found that an ill-fitted rigid brace may be well secured around the thorax but loose around the lumbar region, resulting in an increase in lumbar range of motion. Barron and Feuerstien go on to state that "this potential adverse effect remains a continued but valid argument against the universal use of back belts by workers." (p. 131) The reviewers fail to explain how the results obtained from a single study on rigid braces can be used to produce a 'continued and valid argument' regarding flexible industrial back belts; it is difficult to conceive how a flexible back belt can be firmly attached around the thorax but loosely attached around the lumbar region, unless there has been a gross error in how it is worn. They go on to state that "studies have not been able to demonstrate that belts *currently employed in the workplace* [emphasis added] can restrict trunk movement sufficiently to reduce the risk of low back injury" (p. 131) without the qualifier that, at that time, no study had been published examining the effect industrial back belts on range of motion, that is, only leather weight lifting belts and rigid or semirigid orthoses had been studied.

In their systematic review of the literature regarding the mechanisms of action back belts van Poppel et al. (2000) performed a meta-analysis of suitable results and found that back belts significantly reduce flexion–extension range of motion, with an effect size of 0.7 (95% CI 0.39-1.01), and side flexion, with an effect size of 1.13 (95% CI 0.17-2.08). Axial rotation was generally reduced but failed to reach significance with an effect size of 0.69 (95% CI –0.40-4.31). As with the analysis of intra-abdominal pressure the meta-analysis performed may produce wide confidence intervals and dilute the significance of individual studies. Interestingly the authors chose to include the results of Jonai et al. (1997), discussed previously,

which examined the affect of a pelvic belt, rather than a back belt, on trunk range of motion, and the negative findings of this study may have diluted the overall significance on the analysis.

Table 2 summarises the results of the kinematic studies. From the literature there is strong evidence that back belts significantly reduce lumbosacral range of motion, velocities and accelerations during manual handling activities. As discussed previously, twisting and bending appear to be consistently identified risk factors in the development of low back pain (Andersson, 1981, 1997; Bernard & Fine, 1997; Burdorf & Sorock, 1997; Davis & Marras, 2000b; Fathallah et al., 1998b; Garg & Moore, 1992a; Gerr & Mani, 2000; Granata & Marras, 1999; Magnusson et al., 1990; Marras, 2000; Marras, Allread, Burr & Fathallah, 2000; Marras et al., 1995; Marras et al., 1993; Norman et al., 1998; Shelerud, 1998; Tubach et al., 2002) and an improvement in kinematics while wearing a back belt may prove to be the most readily explainable positive effect of back belts. It should be noted that a direct link has been shown between lifting velocity and increased twisting and lateral flexion during asymmetrical lifts (Lavender, Li, Andersson & Natarajan, 1999) so that even if the back belt only results in a decrease in velocity there will be subsequent reduction in range of motion.

Table 2. The effect of back belts on range of motion (ROM).

Legend: = No change. ↑ Increased. ↓ Decreased. F Flexion. E Extension. LF Lateral flexion. Rot Rotation.

Author	Subjects	Type of support	Activity	ROM	Velocity	Comments
Grew & Dean (1982)	10 male 8 LBP male	Variety of surgical corsets	Active range of motion with pelvis fixed	↓ F/E ↓ LF		
Fidler & Plasmans (1983)	5 male	Surgical corsets	Active full range flexion/extension	↓ F/E		Radiologically assessed lumbar intersegmental range of motion in the sagittal plane
Lantz & Schultz (1986a)	5 male	2 surgical corsets and a moulded thermoplastic brace	Active flexion, extension, lateral flexion and rotation. In sitting and standing with the pelvis fixed.	↓ F/E ↓ LF ↓ Rot		
Buchalter et al. (1989)	33 subjects (gender no specified)	Surgical corsets and elastic belt	Active flexion, extension, lateral flexion and rotation.	↓ F/E ↓ LF = Rot		
Shah (1993b)	Not stated	Traditional patuka	Not stated	↓ LF = Rot		Pilot study

Author	Subjects	Type of support	Activity	ROM	Velocity	Comments
McGill et al. (1994)	22 male 15 female	Leather weight lifting belt	Passive stiffness using frictionless jig.	↑ LF stiffness ↑ Rot stiffness = F/E stiffness		Measured passive stiffness rather than range of motion
Marley & Duggasani (1996)	8 male	Back belt	Symmetrical floor to table lifts at 7 and 14 kg and 3 frequencies	=		Measured lower limb kinematics
Granata et al. (1997)	15 male	Surgical corset, weight lifting belt and back belt	Symmetrical and asymmetrical lifts at 14 and 23 kg	↓ F/E ↓ LF ↓ Rot	↓ E ↓ Rot	
Jonai et al. (1997)	12 package delivery workers	Pelvic belt	Delivery line duties	=	↓ F	Utilised a pelvic belt rather than a back belt
Thoumie et al. (1998)	15 physiotherapist and nurses	Back belt	Single full range sagittal movement and normal work duties	↓ F/E		

Author	Subjects	Type of support	Activity	ROM	Velocity	Comments
Sparto et al. (1998)	2 groups of 13 male	Back belt	Symmetrical and asymmetrical lifting machine tasks	↓ F/E = LF = Rot	↓ E = LF = Rot	
Woldstad & Sherman (1998)	8 male 8 female	Back belt	Maximal isometric lifts at 2 heights. Symmetrical and asymmetrical	= F/E = LF ↓ Rot		Static test
McGorry & Hsiang (1999)	6 male	Rigid and elastic supports	Floor to knuckle lift at 23 kg	↓ F/E		
Thomas et al. (1999)	10 male 10 female	Back belt	Sudden load applied through chest harness. Symmetrical and asymmetrical	= F/E ↓ LF	= F/E ↓ LF	
Marras et al. (2000)	20 male	Back belt	Knee/mid thigh to elbow height lifts at 13.6 and 22.7 kg. Symmetrical and asymmetrical.	↓ F/E ↓ LF	↓ F/E ↓ LF	Decreased extension acceleration

Author	Subjects	Type of support	Activity	ROM	Velocity	Comments
Lavender et al. (2000)	10 male 8 female	Back belt	Response to sudden unexpected load. Symmetrical and asymmetrical.	↓ F stiffness ↓ LF stiffness = Rot stiffness		Back belt appears to stiffen the trunk in response to sudden unexpected loading. Alteration to muscle responses demonstrated.
Giorcelli et al. (2001)	17 male 11 female	Back belt	Asymmetrical floor to hip height lifts of 9.4 kg.	↓ F ↓ LF ↓ Rot	↓ F ↓ E ↓ LF	
Willey (2001)	18 female	Back belt (2 widths)	13.6 and 22.7 manikin from sitting to standing.	↓ F		
Zink et al. (2001)	14 male weight lifters	Leather weight lifting belt	Squat lift at 90% of 1 RM	=	=	

Electromyographic Activity

Results from the analysis of trunk muscle electromyographic (EMG) activity while wearing various forms of back corsets and belts show large variations. In general, investigators are looking for:

1. A decrease in electromyographic activity of the back extensors, in particular the erector spinae, while wearing a back belt as this would suggest that the support is relieving some of the load encountered during a lift.
2. A change in the recruitment pattern which may suggest changes in proprioception or stability requirements.
3. Alterations in abdominal musculature activity, with subsequent changes in intra-abdominal pressure and / or stability.
4. Reduced spinal compression using biomechanical model based wholly or partly on electromyographic data.

Morris, Lucas and Bresler (1961) as part of a larger study on intra-abdominal pressure, had six healthy male subjects performing static loading tests in various degrees of trunk flexion, with and without an inflatable corset. Fine wire electrodes were used to record the electromyographic activity of the abdominal obliques and rectus abdominis muscles. The corset resulted in "consistently and considerably decreased" (p. 341) electrical activity for both muscles, despite there being little change in intra-abdominal pressure.

Waters and Morris (1970) used fine wire electrodes to assess the electromyographic activity of the iliocostalis dorsi, longissimus dorsi, iliocostalis dorsi (usually referred to collectively as the erector spinae muscles), multifidus, rotatores, external oblique, internal oblique and rectus abdominis in 6 healthy male and 4 healthy female subjects at rest and while walking on a treadmill at 4.4 and 5.3 km per hour. Two types of surgical support were assessed; the more rigid chairback brace and a lace up corset. No attempt to normalise the electromyographic G data using maximal voluntary muscle contraction was made so only raw electromyographic data was compared, with increased activity said to occur with

increased amplitude and/or frequency. Although the authors state that erector spinae activity was reduced "in some" subjects at rest while wearing the supports, the results presented indicate that erector spinae activity was reduced in half the subjects by both supports, with one subject demonstrating increased iliocostalis lumborum activity while wearing the chairback brace. Neither support consistently affected erector spinae activity when walking at 4.4 km per hour. When walking at 5.29 km per hour the chairback brace consistently increased erector spinae electrical activity while the corset demonstrated no consistent effect. At rest electrical activity of the rotatores was decreased by both supports and increased by the chairback brace at the higher walking speed. The only condition resulting in an alteration of multifidus activity was the chairback brace at rest where there was a decrease in electromyographic activity. Internal and external oblique activity was reduced in approximately half the subjects at rest and walking at 4.39 km per hour by both supports while no effect was recorded when walking at 5.29 km per hour. No consistent change in rectus abdominis activity was recorded. Stride length and cadence remained the same so changes wére unlikely to be due to changes in walking kinematics.

In the study briefly described in an earlier section by Nachemson, Schultz and Andersson (1983) surface electrodes were used to measure mean electromyographic activity of the erector spinae, rectus abdominis and external obliques in one male and three female subjects. The three types of support examined were a canvas corset, a Rayney flexion jacket and a Boston braces with various amounts of extension. Subjects stood with their pelvis fixed and external loads were applied either horizontally through a chest harness or through weights held in the hands. The loads were also applied both symmetrically and asymmetrically. For some conditions only two subjects were examined. No consistent effect on erector spinae, rectus abdominis or external oblique activity was reported although only raw data is presented for the erector spinae and external obliques. For some conditions only two subjects were examined so it is difficult to draw any conclusion form these results.

Hemborg, Moritz, Holmstrom and Akesson (1985) examined 20 male construction workers with current low back problems and 10 healthy male weight lifters performing both stoop and squat lifts. The back pain group lifted 10 and 25

kg, with and without a semi-rigid back support, while the weight lifters lifted 55 kg, with and without the semi-rigid support and with a leather weight lifting belt. Unprotected surface electrodes recorded electromyographic data from the erector spinae and abdominal obliques. Neither support altered abdominal oblique activity and erector spinae activity increased only during the lowering of 25 kg by the back pain group while wearing the semi-rigid support.

Lantz and Schultz (1986b) studied 5 healthy male subjects performing 19 isometric lifting type activities with the pelvis fixed in both symmetrical and asymmetrical and in standing and sitting postures. Three supports were examined; a chairback brace, a corset and a moulded thermoplastic thoracolumbar orthosis. Surface electromyographic recordings were made for the erector spinae and external oblique muscles. The results for one subject showed very large variation from the remainder so results for this subject were removed from the analysis, leaving 4 subjects. When compared to a no support condition the authors report large variations in electromyographic activity although in general the supports resulted in an increase in mean activity for both muscles during the standing tasks. The authors raised the possibility that the electromyographic signal amplitudes were increased due to direct pressure on the surface electrodes by the supports but dismiss the notion as a bandage was shown to cause only a slight increase in signal strength. However, given that there may have been more pressure applied to the electrodes by the supports examined such an electromyographic artefact must be considered.

Lander, Simonton and Giacobbe (1990), in their examination of the effects of weight lifting belts during a squat lift discussed previously, recorded electromyographic data from the erector spinae, rectus abdominis and external obliques. The electromyographic activity was normalised based on maximum voluntary contraction and, as there was some differences in the calculated spinal forces between conditions, further normalised by the mean calculated L5/S1 moment. The surface electrodes were not protected from pressure from the belt. 6 competitive weight lifters performed a squat lift at 90% of their 1 repetition maximum. Erector spinae and external oblique activity was reduced by the belt, but not always significantly, and there was a trend towards decreased rectus abdominis activity. However, when a similar experimental method was repeated with 5 weight

lifters performing 8 consecutive maximal squat lifts (Lander et al., 1992) no significant change in erector spinae or external oblique activity was demonstrated (rectus abdominis activity was not examined).

McGill, Norman and Sharratt (1990) examined 6 male subjects performing a squat like lift on a lifting machine at a subjectively heavy but safe load. Unprotected surface electrodes recorded electromyographic activity from the erector spinae, intercostal, rectus abdominis, external oblique and internal oblique muscles. The support examined was a leather weight lifting belt. Abdominal oblique activity was reduced slightly by the belt while all other muscles examined demonstrated an increase in activity although only significantly in the case of rectus abdominis.

Hilgen, Smith and Lander (1991) examined 5 male subjects performing floor to knuckle height lifts in the weight range of 11.5 to 31.5 kg. Two belts were examined, an inflatable air belt and a weight lifting belt. Unprotected surface electrodes were used to record the electromyographic activity of the erector spinae and external oblique muscles. Both belts resulted in decreased in electromyographic activity for the two muscles examined but variations in lifting kinematics and a lack of presented data makes it difficult to draw any conclusions.

Magnusson, Pope and Hansson (1996) examined 7 female and 5 male health subjects performing repeated floor to table height lifts of 10 kg. As a percentage of maximum voluntary contraction an industrial back belt resulted in a general decrease in erector spinae electromyographic activity but no inferential statistics were reported.

Granata, Marras and Davis (1997) examined the effect of an industrial back belt, weight lifting belt and a surgical corset on the electromyographic activity of the latissimus dorsi, erector spinae, rectus abdominis, external and internal obliques using protected surface electrodes. 15 healthy males performed symmetrical and asymmetrical lifts of 14 and 23 kg from knee and 10 cm above the knee height to an upright position. During symmetrical lifting the industrial back belt resulted in a significant reduction in normalised activity of the erector spinae and a significant increase in internal oblique activity. During asymmetrical lifting the only significant effect for the back belt was a decrease in erector spinae activity. Neither the weight lifting belt nor the surgical corset had any effect on electromyographic activity.

Lavender, Chen, Li and Andersson (1998) studied the effect of an industrial back belt and floor condition on symmetrical and asymmetrical pulling tasks at 40% of maximum pull. 10 male and 2 female subjects took part in the study. Unprotected surface electrodes recorded the electromyographic activity of the erector spinae, latissimus dorsi, rectus abdominis and external oblique. No significant belt effect was found.

Warren, Appling, Oladehin and Griffin (2001) studied 14 female and 6 male healthy subjects performing a squat lift on a KIN-COM machine, at 13.6 and 22.7 kg by gender respectively, with and without an industrial back belt. Unprotected surface electrodes recorded the electromyography of the abdominal obliques and mean electromyographic values were compared. A significant (p = 0.035) decrease in averaged electromyographic activity occurred of 11.4% for the group as a whole with the back belt compared to a no belt condition, and the authors base their conclusions on this result. However, a consistent variation was apparent between the genders. All 14 female subjects recorded a reduction in mean electromyographic activity while wearing the back belt with an average of 22%. On the other hand, 1 male subject recorded no change while the remaining 5 all demonstrated increased mean electromyographic activity, the average increase for the all 6 male subjects being 18%. These results must raise the question of whether the effects of back belts are gender specific and also must raise doubts about some earlier studies (Lavender et al., 1998; M Magnusson et al., 1996; Majkowski et al., 1998; Nachemson et al., 1983; Waters & Morris, 1970) where both genders where examined and the results pooled due to small sample numbers.

In their study of weight lifters wearing a leather weight lifting belt Zink, Whiting, Vincent and McLaine (2001) found no significant change in erector spinae activity, measured by unprotected surface electrodes, during squat lifts at 90% of 1 repetition maximum.

Lee and Kang (2002) examined 11 healthy male subjects performing repetitive sagittal lifts of 10 and 25 kg, with and without an industrial back belt and found that the back belt significantly decreased normalised electromyographic activity of the erector spinae and significantly increased rectus abdominis and external oblique activity. These authors took particular care to ensure the kinematics

of the lift remained the same between belt conditions but were still uncertain whether the observed electromyographic activity changes were due to small changes in lifting kinematics, which will affect trunk moments, or due to other belt effects such as intra-abdominal pressure. This is of concern in all studies of electromyographic activity as these authors point out that electromyographic activity is very sensitive to changes in kinematics and trunk moments, and as has been discussed earlier, back belts have been shown to lead to significant reductions in kinematic measures.

Majkowski et al. (1998) examined the effect of a weight lifting belt on erector spinae fatigue by recording changes in the electromyographic median power frequency spectrum in 11 female and 13 male volunteers. A box weighing 20% of the subject's maximum isometric lifting force was lifted 10 times a minute for 20 minutes. The belt did not result in any change in erector spinae fatigue.

To assess whether industrial back belts alter trunk muscle activation during sudden loading Thomas, Lavender, Corcos and Andersson (1999) examined unprotected surface electromyographic data from the longissimus thoracis, erector spinae, rectus abdominis and external oblique muscles, normalised with respect to maximum voluntary contraction. 10 female and 10 male subjects stood in a reference frame with the pelvis fixed. Sudden loads were applied through a chest harness both symmetrically and asymmetrically. During asymmetric loading the back belt resulted in a significant decrease in peak normalised electromyography for the erector spinae. In contrast there was an increase, but not significant, in erector spinae activity during symmetrical loading with the back belt. No belt effect was demonstrated for the abdominal muscles studied. Belt effects were found to be independent of gender, in contrast to the trend demonstrated by Warren et al. (2001).

In a similar experiment to the above Lavender, Shakeel, Andersson and Thomas (2000) utilised protected surface electrodes and a sudden unexpected load was applied to a box held in the hands. 8 female and 10 male subjects took part. The back belt resulted in increased erector spinae peak electromyographic activity for both genders in the symmetric loading condition. Under asymmetric loading the contralateral erector spinae activation was increased in males only while the ipsilateral erector spinae activity was decreased for both genders in the back belt condition. The back belt resulted in decreased rectus abdominis and external oblique

activity on the right side, independent of symmetry or gender. During asymmetric loading the contralateral external oblique peak activity was decreased by the back belt in the female subjects. The authors concluded that the back belt altered the muscle strategy in response to perturbations with increased agonist and decreased antagonist activity which would result in "a greater deceleration of the trunk after the onset of the loading, which reduces the motion, which in turn, lowers the peak moment." (p. 1576)

To assess whether direct pressure to surface electromyographic electrodes could alter readings Jorgensen and Marras (2000) examined the effect of an industrial back belt's tension on normalised electromyographic data recorded from protected electrodes during isometric extension efforts. 10 male subjects took part and the muscles examined were the erector spinae, latissimus dorsi, rectus abdominis, external oblique and internal oblique. No significant effect of belt tension was found but it must be remembered that the surface electrodes were protected by foam spacers and does not rule out an effect on unprotected electrodes.

On the whole, the effect of back belt on electromyographic activity is inconclusive although there appears to be some evidence that external oblique activity is reduced while wearing a back belt (see Table 3). When assessing the results of electromyographic studies the concerns regarding the changes in kinematics raised by Lee and Kang (2002) must be considered.

Table 3. The effect of back belts on trunk muscle electromyography (EMG).

Legend: = No change. ↑ Increased. ↓ Decreased. Inc Inconclusive.
EA Erector Spinae RA Rectus Abdominis EO Externa Oblique IO Internal oblique

Author	No. of Subjects	Type of belt	Activity	ES	RA	EO	IO	Comments
Morris et al. (1961)	6 male	Inflatable corset	Isometric load to 91 kg in varying degrees of trunk flexion and stoop and squat lifts to 91 kg.		↓	↓		Fine wire electrodes
Waters & Morris (1970)	6 male 4 female	a) Chairback brace b) Corset	Treadmill walking	a) ↑ b) =	Inc	↓	↓	Fine wire electrodes
Nachemson et al. (1983)	1 male 3 female	a) Corset b) Rayney flexion jacket c) Boston brace	Pelvis fixed. Load applied through chest harness or held in hands. Symmetrical and asymmetrical	Inc	Inc	Inc		Surface
Hemborg et al. (1985)	1) 20 male construction workers with a past history of LBP . 2) 10 male weight lifters	Semi-rigid thermoplastic and leather weight lifting belt	1) Stoop and squat lifts at 10 and 25 kg. 2) Squat lift at 55 kg	=		=		

Author	No. of Subjects	Type of belt	Activity	ES	RA	EO	IO	Comments
Lantz & Schultz (1986b)	4 male	Chairback brace Corset Thermoplastic brace	Isometric Pelvis fixed Symmetrical and asymmetrical	↑		↑		
Lander et al. (1990)	6 male weightlifters	Weight lifting belt	Squat lift at 90% 1RM	↓	↓ trend	↓		
Lander et al. (1992)	5 male weightlifters	Weight lifting belt	8 squat lifts at 8 RM	=		=		
McGill et al. (1990)	6 male	Weight lifting belt	Lifting machine "heavy" load	↑	↑	↓	↑	
Hilgen et al. (1991)	5 male	Inflatable air belt Weight lifting belt	Floor to knuckle height lift. 11.5 and 31.5 kg	↓		↓		
Magnusson et al. (1996)	7 female 5 male	Back belt	Floor to table height at 10 kg	↓				
Granata et al. (1997)	15 male	a) Back belt b) Weight lifting belt c) Corset	Symmetrical and asymmetrical lifts at 14 and 23 kg	a) ↓ b) = c) =	a) = b) = c) =	a) = b) = c) =	a) ↑ b) = c) =	
Lavender et al. (1998)	2 female 10 male	Back belt	Pulling task. Symmetrical and asymmetrical at 40% of maximum	=	=	=		

Author	No. of Subjects	Type of belt	Activity	ES	RA	EO	IO	Comments
Warren et al. (2001)	a) 14 female b) 6 male	Back belt	Squat lift on KIN-COM. 13.6 kg female and 22.7 kg male			a) ↓ b) ↑		
Thomas et al. (1999)	10 female 10 male	Back belt	Pelvis fixed Sudden load Symmetrical and asymmetrical	a) ↑ b) ↓	=	=		No gender effect
Lavender et al. (2000)	8 female 10 male	Back belt	Pelvis fixed Sudden unexpected load a) Symmetrical b) Asymmetrical	a) ↑ b) ↑	↓	↓		Gender effect
Lee & Kang (2002)	11 male	Back belt	Symmetrical lifts	↓	↑	↑		

Spinal Forces

In the small study described earlier Nachemson et al. (1983) where able to measure intradiscal pressure in the L3/L5 intervertebral disc using a needle transducer in 3 of their 4 subjects. The assumption was that intradiscal pressure is a direct measure of spinal compression. For the 3 surgical corsets tested intradiscal pressure was reduced in about two-third of the exercises and increased in the remainder. However, linear regression models suggest that predicted spinal compression was decreased by up to 40%, with the effect of the corsets being more pronounced at higher compression loads.

Lander et al. (1990) examined force platform, kinematic, intra-abdominal pressure and electromyographic data while 6 experienced weight lifters studied performed a squat lift at 90% of 1 repetition maximum. While wearing a weight lifting belt the lifts were performed somewhat faster and with more emphasis on hip extension then for the no-belt condition. Since the load did not change between belt conditions, this resulted in higher L5/S1 moments for the belt conditions and a consequent increase in the derived compressive, anterior shear and erector spinae muscle forces. However, when the forces were adjusted or normalised for the L5/S1 moment there was a significant reduction in L5/S1 compression, anterior shear and erector spinae muscle force. The study performed by Woodhouse et al. (1995) was of a similar design to that performed by Lander et al. (1990), although the subjects were not competitive weight lifters, and these authors found no significant difference in the kinematics or spinal forces between belt conditions. They did note, however, that the anterior shear force was consistently lower in the belt conditions compared to no belt. McGill et al. (1990) proposed that a reduction in anterior shear forces was a possible effect of back belts.

Granata et al. (1997), in their study described earlier of symmetrical and asymmetrical lifts utilising a back belt, a weight lifter's belt and a corset, noted changes in kinematics between belt conditions which resulted in an increase in the L5/S1 moment, although this was only significant for the corset. Predicted L5/S1 compression and shear were significantly reduced by the back belt. In symmetric lifting while wearing the back belt compressive force was reduced by nearly 7% and

in asymmetric lifting by 12%. Shear forces where similarly reduced by 13% and 1?% respectively. No significant differences were found for the corset or weight lifting belt.

Woldstad and Sherman (1998), discussed earlier, predicted L3/L4 compressive forces during maximal isometric symmetrical and asymmetrical lifting exertions and found that the back belt significantly reduced the compressive force by 9%, although they question the clinical significance of this amount.

Marras, Jorgensen and Davis (2000), in the study described earlier, found a significant decrease in the axial twisting moment while wearing a back belt. However, despite the significant decrease in sagittal and transverse plane range of motion and velocity and in sagittal (extension) acceleration, the spinal model utilised demonstrated no change in extension moment or spinal compression. The authors state that although "the overall effect was non-significant, clearly the variability in spinal loading resulting from wearing a back support may place certain individuals at higher risk of LBD [low back disorder] than when not wearing a back support." (p. 661) This statement does not appear supported by the data presented, that is, in 5 of the 7 spinal loading variables described the standard deviation is smaller in the back belt condition than the no back belt condition. In fact, one of the authors (Marras et al., 1995; Marras et al., 1993) has demonstrated that trunk sagittal angle and trunk twisting velocity, both shown to be significantly reduced by wearing the back belt in this study, were 2 of 5 factors which combined to be strongly positively associated with increased risk (OR = 10.7, 95% CI = 4.9 – 23.6) of occupational low back pain. Further to this, Davis and Marras (2000), on reviewing the literature, found that velocity and acceleration measures were good predictors of low back pain risk. The authors acknowledge that, given the changes in kinematics, the expectation would be that spinal loading would be decreased, and go on to cite earlier studies were this has been demonstrated, but then fail to explain the nul result. McGill and Norman (1992) suggest that axial moments produce over 4 times the spinal compression than that produced by the same sized extensor moment so the significant decrease in axial moment reported should be expected to be reflected in a decrease in compression. In a similar earlier study from the same laboratory (Granata et al., 1997), described above, a force platform was utilised but this was not possible in this study as a

requirement was that the subjects be able to freely move their feet. The validity of the spinal loading model applied and, therefore, the conclusion drawn must be questioned.

Lavender et al. (2000), described in more detail earlier, examined the effect of a back belt on several dependant variables, including bending moments, in response to sudden and unexpected loading. The back belt reduced the peak flexion moment at L4/5 by about 9%. The authors concluded that "in unanticipated loading, this same peak moment is likely to occur much faster and with potentially unprepared muscles, showing that even a 9% decrease could be beneficial when it comes to preventing some injuries." (p. 1,576)

Although there appears to be some evidence that back belts reduce spinal loads it must be remembered that, other than the inconclusive study performed by Nachemson et al. (1983), spinal loads are predicted by indirect means and there are several different models, often based on electromyographic assumptions, which can produce varying results. Due to the difficulty of taking direct measures of spinal forces, such as intra-discal pressure, these predictive models remain untested. Table 4 summarises the literature.

Table 4. The effect of back belts on spinal forces.

Legend: = No change. ↑ Increased. ↓ Decreased. Inc Inconclusive.

Author	No. of Subjects	Type of belt	Activity	Spinal Force Measured	Spinal Force	Comments
Nachemson et al. (1983)	1 male 3 female	Variety of surgical corsets	6 activities with pelvis fixed	Intradiscal pressure	↓ trend	Data for 3 subjects available and conclusion based on linear regression
Lander et al. (1990)	6 male weight lifters	Weight lifting belt	Squat lift at 90% of 1 RM	Forces about L5/S1	↓ compression ↓ anterior shear	
Woodhouse et al. (1995)	9 male	Weight lifting belt back belt	Squat lift at 90% of 1 RM	Forces about L5/S1	=	Anterior shear force was consistently lower
Granata et al. (1997)	15 male	Corset Weight lifting belt back belt	Symmetrical and asymmetrical lifts at 14 and 23 kg	Forces about L5/S1	↓ compression ↓ anterior shear	
Woldstad and Sherman (1998)	8 male 8 female	Back belt	Maximal isometric lifts at 2 heights. Symmetrical and asymmetrical	L3/L4 compression	↓ compression	Authors questioned the clinical significance of a 9% decrease in compressive force

Author	No. of Subjects	Type of belt	Activity	Spinal Force Measured	Spinal Force	Comments
Marras, Jorgensen and Davis (2000)	20 male	Back belt	Knee/mid thigh to elbow height lifts at 13.6 and 22.7 kg. Symmetrical and asymmetrical.	Forces about L5/S1	=	
Lavender et al. (2000)	10 male 8 female	Back belt	Response to sudden unexpected load. Symmetrical and asymmetrical.	Flexion moment about L4/5	↓ peak flexion moment	

Strength

The experiments that have been conducted to examine the affect back belts have on trunk strength can be broadly divided into two groups; the first group examine whether the long term use of back belts leads to any alteration in strength while the second group examine the immediate effect on strength of wearing a back belt.

Grew and Dean (1982) are often cited for their proposal that spinal supports can lead to a physical dependence. These authors examined the effect of various surgical corsets on the range of motion and intra-abdominal pressure in normal subjects and subjects with low back pain who had been wearing a support as part of their management. They found that the low back pain group had lower resting intra-abdominal pressure in supine without a support than the healthy group and concluded that this was due to decreased abdominal muscle tone secondary to long term use of surgical supports. This conclusion, however, is flawed as no comparison was made with low back pain sufferers who had not been wearing a support and even then the two groups would need to be closely matched to draw any conclusions.

Schroeder, Rossler, Ziehe and Higuchi (1982) in a discussion of bracing for low back pain state that long term use of surgical corsets requires additional physical therapy to strengthen the trunk muscles but it is not clear whether this statement is based on an assumption of muscle wasting, without any clinical or experimental evidence, or simply stating the fact that chronic low back pain sufferers benefit from exercise. Likewise, Levine (1984) states that within 2 to 3 weeks use of braces or corsets patients develop "psychologic and physiologic dependence" (p. 278) and that prolonged use results in lumbar and abdominal muscle atrophy, although no substantiating evidence is given. The relationship between muscle weakness and long term surgical corset use appears at best anecdotal but even assuming that there is a casual relationship to assume that this relationship extends to back belts in the workplace is unfounded.

In contrast to the above Morris (1974) suggests that one of the indications for lumbar bracing is abdominal and back muscle weakness.

Harman et al. (1989), in discussing the effects of weight lifting belts during near maximal dead lifts, suggests that training with a belt may not strengthen the abdominal muscles as much as training without and that individuals who train while wearing a belt "may thus not reduce vulnerability to injury during lifts without a belt." (p. 189) Harman et al. base this statement not on direct empirical evidence of a strength difference but on the assumption that the increased intra-abdominal pressure observed while wearing a belt results in less abdominal muscle effort and, therefore, less of a training effect. From the electromyographic studies discussed earlier there is no clear evidence that the abdominal muscle activity is reduced while wearing a belt, giving little substance to the assumption.

Walsh and Schwartz (1990) randomly selected 90 subjects from over 800 grocery warehouse workers who were further randomly assigned to three groups; a control group, a manual handling training group and a group who received training and were fitted with a custom moulded lumbosacral orthosis for use during work hours. Abdominal strength was recorded at the beginning of the trial and at 6 month follow-up. Daily use of the support resulted in no loss of abdominal strength.

Woodhouse, Heinen, Shall and Bragg (1990) enlisted 10 healthy male subjects to perform maximal isokinetic squat lifts at 3 different speeds on a Cybex Liftask testing system. The belts examined were a back belt and an experimental leather belt with an abdominal pad. No statistically significant changes in peak lifting force or average power were reported while wearing either belt although there was a trend towards increased force and power at the middle speed (76.2 cm/sec). In a nearly identical experiment Woodhouse, Heinen, Shall and Bragg (1993) examined both isokinetic extension and flexion at four different speeds. Again the two belts resulted in no significant change in extension measures. However, both belts resulted in a significant decrease in peak flexion torque and total flexion work compared to the no belt condition. Isokinetic flexion measures probably have little bearing on lifting and manual handling so the clinical significance of this finding is questionable.

Holmstrom and Moritz (1992) issued 12 healthy construction workers with a soft back belt and 24 workers with a current or past history of low back pain with a weight lifting belt. Trunk strength and endurance was measured at the beginning of

the trial and at 2 month follow-up. The supports resulted in a significant increase in trunk flexor strength of 13 and 12% respectively. No significant change in trunk extensor strength was observed.

In a preliminary report Pati, Perme and DeRoos (1993) on the use of a weight lifting belt by 60 hospital porters found that at 3 month follow-up there had been no change in trunk flexor or extensor strength.

Congleton et al. (1993) in a brief description of several unpublished studies performed at Texas A & M University state that trunk muscle atrophy will occur with extended use of a back belt, not based on laboratory evidence but on the fact that following splint or brace use on any body part physicians recommend strengthening and stretching exercises. This is obviously sound advice after prolonged immobilisation of say a limb in a splint but to generalise this advice to back belts seems unfounded.

Rys and Konz (1995), in a review of the literature concluded that back belts "may weaken the body so injury occurs when they are not being worn." (p. 301) This conclusion is based on the results of Grew and Dean (1982), subjective weakness reported by chronic low back pain sufferers wearing a surgical corset (Alaranta & Murri, 1988: cited in: Rys & Konz, 1995) and the assumptions made by Harman et al. (1989). This conclusion is despite reviewing a random controlled study which demonstrated an increase in strength in low back pain sufferers after 6 weeks use of a back support (Penrose, Chook & Stump, 1991; cited in: Rys & Konz, 1995) and the results of Walsh and Schwartz (1990).

On a review of the literature Perkins and Bloswick (1995) found no evidence to support the contention that back belts lead to muscle atrophy. Calmels and Fayolle-Minon (1996) concluded the there may be evidence in the literature that back belts result in an increase in trunk strength

Reyna, Leggett, Kenney, Holmes and Mooney (1995) examined the effect of a soft, heat retaining neoprene back belt on isolated lumbar extension strength as measured using a lumbar extension machine and dynamic lifting capacity using a symmetrical lifting task to the subjects maximum acceptable weight of lift (MAWL). 9 male and 13 female subjects were examined in the first part and 6 male and 10

female subjects for the second part. The use of the soft belt did not result in any change in extensor strength or lifting capacity.

Sullivan and Mayhew (1995) examined 30 male and 30 female healthy volunteers performing a maximal isometric squat lift. The three conditions examined were no belt, a leather weight lifting belt and an industrial back belt. There was trend towards increased force production in all belt conditions but the increase was only significant in male subjects wearing a back belt. The authors noted some difficulties with fit of both types of belt and their female subjects.

Eisinger, Kumar and Woodrow (1996) attempted to measure the effect of long term back support use on eccentric and concentric isokinetic trunk flexor and extensor strength in both low back pain sufferers and workers using supports for prophylaxis. 4 groups were studied; 6 subjects who suffered chronic low back pain and were wearing a soft lumbar corset; 6 subjects who were hospital employees required to were a back belt during work hours and had no history of low back pain and 6 age and gender matched controls for each belt group. Beyond the mean and median hours a day of belt use for both belt groups combined and the age and gender distribution for all 24 participants combined no group details are provided. When compared to controls there was a significant decrease in isokinetic eccentric and concentric extensor strength and concentric flexor strength, as measured on a KinCom, in the low back pain group while the workers wearing a back belt for prophylaxis demonstrated a significant decrease in eccentric flexor strength and a trend towards decreased strength on the other measures compared to controls. The authors concluded that the differences in strength were due to long term use of a back support although to come to such a conclusion it is assumed that the control groups were perfectly matched except for trunk strength and this has not been demonstrated nor would it be realistically achievable. Even if controls were matched a casual relationship cannot be shown without a prospective study. The most likely explanation for the differences is that the low back pain group had decreased trunk strength due to the chronic low back pain or the weakness was pre-existing and predisposed the individual to the low back pain while the prophylaxis group differences can be explained by the lack of matching discussed above.

Smith, Rasmussen, Lechner, Gossman, Quintana and Grubbs (1996) examined 69 healthy female subjects performing floor to upright lift with a weight that was slowly increased until an observer judged that the lifting effort was maximal. An industrial back belt resulted in a significant increase in the maximum lift compared to a no belt condition. The mean increase of 1.1 kg was judged by the authors to have little clinical significance in an industrial setting. However, this small increase represented a 13% increase in lifting capacity, which must be regarded as clinically significant.

Woldstad and Sherman (1998), described earlier, examined 8 male and 8 female subjects performing maximal isometric symmetrical and asymmetrical lifting tasks, with and without a BB and found no significant difference in lifting forces.

Lavender et al. (1998), also described earlier, examined the effect of a back belt on maximal pulling task in both symmetrical and asymmetrical postures and found no significant change in pulling force.

Miyamoto et al. (1999) examined 7 healthy male subjects performing a maximal isometric arm, squat and stoop lift, with and without a leather weight lifting belt. No significant difference was found for the peak isometric force generated.

There appears to be no convincing evidence that back belts increase back or lifting strength (see Table 5). There is also no experimental evidence that back belts result in muscle atrophy and weakness, in fact the opposite may be true; such claims in the past appear to be based on 'clinical experience' of the use of surgical corsets for managing chronic low back pain. For muscle atrophy to occur, there would need to be a decrease in muscle activity while wearing a back belt and the electromyographic data, described earlier, demonstrates no such decrease.

Table 5. The effect of back belts on strength

Legend: = No change. ↑ Increased. ↓ Decreased. Inc Inconclusive

Author	No. of Subjects	Type of belt(s)	Activity	Strength Measure	Result	Comments
Walsh & Schwartz (1990)	90 warehouse workers (30 in orthosis group)	Custom moulded orthosis	Work activities over 6 months	Abdominal strength	=	
Woodhouse et al. (1990)	10 male	Weight lifting belt back belt	Isokinetic squat lift	Isokinetic lifting strength	=	A trend towards increased peak force and average muscular power was noted at one lifting speed
Woodhouse et al. (1993)	10 male	Weight lifting belt back belt	Isokinetic squat lift	Isokinetic lifting strength	↓ peak torque, total work and average power	
Holmstrom & Moritz (1992)	12 healthy construction workers 24 construction workers with a history of LBP	Weight lifting belt	Construction activities over 2 months	Trunk strength	↑ abdominal strength = extensor strength	
Pati, Perme & DeRoos (1993)	60 hospital porters	Weight lifting belt	Work activities over 3 months	Trunk strength	= abdominal strength = extensor strength	Preliminary report on study

Author	No. of Subjects	Type of belt(s)	Activity	Strength Measure	Result	Comments
Reyna et al. (1995)	9 male 13 female	Back belt	Isometric trunk extension Symmetrical lifting task to MAWL	Isometric extension strength and MAWL	=	
Sullivan & Mayhew (1995)	30 male 30 female	Weight lifting belt back belt	Maximum isometric squat lift	Isometric squat lift strength	↑ strength for male subjects	Authors noted difficulty in fitting the supports to many female subjects
Eisinger, Kumar & Woodrow (1996)	a) 6 chronic LBP b) 6 hospital workers c) 12 controls	a) Corset b) Back belt	Isokinetic trunk strength	Isokinetic trunk flexion and extension strength	a) ↓ extension and flexion strength b) ↓ flexion strength	The authors make causal assumptions that are not supported by the evidence
Smith et al (1996)	69 female	Back belt	Symmetrical lifting task	Investigators judgement of MAWL	↑ MAWL	Authors concluded that 13% increase in lifting capacity was not clinically significant
Woldstad & Sherman (1998)	8 male 8 female	Back belt	Isometric symmetrical and asymmetrical lifts	Isometric force	=	
Lavender et al. (1998)	2 female 10 male	Back belt	Pulling task. Symmetrical and asymmetrical at 40% of maximum	Pulling force	=	

Author	No. of Subjects	Type of belt(s)	Activity	Strength Measure	Result	Comments
Miyamoto et al. (1999)	7 male	Weight lifting belt	Isometric squat and stoop lifts	Isometric force	=	

Endurance

Holmstrom and Moritz (1992), in their follow-up study of back belts in the workplace, found that the weight lifting belt worn by workers with a current or past history of low back pain resulted in a 29% improvement in isometric trunk flexor endurance, as measured by a timed isometric abdominal 'crunch', following 2 months use during work hours. The healthy workers who were issued with a back belt were not tested for trunk flexor endurance. Neither group demonstrated a significant change in trunk extensor endurance, as measured by the length of time the subjects could hold the trunk horizontally with the pelvis and legs fixed, at 2 month follow-up although the low back pain group did demonstrate a significant but apparently temporary decrease in trunk extensor endurance at 1 month.

Ciriello and Snook (1995) examined the effect of a nylon weight lifting belt on maximal isokinetic lumbar extension endurance and erector spinae electromyographic spectral changes during a 4 hour lifting session. Subjects consisted of 13 male industrial workers. No significant difference in the measures was found between belt conditions. These authors instructed subjects "push out against the belt with their abdominal region during the lifting and lowering motion" (p. 1273), an instruction not noted elsewhere in the literature.

Majkowski et al. (1998) examined 13 male and 11 female subjects for differences in erector spinae fatigue with and without a leather weight lifting belt. A dynamic lifting task was performed involving lifting a milk crate weighing 20% of the maximum isometric lifting force from the floor to an erect standing posture then back to floor level at a rate of 10 lifts per minute for 20 minutes. At 0, 10 and 20 minutes a maximal isometric lifting force was measured using a lifting machine. electromyographic data was recorded from the erector spinae muscles to demonstrate changes in the median power spectral frequency, a measure of muscle fatigue. Although isometric lifting force decreased as expected with fatigue no significant difference was found between the belt conditions for lifting force or median power spectral frequency. Interestingly, there was a consistent trend towards increased lifting force while wearing the belt but the authors chose a minimal meaningful effect size of 178 N based "solely on clinical judgement" (p. 2107), a difference of about

20% based on the results presented, with a statistical power of 0.652, introducing an increased likelihood of a type II error. The effect size for median power spectral frequency was chosen to give a statistical power of 0.875.

Sparto et al. (1998), in their study of back belts and range of motion discussed earlier, found that while performing symmetrical lifts to fatigue subjects were able to perform 9% more work while wearing a back belt.

On the whole, there appears to be some evidence that back belts have an effect on reducing muscle fatigue but the limited number of studies in this area suggests that further research is necessary before any real conclusions can be drawn.

Stability and Proprioception

Morris (1974) in discussing the effects of low back bracing in the management of low back pain may have been the first to indirectly suggest the potential stabilising effects of back belts. Morris cites a technical report by Lucas and Bresler (1961) in which the critical buckling load for an isolated ligamentous spine is 2 kg and states that stability of the spine is therefore dependent on the trunk musculature. Morris concludes that (p. 131) "the most significant effect of lumbar supports, including corsets and braces, is the compression of the abdomen resulting in increased intra-abdominal pressure, which creates a semi-rigid cylinder surrounding the spinal column."

McGill, Norman and Sharratt (1990) found that subjects reported a sense of stability from wearing a back belt and proposed that the observed increased intra-abdominal pressure would act to stiffen the trunk. In contrast Perkins and Bloswick (1995.p. 334) suggested that "if the intraabdominal pressure provides support for the spine through the contraction of the abdominal muscles, increasing the intraabdominal pressure by external compression instead of muscular activity may therefore destabilize the spine." However, they fail to explain further this proposition.

McGorry and Hsiang (1999.p. 1129) concluded that "back belts can modulate trunk coordination during lifting/lowering tasks, and the effect is not simply that of a passive feedback device."

McGill, Senguin and Bennett (1994) examined the effect weight lifting belt on the passive trunk stiffness of 22 male and 13 female subjects. Flexion, extension and lateral flexion stiffness were measured with the subjects lying on a near frictionless jig while rotation stiffness was measured standing in another frictionless device. They found that the weight lifting belt led to a significant increase in trunk side flexion and rotation stiffness.

Cholewicki, Juluru, Radebold, Panjabi and McGill (1999) measured the effectiveness of a nylon weight lifting belt in stabilising the lumbar spine. A jig was utilised which fixed the pelvis and extension, flexion and lateral flexion moments were applied through a chest harness which were suddenly released. 10 subjects were studied although their gender was not stated. They found that wearing the belt significantly increased flexion and lateral flexion stiffness, improving spinal stability to about the same level achieved with a voluntary increase in intra-abdominal pressure using a Valsalva manoeuvre. Analysis of electromyographic data suggested that the action of the belt was passive with a significant reduction in erector spinae activity being recorded while wearing the belt. Although the subjects were tested only in an upright posture these authors concluded that the stabilising effect of the belt would be greater in postures away from neutral. The weight lifters belt used was 10 cm wide, compared to 20 cm for the back belt supplied to Bunnings employees, and these authors also suggested that the stabilising effect would be enhanced in a wider belt. Using the data collected in the above study Ivancic, Cholewicki, and Radebold (2002) applied a biomechanical model and concluded that the back belt did not contribute to active spinal stability or reduce L4/5 compression forces during the suddenly applied load although the back belt did increase the passive stiffness of the spine by 34%.

McNiar and Heine (1999) examined the effect of an elastic back belt on trunk position sensing in 20 male and 20 female subjects who were blind folded and fitted with an electrogoniometer and asked to match one of six trunk flexion angles. The back belt resulted in a significant reduction in error, the improvement being greatest in subjects with a larger initial error. This result may be of some importance considering the proposition by Magnusson et al. (1996), discussed earlier, that poor co-ordination may predispose an individual to injury. The possibility arises that

individuals with poor trunk proprioception may be of greater risk of low back pain and, based on these results, may benefit the most from a back belt.

Wilders, Lee, Pope, Magnusson and Goel (1999) examined 10 male and 10 female who held an instrumented pan into which a tennis ball was unexpectedly dropped. Electromyographic data from the erector spinae was recorded. Although little information is presented the wearing of a back belt appears to have resulted in less overcompensation by the erector spinae muscles. Such an overcompensation has been suggested as a possible cause of low back pain (ML Magnusson et al., 1996; Mannion et al., 2000).

Newcomer, Laskowski, Yu, Johnson and An (2001) enlisted 20 healthy and 20 low back pain subjects, with 9 men and 11 women in each group, to study the effect of a back belt on trunk repositioning error in flexion, extension and side flexion. In healthy subjects repositioning error was reduced by the back belt in all directions but the only significant difference was in side flexion while low back pain subjects experienced a significant reduction in repositioning error on flexion, extension and side flexion. After 2 hours of wearing the back belt the authors report a significant increase in repositioning error in healthy subjects but it is unclear from the data presented whether this is increase was compared to when the back belt is first donned or was measured on removal of the back belt after 2 hours.

Miyamoto, Linuma and Kikuike (1995, cited in: Miyamoto et al., 1999) surveyed Japanese weight lifters and found that the majority reported a perception of increased stability and stiffness while wearing a weight lifting belt. This perceived benefit has been noted extensively in the literature (Bourne & Reilly, 1991; Madala, Schlegel & Purswell, 1997; Magnusson et al., 1996; McGill et al., 1990; Miyamoto et al., 1999; Reddell, Congleton, Huchingson & Montgomery, 1992).

Hodges and Richardson (1996) demonstrated that the transversus abdominis was invariably the first muscle recruited by the central nervous system during rapid shoulder movements, suggesting that its role was that of increasing spinal stiffness or stability. Cresswell, Oddsson and Thorstensson (1994) found a similar feed-forward mechanism associated with expected trunk perturbations where the transversus abdominis was always activated before the abdominal obliques, rectus abdominis and erector spinae muscles. The transversus abdominis resulted in a rise in intra-

abdominal pressure which would appear to provide trunk stability in expectation of the load to be applied. It seems likely that the back belt may be able to enhance or support this stabilising mechanism.

Overall, it must be concluded that there is strong evidence supporting the role of back belts in increased stability and/or proprioception (see Table 6). Whether this is a result of the increased intra-abdominal pressure observed while wearing a back belt, the "stiffness" which results from the physical bulk of the back belt, increased feedback from the back belt or other, and as yet unidentified neural enhancement, is not clear and will require further study. However, regardless of the underlying mechanism an improvement in spinal stability may prove to be one of the most beneficial effects of wearing a back belt.

Table 6. The effect of back belts on lumbar stability

Legend: = No change. ↑ Increased. ↓ Decreased. Inc Inconclusive

Author	**No. of Subjects**	**Type of belt(s)**	**Activity**	**Stability Measure**	**Result**	**Comments**
McGill, Senguin & Bennett (1994)	22 male 15 female	Weight lifting belt	Subjects held in near frictionless jig	Passive trunk stiffness	↑ lateral flexion and rotation stiffness	
Cholewicki et al. (1999)	10 (gender not stated)	Weight lifting belt	Hip motion restraining device with sudden load release	Passive trunk stiffness	↑ flexion and lateral flexion stiffness	A latter analysis of these results by Ivancic, Cholewicki & Radebold (2002) that the belt increased passive stiffness by 34%
McNair & Heine (1999)	20 male 20 female	Back belt	Trunk flexion while blind folded	Position matching	↑ position matching	Improvement greatest in subjects with largest positioning error without a back belt
Wilders et al (1999)	10 male 10 female	Back belt	Sudden unexpected load	compensation	↓ overcompensation	

Author	No. of Subjects	Type of belt(s)	Activity	Stability Measure	Result	Comments
Newcomer et al. (2001)	a) 9 healthy male and 11 healthy female b) 9 LBP male and 11 LBP female	Back belt	Trunk flexion, extension and lateral flexion	Position matching	a) ↓ positioning error in laterals flexion b) ↓ positioning error in all movements	The healthy subjects demonstrated a trend to decreased positioning error on flexion and extension

Psychophysical Effects

The concept of psychophysical lifting limits were introduced in the mid 1960's (Snook & Ciriello, 1991) and is based on data collected from individuals performing lifting exertions to their maximum acceptable weight of lift (MAWL).

McCoy, Congleton, Johnston and Jiang (1988) enlisted 12 healthy male subjects to examine the effect of an air belt and an industrial back belt on the maximum acceptable weight of lift. The subjects lifted a box from floor to knuckle height at a rate of 3 lifts per minute for 45 minutes. Once the lift was completed the box was returned to the start position by lowering device. The box had a false bottom which contained a random weight from 11 to 35 kg. Throughout the 45 minute test procedure the subjects were encouraged to add or remove weight to the box so that they could "lift without strain or discomfort and without becoming tired, weakened, overheated or out of breath". (p. 262) To compare the data to earlier maximum acceptable weight of lift results the maximum acceptable weight of lift was multiplied by the average height of lift and the number of lifts per minute to give a maximum acceptable work load in kg.m/min. There was no significant difference between the two belts but both belts produced a significantly higher mean acceptable work load, by about 16%, compared to the no belt condition.

Lavender and Kenyer (1995) examined 11 male and 5 female subjects performing a 30 cm to elbow height lift of a box at a frequency of 2 per minute for 40 minutes. As with the study by McCoy et al. (1988) the box had a false bottom and the subjects continually adjusted the weight to establish their maximum acceptable weight of lift. An elastic back belt resulted in no significant change in maximum acceptable weight of lift, compared to the no belt condition, although there was a trend to increased maximum acceptable weight of lift in the male subjects and decreased maximum acceptable weight of lift in the female subjects while wearing the belt.

Bowen, Purswell, Schlegel and Purswell (1995) examined 24 male and 19 female subjects performing floor to knuckle height and knuckle height to shoulder lifts. The subjects had to return the load to the starting position themselves and performed 2 lifts per minute for 20 minutes. An elastic belt resulted in a reportedly

increased maximum acceptable weight of lift of 9 to 18 % although the presentation of the results is not clear.

Hoff and Waly (1998) measured the maximum acceptable weight of lift of 10 male subjects performing floor to knuckle height lifts at 2 and 6 lifts per minute for 30 minutes. The belt conditions examined were no belt, a leather weight lifting belt and an elastic back belt. No significant effect on maximum acceptable weight of lift for the belts was found

Although maximum acceptable weight of lift is the measure used in classic psychophysical lifting studies the rating of perceived exertion can be seen as a similar measure and one that is easily included in studies. In the studies described in a previous sections Ciriello and Snook (1995), Marley et al. (1996), Marley and Duggmasani (1996) and Rabinowitz et al. (1998) found no significant change in rating of perceived exertion with back belt use. However, Reilly and Davies (1995) found a significant decrease in rating of perceived exertion with the use of leather weight lifting belt although the fact that weight lifters were used as subjects must raise questions about the preconceptions regarding weight lifting belts these subjects must have. Although not a true measure of rating of perceived exertion the subjects studied by Bourne and Reilly (1991) reported significantly less discomfort while wearing a weight lifting belt but, again, these subjects were weight lifters.

Chen (2003) endeavoured to examine the effect of back belt tension on with so maximum acceptable weight of lift me surprising results. 20 healthy male subjects performed floor to knuckle height and knuckle to shoulder height symmetrical lifts at one time only and at 4 lifts per minute. During both of the floor to knuckle height lifts the maximum acceptable weight of lift was shown to be significantly related to back belt tension. However, in the one time lift the relationship was positive while the relationship was negative at 4 lifts per minute. In fact, at the maximum belt tension of 25 mm of Hg, as measured by an air bladder between the abdomen and the belt, the change in maximum acceptable weight of lift was about 17% in each direction. No significant difference was reported for maximum acceptable weight of lift during knuckle to shoulder height lifts.

Van Poppell et al. (2000) in a systematic review of the literature found no evidence that to support the contention that workers will lift heavier weights while wearing back belts.

Although 3 of the studies examined above would suggest that there is evidence of an increase in maximum acceptable weight of lift while wearing a back belts the remaining variable and nul results would suggest that on, the whole, the evidence is at best inconclusive.

Summary of Proposed Mechanisms of Back Belts

Table 7 summarises the results of the proposed mechanisms of back belts. There is strong experimental evidence that back belts result in an increase intra-abdominal pressure and this has been a long held belief amongst supporters. There is also strong evidence supporting a alteration in kinematics during lifting, resulting in decreased range of motion and velocities. Both these results can be explained in a fairly straight forward manner as they are the mechanical changes one would expect. Strong evidence is also found that back belts improve lower back stability.

Table 7. Evidence relating to the mechanism of back belts

Mechanism	Evidence	Comments
Intraabdominal Pressure	Strong	Although the intra-abdominal pressure was generally found to be increased while wearing back belts the is considerable disagreement on whether this leads to spinal unloading
Spinal Shrinkage	Limited	Limited number of studies. Assumption is that decreased spinal shrinkage is an indication of decreased intervertebral disc loading
Kinematics	Strong	Back belts reduce not only the trunk range of motion during lifting task but also velocity and acceleration
EMG Activity	Inconclusive	Some evidence external oblique activity may be reduced while wearing back belts. Effect of kinematic changes on EMG activity to be established
Spinal Forces	Limited	Several biomechanical models are used to indirectly estimate spinal forces which makes direct comparisons between studies difficult. To draw meaningful conclusions it must be assumed that the biomechanical models applied truly represent the forces developing during lifting tasks
Strength	None	Many statements regarding the effect of back belts on back strength appear based on anecdotal evidence
Endurance	Limited	Small number of studies
Stability and Proprioception	Strong	Although there is strong evidence that back belts provide a stabilising effect the underlying mechanism(s) remains unclear
Cardiovascular Responses a) Blood Pressure b) Other	a) Limited b) None	There is limited evidence that back belts result in a statistically significant increase in blood pressure but the changes are small and the clinical significance has not been established
Psychophysical Effects	Inconclusive	Some studies have shown a positive effect but on the whole the finding are too inconsistent to draw a conclusion.

Workplace Interventions

The difficulty controlling low back pain in the workplace is well documented (Daltroy et al., 1997; Frank et al., 1996; Garg & Moore, 1992b; Gebhardt, 1994; Kaplanski, Wei & Reecer, 1998; Kumar & Mital, 1992; Kuorinka, Lortie & Gautreau, 1994; Lahad, Malter, Berg & Deyo, 1994; Leamon, 1994; Maher, 2000; Marras, Allread et al., 2000; Pope & Andersson, 1997; van Poppel, Koes, Smid & Bouter, 1997; Volinn, 1999; Westgaard & Winkel, 1997) and many long established interventions have been questioned.

In a small study of the manual handling activities in a retail grocery warehouse Kuorinka, Lortie and Gautreau (1994) 16 workers were examined while performing their normal work activities to access whether a knowledge of 'correct lifting' was converted into action on the workshop floor. The authors observed that correct lifts were rare, stating that:

> The 'correct lifting' recommendations are based mainly on biomechanical truisms whose goal is to decrease the compression and shear loads on the back. Such recommendations do not take into account the variety of factors that influence the possibility of complying with a recommendation because of environmental restrictions on the one hand, and on the other hand, because the handling action is a complex, goal-orientated phenomenon involving compromises by the handler (p. 659).

Kuorinka et al. rarely observed a correct lift with the lifting technique adopted being dependent on the space restrictions, the available grips and the size and shape of the load.

Daltroy et al. (1997) followed approximately 4,000 postal workers over 5.5 years after they had been randomly assigned to a 'back school' education program run by experienced physical therapists or a control group. At the end of the study period no significant difference was found in the rate of low back pain, median cost per injury, lost time per injury, the rate of recurrence or the rate of other musculoskeletal injuries.

In a systematic review of the literature van Poppell et al. (1997) found limited evidence that education does not prevent occupational low back pain. A similar

conclusion was drawn by Lahad et al. (1994), Westgaard and Winkel (1997), Kaplanski, Wei and Reecer (1998) and Maher (2000).

Gebhardt (1994) performed a meta-analysis of six experimental studies of the effectiveness of training in preventing occupational low back pain. The conclusion was drawn that training had a modest effect on low back pain and lost time but the author made no attempt to distinguish between education training and physical/exercise training so the validity of the analysis must be questioned.

The lack of evidence supporting education is of concern as manual handling training forms the basis of recommended control measures for occupational low back pain (Worksafe Western Australia Commission, 2000) and is required by legislation in Western Australia (Western Australian Government, 1984) as it is elsewhere.

Symonds et al. (1995) examined the affect of a psychosocial pamphlet titled 'Back Pain – Don't Suffer Needlessly' distributed to all 1,615 employees of a light industrial company on the absentee records for low back pain over a one year period, compared to the previous 4 years. 2 companies were selected as controls but there was a significant difference in the baseline incidence of low back pain and absentee patterns between the control and experimental companies so no useful comparison can be made. The outcome measures were unusual in that they were defined as; 1) an initial spell of absence, that is, the time off initially prescribed by the medical officer and; 2) an extension of a spell of absence, that is, the time off beyond the initial fist certificate. It was reported that a large and significant reduction occurred in the number of extensions of initial spells and the number of days lost but only percentages were reported and these decreases were in the same direction as the fluctuating 4 year trend. The validity of the outcome measures must be questioned as it appears to measure more the medical officers prescribing habits.

Exercise and fitness programs have been consistently found to reduce the incidence of low back pain (Kaplanski et al., 1998; Lahad et al., 1994; Maher, 2000; van Poppel et al., 1997) but the cost and difficulty with workforce compliance make them impractical in most industrial settings.

Workplace or ergonomic interventions have been found to control occupational low back pain in some cases (Marras, Allread et al., 2000; Westgaard & Winkel, 1997) while other reviewers have found questionable benefits (Leamon,

1994; Maher, 2000). Marras et al.(2000) state that "workplace redesigns and equipment interventions are probably capable of successfully reducing the incidence rate, *if* ergonomics concepts are applied appropriately" (p. 1883). The difficulty encountered when applying ergonomic principles to intervention program is that the underlying causes of low back pain are probably many and care must be exercised to avoid creating new risks with the introduced changes (Westgaard & Winkel, 1997).

Epidemiological Studies of Back Belts in the Workplace

The uncertainty regarding the proposed mechanisms of action of back belts may be due, in part, to the uncertainty surrounding the etiology of occupational low back pain. Although it is clearly important to establish a plausible mechanism, until low back pain is better understood a decision on the effectiveness of back belts must rely more on workplace epidemiological evidence.

Walsh and Schwartz (1990) randomly selected 90 subjects from over 800 grocery warehouse workers who were further randomly assigned to three groups; a control group, a manual handling training group and a group who received training and were fitted with a custom moulded lumbosacral orthosis for use during work hours. At six month follow-up 82 subjects remained. No differences in lost time injury rates were apparent in the first two groups while the back support group demonstrated a significant decrease in lost time injuries. It is not clear whether the recorded lost time injuries were low back pain incidences or general work injuries and, although the authors reported that compliance was measured, no level of compliance is presented. The small number of subjects and short time period of the study compared to the expected incidence rate for low back pain lost time injuries makes it difficult to draw any conclusions. In addition, the support utilised in this study varies substantially from the back belts now commonly used in the workplace. Walsh and Schwartz (1991) attempted to clarify the outcome measure used above in a letter to the editor. Total days lost for both low back pain and non-low back pain injuries were presented and demonstrated that both types of injury were reduced by the training program and training combined with the orthosis, albeit more so in the case of low back pain. This was in contrast to an increase in days lost for low back pain and non-low back pain in the control group. However, it remains unclear whether the lost time injuries described in the earlier paper are due solely to low back pain or to general injury claims.

Galka (1991) reported on a back injury prevention program introduced for nurses employed on a spinal cord injury unit. The program included the mandatory

use of a back belt. No rate data is presented although the author reports that low back pain incidence rates decreased following the introduction of the back belt.

Reddell, Congleton, Huchingson and Montgomery (1992) randomly assigned 896 baggage handlers into 4 treatment groups. The first group was fitted with a leather weight lifting belt, the second group received the belt and a 1 hour training session, the third group training only and the fourth acted as controls. Outcome measures were low back pain incidence frequency rate (although it is not clear whether this is for all claims or only lost time injuries), number of days lost per low back pain injury, restricted workdays an worker's compensation cost. At 8 month follow-up 254 or 28% of the participants had dropped out. In the two groups issued with the belt the drop out rate was 58%. A total of 25 low back pain injuries occurred during the study period although details of the injuries were not presented. No significant difference in injury incidence rates, days lost or cost between groups was found. There was a trend towards increased injury rates in the drop outs from the two belt groups and the authors concluded that workers may be at higher risk of injury following a period of belt use although they appear to fail to consider the potential for bias in this sub group. Surprisingly, given the large drop out rate, less than 20% of subjects in the belt groups responded negatively when asked whether the belt should be used throughout their organization. Leather weight lifting belts are intended for short term use during training and competition and the poor compliance in the workplace is not surprising. The authors rightfully concluded that a leather weight lifting belt cannot be recommended for use in the workplace.

Anderson, Morris and Del Vechio (cited in: Barron & Feuerstein, 1994) studied 266 grocery warehouse workers in 3 locations over a 12 month period. 2 sites acted as controls while the third site was issued with belts. Observed compliance was reported at over 80% by supervisors and after 12 months a 30% decrease in low back pain was reported for the belt group compared to controls.

Pati, Thompson and Thompson (1992) briefly describe the results of a pilot study in which 145 hospital workers were issued with a nylon weight lifting belt for an 18 month period. They reported a drop in low back pain incidence from 8% before the study to 0% during the last 12 months of the study period.

In a preliminary report on 2,000 warehouseman wearing back belts over a 2 ½ year period Sandler (1993) reports an almost 50% reduction in initial and repeat low back pain. Although the author attributes some of the improvement to a comprehensive prevention campaign including training he noted that the improvement was not as large in a control group. No descriptive or inferential statistics were presented. Back belt compliance was not stated although their use during the study period was mandatory.

Mitchell et al. (1994) performed a retrospective study from 1985 to 1991 of 1,316 employees who performed lifting duties at a US Air Force Base. Back belt use was mandated in employees who lifted more than 9.09 kg for more than 50% of the work shift and had suffered a low back pain within the past 2 years. Back belts were also issued to employees performing similar manual handling duties at the individual's request. This resulted in 3% mandated back belt use and 13% voluntary use. For the first 2 years of the study a leather weight lifting belt was issued but this was replaced with an industrial back belt with suspenders. Outcome measures were low back pain incidence and days lost per injury based on the subjects recall at the end of the study period. It was not clear whether low back pain due to manual handling injury were analysed or whether all low back pain cases included. When controlled for other factors the back belts were found to be marginally effective at preventing low back pain (odds ratio (OR) = 0.60, p = 0.0508) for employees engaged in regular heavy lifting. When the average cost per injury was analysed, however, the authors concluded that the back belt were not a cost-effective control measure for low back pain, although they go on to acknowledge that there is likely to be some bias in the back belt population due to the Air Force policy regarding their use. No measure of compliance was reported nor was any attempt reported to distinguish the effects of the 2 different types of belt used. In an earlier report of the same research Asundi, Purswell and Bowen (1993) reported an odds ratio of 0.455 suggesting that the back belt reduced the risk of low back pain by more than a half.

Following the results of Walsh and Schwartz (1990), Reddell et al. (1992) and Mitchell et al. (1994), and based also on some laboratory studies, the National Institute for Occupational Safety and Health (NIOSH) Back Belt Working Group concluded that back belts do not prevent injuries among uninjured workers, do not

reduce the risk manual handling and should not be considered as personal protective equipment (NIOSH, 1994, p.2).

Alexander, Wooley, Bisesi and Schaub (1995) randomly assigned 60 hospital workers into either a back belt group or controls and examined self reported cases of low back pain over a 3 month period. No significant difference in low back pain incidence was found although the authors acknowledged that the study size lacked statistical power, with only 3 incidents of low back pain being recorded in all, so it is not possible to draw any conclusions. Interestingly, subjects with a past history of back surgery or a current workers' compensation claim were excluded from the study but no attempt was made to control for past or current low back pain. Of the back belt group 29 of the 30 participants reported that they would continue back belt use voluntarily.

In another small study of hospital workers Allen and Wilder (1996) randomly assigned 47 volunteer nurses into a back belt group and controls and examined recorded lower back injuries over a 6 month period. The control group worked a total of 23,109 hours and experienced 3 low back lost time injuries for a total of 80 hours lost, while the back belt group worked 22,243 hours for no low back lost time injuries. As with the Alexander et al. (1995) study there was a lack of statistical power and the existence of past or current low back pain was not reported.

Kraus et al. (1996) performed a retrospective study of 36,000 employees in a large home improvement retail chain from 1989 to 1994 for a total of 101 million working hours. In 1990 mandatory back belts were introduced with all stores using them by 1992. The frequency rate for all reported acute low back pain associated with work, regardless of mechanism, decreased from 30.6 to 20.2 per million hours worked. This produced a statistically significant prevented fraction (PF), defined as 1 – relative risk (Rothman, 1986), of 34%, that is, 34% of potential cases were prevented from occurring. The effect was slightly stronger in male workers, with a prevented fraction of 36.2% compared to 24.0% for female employees. The effect was strongest in workers over 55 years of age (PF = 60.0%) and for workers younger than 25 years (PF = 50.5). Interestingly, those workers performing low intensity lifting in the work place experienced the largest improvement in injury rate, with a prevented fraction of 76.4%. Observed compliance was reported as 98% based on

walk-through surveys performed by the authors. The authors acknowledge that a short coming of this study was that the severity of injury was not examined as lost time data was not recorded consistently on injury forms. This study is by far the largest reported to date and gives the strongest support available for the positive benefits of back belts in industry. The back belt used in this study is essentially identical to that supplied to Bunnings employees.

Following the publication of the results of Kraus et al. (1996) Gardner, Sweeny, Waters and Fine (1997) made several recommendations regarding future research. They felt that examining non-back injury rates should establish whether the decrease in low back pain was due to back belt intervention alone or some other factor(s); if non-back injuries decreased by a similar amount then the improvement in low back pain cannot be attributed to the back belt, a measure also suggested by Berry (1991) following the publication of the investigation of Walsh and Schwartz (1990). Gardner et al. also suggested that store by store differences and a past history of low back pain effects should be examined and query the lack of randomised controls. In response Kraus, McArthur and Peek-Asa (1997) state that unpublished data demonstrates no significant decrease in non-back injury rates during the study period. Regarding the lack of randomised groups within the study Kraus and McArthur (1999) state that:

> In the commercial world of today the contingencies of business and the necessity to constantly evaluate and change working circumstances may effectively preclude any true randomization. Barring a mandatory company policy, volunteers will always differ from non-volunteers in any randomized situation. While randomized trials may be the best of study designs with regard to minimizing bias and control of confounding, in the real world they remain extremely difficult to undertake. (p. 13)

In a prospective 6 month study by van Poppel, Koes, van der Ploeg, Smid and Bouter (1998) 312 air cargo handlers were randomly assigned to 4 groups; lifting instruction and back belt, lifting instruction only, back belt only and controls. Participation was voluntary and the study suffered from an overall drop-out rate of 14%, with just over 20% withdrawing from the back belt only group, leaving 282 subjects available at 6 month follow-up. Compliance with wearing the back belt was reported as 43% although the measure of compliance used suggested that, in reality, compliance was very much lower; compliance was measured by monthly

questionnaire in which subjects were asked whether they had worn the back belt in the previous month and compliance was accepted if they answered in the affirmative in more than half of the questionnaires. No significant difference in self reported low back pain or self reported sick leave due to low back pain rates were found although in subjects with low back pain at baseline there was a significant decrease in days with low back pain in the two back belt groups. The poor compliance and drop-out rate makes drawing a conclusion from this study difficult. It also appears that both back belt groups had a higher rate of both previous and current low back pain at baseline, compared to the education and control groups.

Kraus and McArthur (1998) criticised the results of van Poppel et al. (1998) for "severe faults" (p. 1993) in compliance, randomisation and relying on self-reported low back pain as an outcome measure. They also defended there own research from criticism by van Poppel et al. stating that:

> Dismissing historical cohort studies on the basis of non-randomization demonstrates flawed reasoning. Such studies, when premised on evidence gathered from objective sources, can provide much stronger indications of effect than small, partially randomised trials like this one [van Poppel et al. (1998b)] that rely heavily on each participant's personal recall of pain". (p. 1993)

In a NIOSH supported study (Wassell, Gardner, Landsittel, Johnston & Johnston, 2000), a retail merchandise chain with 160 stores required back belt use in 89 stores and supplied back belts for voluntary use in the remaining stores. The back belt supplied was a flexible elastic belt without shoulder braces. Self reported low back pain, back belt use and workers compensation claims data was recorded over an average of 6.5 months for each store. 9,377 subjects completed a baseline interview of whom 6,311 (67%) went on to complete a follow-up. Self reported episodes of low back pain and workers' compensation claim were not significantly affected by back belt use. However, the 3,066 subjects who were lost to follow-up experienced nearly twice the number of low back pain claims of those who completed the study, introducing what must be regarded as a significant potential selection bias. Compliance with back belt use was poor, with only 58% of subjects employed in stores where their use was compulsory reporting wearing the belt 'usually every day', dropping to 33% in stores where their use was voluntary, and compliance was more likely in employees required to perform heavier lifting, again introducing

potential selection bias. A similar relationship between increased voluntary back belt use and heavier lifting activity was noted in a study of retail store workers (Pan et al., 1999) and of retail home improvement workers (Merdith, 2000). In a letter to the editor following publication of the Wassell et al. research Dorinson (2001) questions whether a lack of effect has been shown due to the fact that workers often do not wear their back belt properly. In response Wassell, Landsittel, Gardner and Johnston (2001) state that they observed back belt use in 77% of workers who claimed to wear the back belt 'usually every day', reducing further the already poor compliance, and admit that there was no way belt tension could be measured. In other words, in the 77% of workers observed wearing the back belt it was not possible to say whether the back belt was being worn loosely around the waist or cinched up correctly.

Kraus, Schaffer, Rice, Maroosis, and Harper (2002) examined the effects of back belts on back injuries occurring in female home carers. For reasons discussed above true randomisation was not applied but the nine agencies that took part in the study were randomly assigned to one of three exposure groups: a back belt group, a training only group and a control group. In all 12,772 workers were followed for 28 months for a total of 44,922,000 hours worked. Only acute low back pain incidents, regardless of lost time, resulting from a sprain or strain, that is an manual handling injury, were examined and converted to injury rates per 100 full time equivalents, were one full time equivalent is equal to 2,000 work hours. The back belts group experienced the lowest low back pain injury rate of the exposure groups although the difference was only significant between the back belt group and control group. When presenting the relative risk the authors chose to use the back belt group incidence frequency rate as the reference rate, which means that a positive benefit to the back belt group is shown as relative increase in the control group incidence frequency rate (RR = 1.36, 95% CI = 1.02 – 1.82). To keep these results consistent with those discussed earlier in this review and allow a more simple comparison the incidence frequency rates can be examined with the control group as the reference which gives a relative risk for the back belt group of 0.74 (95% CI = 0.55 – 0.95). The average compliance with the back belt was 92.2%, increasing to 97% towards the end of the study period.

Karas and Conrad (1996) reviewed 4 back belt studies and concluded that there was some evidence of positive outcomes. One of the studies examined was that of Mitchell et al. (1994) for which the reviewers claimed there was an increase in back injury rate and lost time with the back belt, despite Mitchell et al. stating that "our preliminary efforts support their marginal effectiveness in injury prevention when related factors are controlled for using a population of workers regularly engaged in heavy lifting activities" (p. 93).

In a systematic review of controlled clinical trials of back belts in the workplace van Poppel et al. (1997) found that there was inconclusive evidence for the effectiveness of back belts.

A Cochrane systematic review was performed by the Cochrane Back Group (Van Tulder, Jellema, van Poppel, Nachemson & Bouter, 2000) of 5 randomised and 2 nonrandomised controlled studies of back belts in the workplace. The review found moderate evidence that back belts were not more effective than other interventions or no intervention at all but there was limited evidence that a back belts combined with an eduction school program is more effective than education alone. Analysis of two of the studies (van Poppel et al., 1998; Walsh & Schwartz, 1990) suggested that back belts may reduce the risk of low back pain in workers with a past history of low back pain, that is, back belts may offer some secondary protection. The reviewers note the poor compliance in the studies of Reddell et al. (1992) and van Poppel et al. (1998) and state that "it will be impossible to find evidence for the effectiveness of lumbar supports if the subjects in a trial are not compliant with wearing them." (p. 13) but despite this statement included the two studies in their analysis. In fact, 4 of the studies failed to report compliance and only one (Anderson, Morris and Del Vechio. cited in: Barron & Feuerstein, 1994) reported compliance of over 80%. Regarding future studies they suggest that "one of the most essential issues to tackle in these future trails seems to be the realisation of an adequate compliance." (p. 3) A concern with this Cochrane review is that two of the reviewers, van Poppel and Bouter, co-authored one of the reviewed studies which received the highest methodological quality rating of the 7 intervention studies.

In a summary of the above Cochrane review Jellema, van Tudler, van Poppel, Nachemson and Bouter (2001) again state that back belts may offer some secondary

protection to workers with a past history of low back pain but then go on to contradict this in their conclusion stating that there is no evidence supporting secondary prevention. Given the fact that a past history of low back pain is a risk factor/indicator for future low back pain (Battie & Videman, 1997; Biering-Sorensen, 1983; Bigos & Battie, 1992; Bigos et al., 1992; Dempsey et al., 1997; Ferguson & Marras, 1997; Frank et al., 1996; Garg & Moore, 1992a, 1992b; Marras, 2000; Shelerud, 1998; van Poppel et al., 1998) this potential effect deserves more attention.

Gatty, Turner, Buitendorp and Batman. (2003), in examining the effectiveness of workplace low back pain intervention programs, reviewed 4 back belt interventions ((Kraus et al., 1996; van Poppel et al., 1998; Wassell et al., 2000)) and found that the evidence for their effectiveness was inconclusive. These authors noted the lack of compliance in the two most recent studies.

The Canadian Task Force on Preventive Health Care (2003) reviewed 5 randomised controlled studies (Alexander et al., 1995; Kraus et al., 1996; van Poppel et al., 1998; Walsh & Schwartz, 1990) and concluded "that the existing evidence is conflicting and does not allow the task force to make a recommendation for or against the use of back belts to either prevent occupational low-back pain or to reduce lost work time due to occupational low-back pain" (p. 213).

The results of these back belt intervention studies are summarised in Table 8. Taken as a whole there appears to be some evidence of a positive affect of back belts in protecting workers from occupational low back pain. There are, however, many weaknesses in these studies which can make drawing a conclusion difficult. Some of these weaknesses include:

1. Voluntary use of back belts introduces potential for selection bias, particularly where workers who perceive that they are performing heavier lifting duties and are therefore exposed to higher risk of low back pain are more likely to be compliant with back belt use, as has been observed (Mitchell et al., 1994; Pan et al., 1999; Wassell et al., 2000).
2. Voluntary use of back belts appears to lead to higher drop-out rates (Reddell et al., 1992; Wassell et al., 2000) and poor compliance (Reddell et al., 1992; van Poppel et al., 1998; Wassell et al., 2000).

3. Lack of blinding during controlled studies.
4. Other than Reddell et al.(1992) and Mitchell et al.(1994) no studies have examined the effect of back belts on severity and cost of low back pain.
5. The outcome measure of low back pain more often than not includes cases not resulting from manual handling injury.
6. No measures of internal validity.
7. With the exception of the three largest studies (Kraus et al., 1996; Mitchell et al., 1994; Wassell et al., 2000) and possibly two others (Reddell et al., 1992; van Poppel et al., 1998) most studies lack sufficient power to detect anything but very large changes in injury incidence rates. With expected low back pain lost time incidence frequency rates in the vicinity of 4 to 12 per million hours worked (Gardner et al., 1999; Kraus et al., 1997) and a million work hours representing 500 full-time workers engaged for 12 months it is clear that the sample size and/or study period have been too small in many studies.
8. Several studies failed to describe the support used (Alexander et al., 1995; Allen & Wilder, 1996; Pati et al., 1992; Sandler, 1993) or used a support of a type not typically seen in the workplace (Mitchell et al., 1994; Reddell et al., 1992; Walsh & Schwartz, 1990).

Table 8. Summary of back belt intervention studies. *Italics denotes a statistically significant result

Authors	Type of Belt	Sample Details	Outcome Measures	Effect of Belt*	Compliance	Comments
Walsh & Schwartz (1990)	Custom moulded orthosis	90 warehouse workers. Randomly assigned to 3 groups. 82 available at 6 month follow-up.	(unclear whether only LBP cases)	*Decrease in LTI incidence.*	Not stated	
Galka (1991)	Not stated	Nurses. No sample size details provided.	LBP incidence but not clear how recorded	Decreased LBP incidence	Not stated	No rate data presented
Reddell et al. (1992)	Leather weight lifting belt	896 baggage handlers randomly assigned to 4 groups. 642 available at 8 month follow-up.	LBP IFR, days lost and cost.	No effect	Not stated.	58% drop out from belt group.
Anderson et al. (cited inBarron & Feuerstein, 1994)	Not stated	266 grocery warehouse workers divided into 3 groups. 1 group belt use and 2 groups controls. 12 month follow-up.	LBP incidence but not clear how recorded	30% decrease in LBP in belt group compared to controls.	Over 80%	Cited in Barron & Feuerstein (1994)

Authors	Type of Belt	Sample Details	Outcome Measures	Effect of Belt*	Compliance	Comments
Pati et al. (1992)	Nylon weight lifting belt	145 hospital workers. 18 month follow-up.	LBP incidence but not clear how recorded	Decrease in LBP incidence with belt use.	Not stated	Pilot study
Sandler (1993)		2,000 warehouse workers followed for 2.5 years.	LBP incidence but not clear how recorded	50% reduction in LBP incidence and recurrence.	Not stated but mandatory	Preliminary report
Mitchell et al. (1994)	Leather weight lifting belt followed by back belt	1,316 US Air Force warehouse workers. Followed for 6 years.	LBP incidence and days lost based on subjects recall.	*Decreased LBP incidence.*	Not stated but 3% voluntary and 13% mandatory	Bias introduced due to Air Force policy on back belt
Alexander et al. (1995)	Back belt	60 hospital workers randomly assigned into back belt or control group.	LBP incidence	No effect	Not stated	Small subject numbers
Allen & Wilder (1996)	Back belt	47 nurses randomly assigned to back belt or control group.	LBP LTI	Decrease in LTI	Not stated	Small subject numbers

Authors	Type of Belt	Sample Details	Outcome Measures	Effect of Belt*	Compliance	Comments
Kraus et al. (1996)	Back belt	36,000 home improvement chain workers followed for 5 years.	Recorded LBP incidence	*Decrease in LBP incidence.*	98%	
Van Poppel et al. (1998)	Back belt	312 air cargo handlers randomly assigned into 4 groups; lifting instruction and back belt, back belt only, instruction only and control	Self reported LBP incidence and days lost	No effect	<43%	High drop-out rate from back belt group
Wassell et al. (2000)	Back belt	6,311 retail merchandise workers	Self reported LBP incidence and worker's compensation claims incidence	No effect	58%	33% drop out rate
Kraus et al. (2002)	Back belt	12,772 female home carers followed for 28 months. Cluster randomly assigned to back belt, training or control.	Recorded LBP incidence resulting from manual handling injury	*Decrease in LBP incidence*	92-97%	

Regulatory Bodies and Back Belts

NIOSH released an often quoted position paper on the workplace use of back belts in 1994. The paper stated:

> The working group does not recommend the use of back belts to prevent injuries among uninjured workers, and does not consider back belts to be personal protective equipment. The Working Group further emphasizes that back belts do not mitigate the hazards to workers posed by repeated lifting, pushing, pulling, twisting or bending (NIOSH, 1994p. 2)

A recommendation arising from the 1994 statement was to exercise "caution in interpreting the results of epidemiological studies; the experience with these studies should be used to develop better designed epidemiological research." (B. B. W. G. NIOSH, 1994 p. 2)

In contrast to the NIOSH stand the Agency for Health Care Policy and Research (AHCPR) found that "lumbar corsets, used preventively, may reduce time lost from work due to low back problems in individuals required to do frequent lifting at work" (AHCPR, 1995). Similarly, although NIOSH do not regard back belts as personal protective equipment (PPE) (NIOSH, 1994) the United States Occupational Safety and Health Administration (OSHA) has recently accepted that back belts are a form of PPE (cited in: Canadian Task Force on Preventive Health Care, 2003).

The positive findings of Kraus et al. (1996) also led NIOSH to ease the earlier stand on back belts stating:

> After an extensive review of the scientific literature completed in 1994, NIOSH concluded *at that time* [emphasis added] that insufficient evidence existed to prove the effectiveness of back belts in preventing back injuries related to manual handling job tasks….[referring to Kraus et al.(1996)] NIOSH believes this study provides limited evidence that back belts may be effective in some settings for preventing back injuries….many of the earlier studies did not evaluate the type of industrial back belt most widely in use today (NIOSH, 1997b, p. 1)

NIOSH made a similar somewhat more contradictory statement in its *Elements of Ergonomics Programs: a Primer based on Workplace Evaluations of*

Musculoskeletal Disorders (Cohen et al., 1997) based on the findings of Kraus et al. (1996), stating:

> Although NIOSH believes this study provides evidence that back belts may be effective in some settings for preventing back injuries, NIOSH still believes that evidence for the effectiveness of back belts is inconclusive (p. 35).

Despite this announcement many Australian authorities still appear to refer directly to the 1994 statement. Worksafe Western Australia quotes directly from this statement in a recent newsletter on back belts (2000) and a report on back belts in the workplace (2002c).

The Victorian Worksafe Authority includes a section on back belts in its *Code of Practice for Manual Handling* (2000) which states:

> Many people believe that devices such as back braces or back belts can prevent MSD [musculoskeletal disorders]. Sometimes these devices are used by health professionals as a rehabilitation aid for patients recovering from back injuries or similar problems. However, scientific studies have been unable to confirm whether these devices can eliminate or reduce risks and prevent MSD. For this reason, back belts and similar devices are not considered to mechanical aids , and are not a valid risk control. (p. 41)

The Victorian Worksafe Authority went on to publish a guidance note regarding back belts (2002) based on a review of the literature. The guidance notes make 7 points:

1. Back belts don't reduce forces on the spine.
2. Back belts don't reduce the strain on muscles and tendons.
3. Back belts do nothing to reduce fatigue or to increase the ability to lift.
4. Back belts are like holding your breath when lifting.
5. Back belts can increase blood pressure and breathing rate.
6. Back belts don't reduce the chance of injury or reduce back pain.
7. Back braces can be useful after injury. (p. 1-2)

The reference list for the Victorian guidance notes, which is supplied on request, contains 13 references, including an anonymous report in a safety newsletter, one reference which deals with rehabilitation following injury and the NIOSH 1994 statement. Only one epidemiological study is cited, that of Wassell et

al. (2000). This seems like a somewhat limited literature review for a legislative body to base this conclusion on.

The Queensland Division of Workplace Health and Safety (1999) takes a far more conciliatory approach, citing several advantages and disadvantages, and stating:

> Abdominal Belts *may* be helpful in reducing the incidence of back injury *only if*: They are used in conjunction with longer-term measures like worker selection, job redesign and manual handling. Workers are trained in correct belt use and their possible detrimental effects. Belts are fitted and worn correctly (p. 1)

Neither the Australian National Occupational Safety and Health Commission or the Workcover Authority of NSW provide statements regarding back belts.

METHODS

Population

All employees of Bunnings Building Supplies Pty Ltd home improvement retail stores in the Perth metropolitan area, Western Australia, where enrolled in a retrospective or historical cohort (Hernberg, 1992; Rothman, 1986). It should be noted that the cohort did not include employees based at the head office but it did include a small number of administrative personnel at each store. The cohort was followed from July 1, 1995 through to December 31, 1999. The cohort was dynamic so members leaving employment with Bunnings were replaced by new employees.

The Bunnings stores are similar in layout to the Home Depot stores examined in the Kraus et al. (1996) study (Bunnings Building Supplies, 2000). Figures 7 to 16 show different areas in one store that may be regarded as typical of the layout of Perth metropolitan Bunnings stores.

Figure 7. Timber department.

Figure 8. Trade department.

Figure 9. Timber department.

Figure 10. Storage section.

Figure 11. Ladders and metal supplies.

Figure 12. Paint department.

Figure 13. Plumbing and bathroom department.

Figure 14. Bulk garden supplies.

Figure 15. Garden and outdoor department.

Figure 16. Centre isle.

Design

The study was of a non-experimental before-and-after design, otherwise known as an intervention study (Hernberg, 1992; Panel on Musculoskeletal Disorders and the Workplace, Commission on Behavioural and Social Sciences and Education & Medicine, 2001). These studies are sometimes also termed historical cohorts (Panel on Musculoskeletal Disorders and the Workplace et al., 2001) although others have made a distinction between the designs (Deeks et al., 2003).

The back belt intervention was introduced to all stores through the month of April, 1997, and its use by all employees was mandated by Bunnings Management. The workforce prior to the introduction of the back belt act as historical controls (Zwerling et al., 1997). Extending the before-and-after examination to a time series over the period of the cohort adds a quasi-experimental aspect to the study design (Robson, Shannon, Goldenhar & Hale, 2001). The internal validity of the design is further improved by examining additional outcome measures that are similar to the main outcome measure of interest but would not be reasonably expected to be affected by the intervention (Robson et al., 2001).

Materials

Data on person-hours worked by store and by calendar month was supplied by Bunnings Building Supplies Pty Ltd in hardcopy spreadsheet format. No data was available for the age of gender mix of the population as the information would have been of no use given the nature of the injury data examined.

Workers' compensation insurance claims data was supplied by Wesfarmers Insurance in the form of a 'Group Risk Management Report' (see Appendix 1). It should be noted that Bunnings Building Supplies is part of the Wesfarmers Limited group of companies so, effectively, is self insured. This report was supplied on computer disk in Adobe® Acrobat® portable document format (PDF) and included information on claim number, injured worker's name, date of injury, store location, bodily location of injury, cause of injury, number of days lost from work and total cost of injury or the insurer's estimated cost if the claim was still open as of February

28, 2000. All workplace injuries requiring a medical attendance, regardless of whether an LTI occurs, are recorded on this report.

The back belt supplied by Bunnings Building Supplies Pty Ltd to all employees is a Rooster™ Back Support Belt which is an elastic type with semi-rigid stays, adjustable elastic straps with Velcro® closures and shoulder suspenders (Fig. 17, 18 and 19).

Bunnings had a policy of mandatory use on back belts which read as follows:

> The back brace was introduced into Bunnings stores in April 1997. Bunnings Building Supplies policy requires all team members to wear and correctly use a back brace when performing manual handling functions in the workplace. The brace must be worn done up when lifting and loosened or undone when not performing lifting activities. The back brace supports the lower back when lifting and reminds the user to lift correctly. It should be noted that wearing a back brace **does not** increase your lifting capacity. If an item is too heavy to be lifted by a team member, then one of the other manual handling methods must be utilised (e.g. trolley, team lift).

Training in the correct use of the back belt involved a short videotape presentation provided by the supplier and the instructions on the packaging. Following the initial roll-out to existing employees this videotape presentation became part of the standard new employee induction package. Other than these additions there were no changes to the manual handling training provided to employees over the course of the study (Bunnings Building Supplies, 2000).

The back belt was worn outside of the clothing, which allowed for unobtrusive monitoring of compliance by supervisors. Compliance was also improved by the ease with which the back belt can be adjusted or loosened when not required without the need to remove clothing. Compliance with back belt use had been previously established (Merdith, 2000) on a questionnaire distributed to 660 employees in Bunnings Building Supplies' metropolitan outlets, with a 74.2% response rate. Overall back belt compliance during normal duties was 62.2% and increased to 89.7% during heavy lifting. Compliance was higher amongst workers performing heavier general duties with employees in the goods inwards/receivals area reporting 100% compliance during heavy lifting.

According to Bunnings' management. during the course of the study there were no other significant changes made to occupational health and safety practices within the organisation (Bunnings Building Supplies, 2000).

Figure 17. Close up of the Rooster back belt.

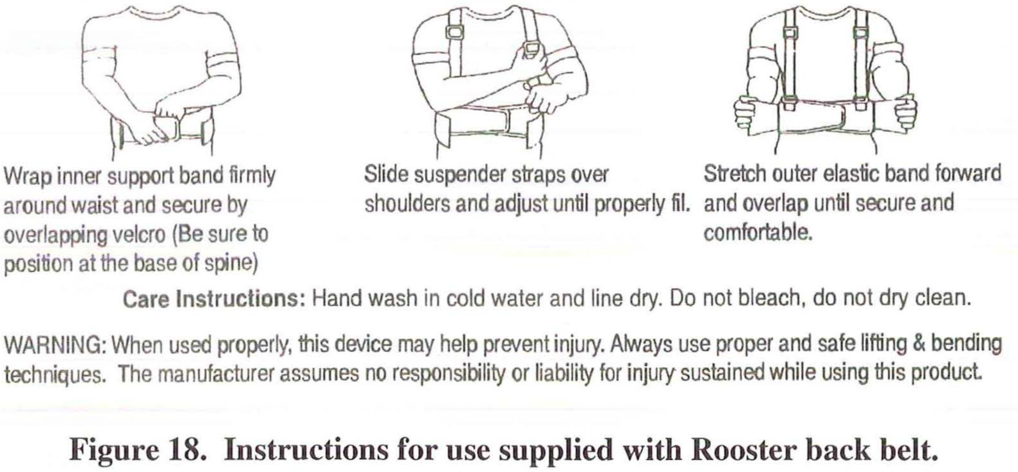

Figure 18. Instructions for use supplied with Rooster back belt.

Figure 19. The back belt in use.

Data Analysis

The Group Risk Management Report document containing claims data was printed to hardcopy then transcribed to a Microsoft® Excel 2000 spreadsheet. Data transcription was compared visually between two hardcopies for accuracy by both the data processor and the investigator.

Data on bodily location of injury was coded to separate low back pain cases from non-low back pain cases; all cases where the bodily location recorded as lumbar, lumbosacral, lower back or back (with the exception of 'thoracic back') were coded as low back pain.

The cause of injury was also coded to separate manual handling injuries from non-manual handling injuries. This coding allowed low back pain cases to be further divided into those arising from manual handling injury and those not. It is low back pain resulting from manual handling injury that is the main interest of this study as it

is these injuries which the back belt is aimed at controlling. Low back pain claims arising from non-manual handling injury injuries, for example slips, trips and falls, were coded separately for comparison purposes.

Therefore, the nature of the injury could be divided into one of two subsets; those injuries attributed to manual handling and those injuries to the lower back. The intersection of these two subsets were low back pain resulting from manual handling, which was the main outcome of interest, and for the purposes of the following discussion is referred to as low back pain. This division of workers' compensation claims is represented graphically in Figure 20 and the definition of the injury categories is given in Table 9.

The claims were further divided into all workers compensation claims, that is, any work related injury requiring a medical consultation and those claims resulting in a lost time injury, that is, injuries resulting in one or more complete shift away from work.

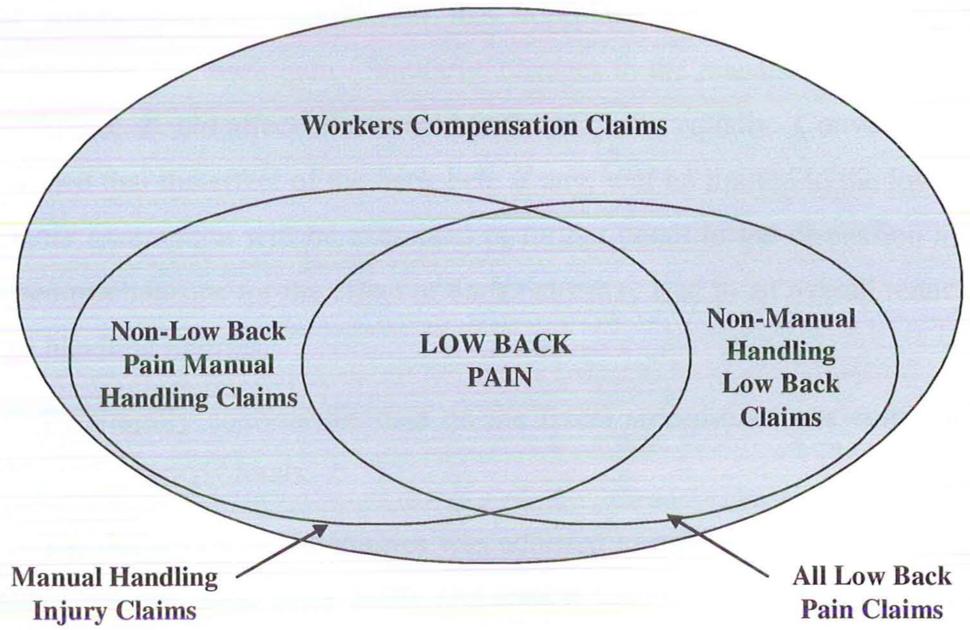

Figure 20. Categorisation of workers' compensation claims.

Table 9. Injury categories

Category	Definition
Low back pain	Low back pain claims resulting from a manual handling injury
Other manual handling injury	All injuries resulting from a manual handling injury other than low back pain
Non-manual handling injury low back pain	Low back pain claims resulting from causes other than a manual handling injury

Other manual handling injury data can be used to establish the presence and size of effect of confounding factors on the dependent variables on the assumption that the back belt will have no effect on manual handling injuries to areas other than the lower back but other factors affecting manual handling injury incidence, duration and cost will likely effect all manual handling injuries equally. For example, control measures aimed at reducing the risk of manual handling injury through elimination or substitution should have a similar affect on all manual handling injury, particularly as the injury generally targeted in the workplace for manual handling injury interventions is low back pain. Similarly, changes in the management of injuries in the workplace should affect all manual handling injuries equally. Conversely, it may be assumed that the effect of the back belt, if any, will be limited to the lower back. This latter assumption will be examined in further detail in the discussion as some proposed mechanisms for the effect of back belts may lead to an overall reduction in manual handling injuries.

To simplify analysis the data on the Excel spreadsheet was combined into monthly and quarterly totals.

The dollar cost of the injuries was adjusted to reflect inflationary changes in the published consumer price index (Australian Bureau of Statistics, 2002). The adjustment was performed by dividing the dollar value by the published index for that quarter and multiplying by the published index for the quarter ending December, 1999. All cost are therefore presented in December 1999 dollars (see Table 10).

Table 10. Conversion table using quarterly Consumer Price Index (CPI). To convert dollar value to value as of December 1999 the value is divided by the index number for the appropriate quarter and multiplied by 124.1 (Australian Bureau of Statistics, 2002)

Year	Quarter Ending			
	March	June	September	December
1995			117.6	118.5
1996	119.0	119.8	120.1	120.3
1997	120.5	120.2	119.7	120.0
1998	120.3	121.0	121.3	121.9
1999	121.8	122.3	123.4	124.1

The number of days lost per injury were recorded as the actual number of days as well as being recorded according to the Australian Standard (Standards Australia, 1990) where the maximum number of days recorded is 220 days, representing 12 months off work. Both duration figures were analysed to allow for comparison with past and future data. Claims resulting in 60 or more lost days were categorised as long duration (WorkCover Western Australia, 2000).

Incidence frequency rates (IFR) were calculated according to the following formula:

$$\text{IFR} = \frac{\text{number of occurrences in the period}}{\text{number of hours worked in the period}} \times 1{,}000{,}000$$ (Standards Australia, 1990)

The average lost time rate was calculated in each category for all cases and for lost time injury cases only, and using both raw lost time data and lost time data restricted to a maximum of 220 days.

The average cost of injury was calculated in each category for all cases and for lost time injury cases only.

For statistical calculations a level of significance was set at 5%, that is, $\alpha = 0.05$. Where appropriate p values and 95% confidence intervals (CI) are presented.

Incidence frequency rates were compared using chi-squared (χ^2) with one degree of freedom based on the following formula (Robson et al., 2001):

$$\chi^2 = \Sigma\ (\text{Observed} - \text{Expected})^2 / \text{Expected}$$

Where χ^2 is significant ($\alpha = 0.05$) > 3.84.

Further analysis was performed to calculate the relative risk (RR), a simple measure that gives an immediate indication of the strength of an effect (Robson et al., 2001). Relative risk is given as:

$$[RR] = [IFR_1]/[IFR_0]$$

The confidence interval for the relative risk was calculated according to the formula:

$$CI = \ln[RR] \pm Z \times SE$$

Where:

$\ln[RR]$ = natural log of RR

$Z = 1.96$ for 95% CI

$$SE = \text{standard error of } \ln[RR] = \sqrt{\frac{1}{\text{No. of Injuries}_0} + \frac{1}{\text{No. of Injuries}_1}}$$

Therefore:

$$95\%\ CI = \ln[RR] \pm 1.96 \times \sqrt{\frac{1}{\text{No. of Injuries}_0} + \frac{1}{\text{No. of Injuries}_1}}$$

For comparing relative risks between the primary outcome measure, low back pain, and the additional non-low back pain measures it is inappropriate to simply examine the state of significance for each measure (Robson et al., 2001). To establish whether the difference between two relative risks is statistically significant, for example, to demonstrate that a change in low back pain rates can be attributed to the back belt and not to some unidentified factor which affects other workplace injury types, the following formula was applied:

$z = (\ln(RR_1) - \ln(RR_2)) / SE$

Where the standard error is the square root of the sum of the inverses of the number of injuries in for each category and before and after the intervention and z is significant at greater than +/-1.96 ($\alpha = 0.05$) (Robson et al., 2001).

The above equations where entered into Excel spreadsheets to which the raw data was transferred for manipulation and analysis.

The introduction of back belts is not generally expected to have an effect on the incidence rates, duration or cost of manual handling injuries to areas other than the lower back (the validity of this assumption will be discussed in later sections) while other unidentified factors in the workplace that alter the manual handling exposure of workers should have a similar effect on both low back pain resulting from manual handling and manual handling injuries to areas other than the lower back. Where there is a change in non-low back pain manual handling injury rates it was assumed that the unidentified factor will have had a similar sized effect on both low back pain and non-low back pain manual handling injury. To correct for the effect of this unidentified factor(s), the percentage change in low back pain incidence frequency rates, duration and cost during the intervention period were reduced (or increased) by the same amount of variation observed in other manual handling injury claims. The low back pain data so treated is noted with 'corrected for manual handling injury affect' in brackets. The treatment of the low back pain data in such a way has not been presented previously in the literature so the results of such treatment will be used simply to examine internal validity, rather than as a standard discussion tool.

Similarly, average days lost per low back pain claim and average dollar cost per low back pain claim can be corrected for the unidentified effect on manual handling injury. These corrections have the effect of reducing/increasing the size of any effect on the main dependant variables of interest, that is, low back pain, by the same amount as the reduction/increase, if any, in the manual handling injury variables.

Data from the month of April 1997 is excluded from the analysis as this is the month during which the intervention was introduced. Where quarterly figures are presented the quarter from April 1 to June 30 1997 will likewise be excluded.

RESULTS

Cohort Details

The pre-intervention period extended from 1st July 1995 through to 31st March 1997, a total of 21 months. Over this period 2,265,933 work hours occurred for a yearly average of 1,294,819 work hours. The hours worked gives an average full-time equivalent positions for the pre-intervention period of 647. This workforce was distributed between 22 retail and 2 trade centres in July 1995, reducing to 21 retail and 2 trade centres by March 1997.

The back belt intervention was introduced in the month of April 1997 through all the retail and trade centres.

The intervention period extended from 1st May 1997 through to 31st December, 1999, for a total of 32 months. During the intervention period 4,411,352 hours were worked, at an average of 1,654,247 hours worked a year. This represents a full time equivalent workforce of 827 or a 27.8% growth in the workforce. The number of retail and trade outlets did not vary from that at the end of the pre-intervention period (see Table 11).

The increase in the full-time equivalent workforce with increased hours worked during the study period was due to the closing of one smaller retail outlet which was replaced by a larger 'warehouse' style outlet and increasing trading hours.

Although no figures for the actual staff breakdown where available for the study period, following the study period, in March 2000, the staff breakdown was 571 full-time, 305 part-time and 368 casual, for a total workforce of 1,244. The figures for casual employees will be somewhat inflated as worker's names who were hired casually over the busy Christmas period remain on the books for some time after.

From the data available it was not possible to distinguish between job positions. The cohort included job description such as yard workers, floor staff,

cashiers and a small number of office staff at each location. Many of these positions rotated through the store at various times.

Although it was possible, in the majority of cases, to establish the gender of injured workers from their name no such data was available for the gender breakdown of the workforce as a whole. Therefore it was not possible to analyse the injury data by gender and no raw results will be presented as they would be meaningless.

Although it was possible to breakdown the data by store location this would have reduced the power of the inferential statistics and, for reasons that will be discussed in a following section, the results would have been inconclusive. Therefore, no attempt was made to present data by location.

From the pre-intervention period 2 claims remained open as of February 28, 2000, while the intervention period saw 13 claims remaining open. However, in all the open cases the worker had returned to work so was not accumulating days lost, which, from Figure 3, is the major cost associated with an injury. Estimates were provided on the Group Risk Management Report of the final cost of these open cases.

19 records were excluded from the analysis due to duplication or incomplete information.

Table 11. Summary of cohort details.

	Period	Number of months	Total hours worked	Average hours worked per year	Full Time Equivalents
Pre-intervention	1 July 1995 – 31 March 1997	21	2,265,933	1,294,819	647
Intervention	1 May 1997 – 31 December 1999	32	4,411,352	1,654,247	827

Incidence Rates

All Claims

During the pre-intervention period there were 165 workers compensation injuries from all causes recorded, for an incidence frequency rate of 72.82 per million hours worked, of which 41 resulted in a lost time injury claim, the lost time injury incidence frequency rate being 18.09 per million hours worked. During the intervention period there were 316 injuries recorded, for an incidence frequency rate of 70.05, which represents a non-significant decrease of less than 4% (RR = 0.96. 95% CI = 0.80 – 1.16. $\chi^2 = 0.16$) During the intervention period there were 44 lost time injuries from all causes, giving an incidence frequency rate of 9.75 and a statistically significant reduction of 46% (RR = 0.54. 95% CI = 0.35 – 0.82. $\chi^2 = 8.37$).

Manual Handling Injury

Manual handling injury accounted for 54 claims in the pre-intervention period (IFR = 23.83), or 34% of all claims, and 96 claims during the intervention period (IFR = 21.27), accounting for 30% of all claims. This represents a decrease in the manual handling injury frequency rate of 11 %, which did not reach statistical significance (RR = 0.89. 95% CI = 0.64 – 1.25. $\chi^2 = 0.44$). Lost time injury claims resulting from manual handling injury amounted to 20 in the pre-intervention period, for an incidence frequency rate of 8.83 per million hours worked. In the intervention period there were 24 lost time injury claims resulting from manual handling injury (IFR = 5.32) which represents a 40% reduction which just failed to reach statistical significance (RR = 0.60. 95% CI = 0.33 – 1.09. $\chi^2 = 2.86$). As a proportion of all lost time injuries manual handling injury accounted for 49% of the total in the pre-intervention period and 55% during the intervention period.

Low Back Pain

During the pre-intervention period there were 29 injuries to the lower back recorded, of which 25 were due to manual handling injury. These 25 low back pain cases, which represented 15% of all claims, produced an incidence frequency rate of 11.03 injuries per million hours worked. During the intervention period there were 56 injuries to the lower back, of which 43, or 14% of the total cases, were due to manual handling injury for a low back pain incidence frequency rate of 9.53 injuries per million hours worked. This represents a 14% reduction in incidence frequency rate which was not statistically significant with a $\chi^2 = 0.34$ and a relative risk of 0.86 (95% CI = 0.53 – 1.41). The pre-intervention period saw 12 low back pain injuries resulting in a lost time injury, for an incidence frequency rate of 5.30 per million hours worked, compared to 16 low back pain lost time injuries for an incidence frequency rate of 3.55 per million hours worked during the intervention period. For low back pain lost time injury this difference represented a 33% reduction in the incidence frequency rate although the decrease failed to reach a level of statistical significance (RR = 0.67. 95% CI = 0.32 – 1.42. $\chi^2 = 1.12$). Low back pain lost time injuries accounted for 29% of all lost time injuries in the pre-intervention period and 36% during the intervention period (see Table 12).

Other Manual Handling Injury

Manual handling injury other than those resulting in low back pain, categorised as other manual handling injury, accounted for 29 cases (IFR = 12.80) in the pre-intervention period and 53 (IFR = 11.75) in the intervention period, giving a relative risk of 0.92 (95% CI = 0.58 – 1.44) and χ^2 =0.14. Of these cases 9 resulted in a lost time injury claim in the pre-intervention period and 8 during the intervention period, for a pre-intervention incidence frequency rate of 3.97 per million hours worked and an intervention period incidence frequency rate of 1.77. This represented a 55 per cent decrease but failed to reach a level of statistical significance (RR = 0.45. 95% CI = 0.17 - 1.16. $\chi^2 = 2.91$).

The difference between pre and post-intervention relative risks for low back pain and other manual handling injury claims was not statistically significant (z = -

0.20), nor was there a statistical difference found for the difference in lost time injury claims (z = 0.47) (see Table 13).

Non-Manual Handling Injury Low Back Pain

If low back pain cases arising from causes other than manual handling injury, that is those claims coded as non-manual handling injury low back pain resulting from injuries such as slips and falls, are examined separately from low back pain claims there were 4 cases in the pre-intervention period (IFR = 1.77) and 13 during the intervention period (IFR = 2.88), representing a 63% increase in the incidence frequency rate, although the increase failed to reach statistical significance (RR = 1.63. 95% CI = 0.53 – 5.00. χ^2 =0.75). Only one non-manual handling injury low back pain claim resulted in an lost time injury for the whole study period.

The difference between pre and post-intervention relative risks for all low back pain and non-manual handling injury low back pain claims was not statistically significant (z = -1.02) (see Table 14).

Table 12. Low back pain incidence

	LBP cases	LBP IFR	LBP LTI cases	LBP LTI IFR
Pre-intervention	25	11.03	12	5.30
Intervention	43	9.53	16	3.55
RR (95% CI)		0.86 (0.53 – 1.41)		0.67 (0.32 – 1.42)

Table 13. Other manual handling injury (MHI) incidence.

	Other MHI cases	Other MHI IFR	Other MHI LTI cases	Other MHI LTI IFR
Pre-intervention	29	12.8	9	3.97
Intervention	53	11.75	8	1.77
RR (95% CI)		0.92 (0.58 – 1.44)		0.45 (0.17 – 1.16)

Table 14. Non-manual handling injury (MHI) low back pain (LBP) incidence

	Non-MHI LBP cases	Non-MHI LBP IFR	Non-MHI LBP LTI cases	Non-MHI LBP LTI IFR
Pre-intervention	4	1.77	0	-
Intervention	13	2.88	1	0.22
RR (95% CI)		1.63 (0.53 – 5.00)		-

Lost Time Duration

Low Back Pain

During the pre-intervention period 1,699 days were lost due to low back pain compared to 317 days lost during the intervention period. When these days lost are examined by hours worked there was a significant 91% reduction (RR = 0.09. 95% CI = 0.08 – 0.11. χ^2 =2341.46) in days lost attributed to low back pain following the introduction of the intervention. During the pre-intervention period there were 3 low back pain cases that resulted in more than 220 days lost while there were no such cases in the intervention period. If these 3 very long duration cases are restricted to 220, as recommended by the Australian Standards (Standards Australia, 1990), the days lost during the pre-intervention period are reduced to 772, leaving a still significant decrease of 79% (RR = 0.21. 95% CI = 0.18 – 0.24. χ^2 =686.50). The average days lost per low back pain lost time injury during the pre-intervention period was 141.58 (SD = 242.35), reducing by 86% to 19.81 (SD = 33.62) during the intervention period. However, adjusting days lost to a maximum of 220 days reduces the pre-intervention average to 64.33 (SD = 96.30) days and the decrease in average days lost pre-intervention to intervention becomes 69% (see Table 15). If the data is examined for the 12 months prior to the intervention and the two 12 month periods

following its introduction there were 579 days lost per million hours worked in the pre-intervention 12 months, dropping to 11 days lost per million hours worked for the first 12 months of the intervention period but increasing to 175 days lost per million hours worked for the second 12 month period (see Figure 21).

Other Manual Handling Injury

Manual handling injury other than those resulting in low back pain accounted for 440 lost days in the pre intervention period, at an average of 48.89 days (SD = 90.01) per lost time injury claim, and 423 days if restricted to a maximum of 220 days or 47 lost days (SD = 85.64) per lost time injury claim. When examined per million hours worked this gives an incidence frequency rate of 194.18 and 186.68 respectively. During the intervention period there were 299 days lost, with no single case over 220 days, for an incidence frequency rate of 66.28 per million hours worked and an average of 37.38 lost days (SD = 64.84) per lost time injury claim. For unadjusted days lost this represented a statistically significant reduction of 66% (RR = 0.34. 95% CI = 0.29 – 0.40. χ^2 = 226.29) and for adjusted days lost a significant 64% reduction (RR = 0.36. 95% CI = 0.31 – 0.41. χ^2 = 205.25). The average days lost per lost time injury claim was reduced by 24%, or 20% when adjusted (see Table 16). Like the low back pain data the days lost to other manual handling injuries can be examined in 12 month periods. During the 12 months immediately before the intervention there were 180 days lost per million hours worked, decreasing somewhat to 135 days lost per million hours worked for the first 12 months of the intervention period and 46 days lost per million hours worked for the second 12 months (see Figure 21).

The difference pre and post intervention between total days lost from low back pain per hours worked and total days lost from non-low back pain per hours worked was statistically significant (z = -13.04 raw data, z = -5.56 adjusted data), that is, the decrease in total days lost from low back pain was significantly larger than the reduction associated with other manual handling injury.

Low Back Pain (corrected for manual handling injury affect)

When the days lost resulting from low back pain claims are adjusted to take into account of the observed change in manual handling injury claims the size of the back belt affect is reduced to a 25% reduction in total days lost to low back pain per million hours worked and a 15% reduction in adjusted days lost per million hours worked. However, the validity of this correction will be examined further in the discussion.

Long Duration Claims

For long duration claims, that is, claims resulting in 60 or more days lost (WorkCover Western Australia, 2000), there were 4 long duration low back pain claims during the pre-intervention period, accounting for a total of 1,666 days lost (mean = 416.5, SD = 253.31) or 739 adjusted days lost (mean = 184.75, SD = 108.14), and 2 claims during the intervention period resulting in 204 days lost. On an hours worked basis this represents a 75% decrease in the incidence frequency rate for long duration claims, although the reduction is not statistically significant (95% CI = 0.05 – 1.37). However, the total days lost per hours worked demonstrated a significant 94% reduction for the raw days lost (RR = 0.06. 95%CI = 0.05 – 0.07) and a significant 86% reduction for adjusted data (RR = 0.14. 95% CI = 0.12 – 0.16).

Manual handling injury other than those resulting in low back pain resulted in 2 long duration claims for each study period which represents a non-significant 50% reduction (95% CI = 0.07 – 3.57). During the pre-intervention period there were 410 days lost in total, 393 days adjusted while the intervention period accounted for 253 days lost.

Not surprisingly, given the small incidence of long duration injuries, the difference between the incidence frequency rate and days lost per man hours worked for long duration low back pain claims and manual handling injury other than those resulting in low back pain was not statistically significant.

Table 15. Lost time duration for low back pain claims

	LBP days lost (average)	LBP days lost IFR	LBP days lost adjusted (average)	LBP days lost IFR adjusted
Pre-intervention	1,699 (141.58)	749.80	772 (64.33)	340.70
Intervention	317 (19.81)	70.27	317 (19.81)	70.27
RR (95% CI)		*0.09 (0.08 – 0.11)*		*0.21 (0.18 – 0.24)*

Table 16. Lost time duration of other manual handling injury (MHI) claims.

	Other MHI days lost (average)	Other MHI days lost IFR	Other MHI days lost adjusted (average)	Other MHI days lost IFR adjusted
Pre-intervention	440 (48.89)	194.18	423 (47.00)	186.68
Intervention	299 (37.38)	66.28	299 (37.38)	66.28
RR (95% CI)		*0.34 (0.29 – 0.40)*		*0.36 (0.31 – 0.41)*

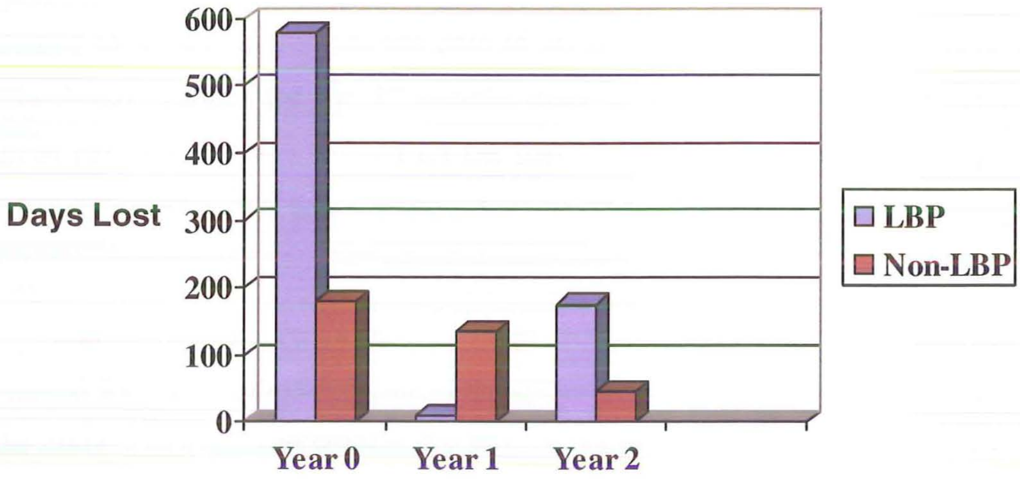

Figure 21. Days lost to low back pain and other manual handling injury for 12 month period before intervention and 24 month period following intervention.

Cost

Low Back Pain

During the pre-intervention period the total direct cost of low back pain claims was $514,517 at an average of $20,581 (SD = 53,530) per claim. The intervention period saw a reduction in total low back pain cost to $207,551 and the average cost per low back pain claim fell to $4,827 (SD = 12,588), representing a 77% decrease the average cost per claim. When examined per hours worked low back pain claims cost $227,006 per million hours worked during the pre-intervention period, reducing by 80% to $47,049 per million hours worked during the intervention period (RR = 0.20. 95% CI = 0.20 – 0.20. χ^2 = 464109). For low back pain claims resulting from an lost time injury the total cost in the pre-intervention period was $507,258, at an average of $42,272 (SD = 72,556) per claim, while these claims accounted for $174,259 during the intervention period, at an average of $10,909 (SD = 19,226), a 74% reduction. On an hours worked basis this represents an 83% reduction in the cost of low back pain lost time injuries, from $223,863 per million hours worked for the pre-intervention period to $38,627 per million hours worked for the intervention period (RR = 0.17. 95% CI = 0.17 – 0.17. χ^2 = 514668). When examined in 12 month periods the cost of all low back claims was $392,205 per million hours worked for the 12 months prior to the intervention, decreasing to $40,704 per million hours worked for the first 12 months of the intervention period and $76,277 per million hours worked for the second 12 month period (see Figure 22).

During the pre-intervention period 10% of the low back pain claims accounted for 98% of the total cost. During the intervention period it required 56% of the number of claims to account for 98% of the total cost. This demonstrates that the cost of low back pain claims was heavily skewed towards the few very expensive claims during the pre-intervention period, while during the intervention period the bulk of the cost of low back pain claims was spread over a much larger proportion of the claims (see Table 17).

Other Manual Handling Injury

Manual handling injury claims other than low back pain accounted for \$168,768 during the pre-intervention period, at an average of \$5,820 (SD = 20,115) per claim, increasing to \$285,840 during the intervention period, at an average of \$5,393 (SD = 16,408) per claim. This represented a 7% decrease in the average cost of other manual handling injury claims. On an hours worked basis these claims cost \$74,481 per million hours worked in the pre-intervention period, reducing 15% to \$63,360 per million hours worked during the intervention period (RR = 0.85. 95% CI = 0.85 – 0.86. $\chi^2 = 2701$). During the intervention period manual handling injury claims other than low back pain that resulted in a lost time injury cost a total of \$165,533 or \$72,965 per million hours worked at an average of \$18,370 (SD = 34,046). During the intervention period the total cost of these lost time injuries changed little at \$162,209 but there was a 51% reduction in the cost per million hours worked, decreasing to \$35,956 (RR = 0.49. 95% CI = 0.49 – 0.50. $\chi^2 = 42746$) although the cost per lost time injury claim increased by 7% to \$20,276 (SD = 32,925) (see Table 17). Examined in 12 month periods the cost of all non-back pain manual handling injuries was \$76,991 per million hours worked for the 12 months prior to the intervention and \$63,332 and \$32,389 per million hours worked for the first two 12 month periods of the intervention (see Figure 22).

On a cost per million hours the reduction in low back pain claims compared to the reduction in manual handling injury claims was significantly greater for all claims (z = -359.65) and LTI claims (z = -237.21).

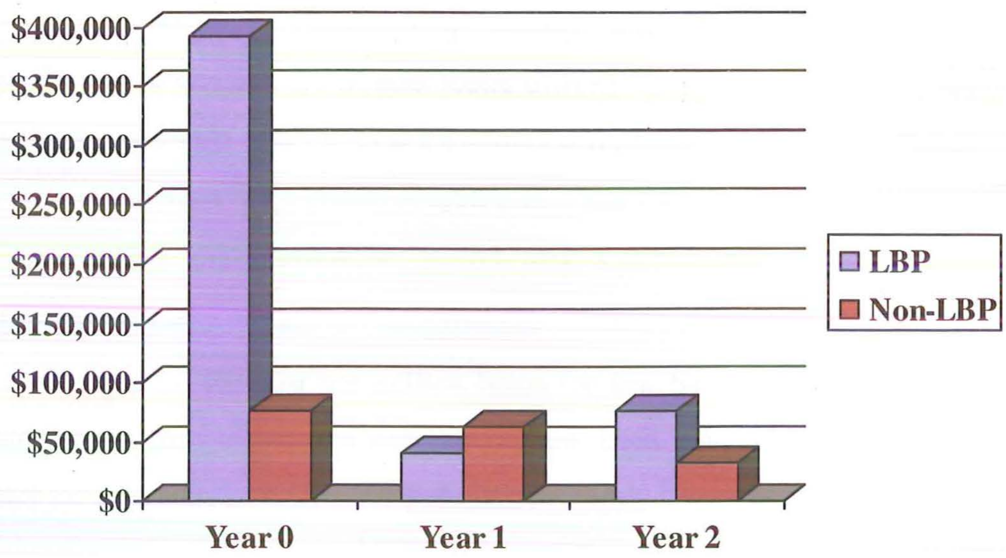

Figure 22. Low back pain cost versus other manual handling injury cost for 12 month period before intervention and 24 month period following intervention.

Low Back Pain (corrected for manual handling injury affect)

When the cost of low back pain claims is corrected for the observed change in manual handling injury claims the decrease in average cost per low back pain was less than that previously noted but still large with a 66% reduction, while the size of the reduction in the average cost per low back pain lost time injury claim actually increased slightly to 77%. The size of the effect in cost per low back pain claim per million hours worked was similarly reduced but remained large at 67% and the cost per low back pain lost time injury claim per million hours worked demonstrated a reduction of 65% (see Table 17).

Non-Low Back Pain

Non-low back pain claims accounted for $555,260 during the pre-intervention period, at an average of $3,966 (SD = 21,857) per claim, and $570,365 during the intervention period, at an average of $2,089 (SD = 8,610) per claim. On an hours worked basis these injuries cost $245,046 per million hours worked during the pre-intervention period and $126,429 per million hours worked during the intervention period which represents a significant 48% reduction (RR = 0.52. 95%

CI = 0.51 – 0.52. χ^2 = 127,779). Non-low back pain lost time injuries cost a total of $525,072 or $231,724 per million hours worked during the pre-intervention period and $283,823 or $62,913 per million hours worked during the intervention period, a decrease of 73% (RR = 0.27. 95% CI = 0.27 – 0.27. χ^2 = 360,134). The average cost of non-low back pain claims resulting in a lost time injury was $18,753 (SD = 46,621) for the pre-intervention period and $10,137 (SD = 20,590) for the intervention period.

Comparing the cost per million hours for low back pain claims opposed to non-low back pain claims the decrease in low back pain costs was significantly greater for all claims (z = -297.50) and lost time injury claims (z = -127.63).

Non-Manual Handling Injury Low Back Pain

Low back pain cases arising from causes other than manual handling injury accounted for $4,731 during the pre-intervention period, at an average of $1,183 (SD = 1,871) per claim. During the intervention period the total cost of these injuries increased to $21,606, while the average cost increased to $1,162 (SD = 3291) per injury. On an hours worked basis this resulted in a 129% increase in the cost of these injuries, from $2,088 per million hours worked during the intervention period to $4,789 per million hours worked during the intervention period (RR = 2.29. 95% CI = 2.22 – 2.38. χ^2 = 2832). As discussed above, this category only resulted in 1 lost time injury so comparison of lost time injury costs is not appropriate (see Table 17).

The difference between low back pain claims and non-manual handling injury low back pain was statistically significant (z = -149.93).

Long Duration Claims

During the pre-intervention period long duration low back pain claims cost a total of $500,171 or 98.6% of the total cost arising from low back pain lost time injuries and 97.2% of the cost of all low back pain claims. During the intervention period the cost of these claims dropped to $88,771, now representing 50.9% of the total cost of low back pain lost time injuries and 42.8% of the total low back pain cost. On an hours worked basis this represents a 91% decrease.

Long duration non-low back pain claims cost $480,424 during the pre-intervention period or 91.5% of the cost of the total cost of non-low back pain lost time injuries and 86.5% of the total cost of all non-low back pain claims. During the intervention period these claims cost $223,793 or 78.8% of the non-low back pain lost time injury cost and 39.2% of the cost of all non-low back pain claims. On an hours worked basis this represents a 77% decrease.

For manual handling injury claims other than those resulting in low back pain the cost of long duration claims during the pre-intervention period was $152,172, which was 92% of the cost of lost time injuries for this category and 90% of the total cost. During the intervention period the cost was $143,907 or 88.7% of the lost time injury cost and 50.6% of the total cost. On an hours worked basis this represents a 53% decrease.

As with the incidence and days lost the difference in cost on an hours worked basis between claim categories failed to reach statistical significance on the z test.

Table 17. Average cost per claim and cost per million hours worked.

Injury type	Average cost per claim ($)			Average cost per LTI claim			Claims cost per million hours worked			LTI claims cost per million hours worked		
	Pre	Post	%	Pre	Post	%	Pre	Post	%	Pre	Post	%
LBP	20,581	4,827	↓77	42,272	10,909	↓74	227,006	47,049	↓80	223,863	38,627	↓83
Other MHI	5,820	5,393	↓7	18,370	20,276	↑10	74,481	63,360	↓15	72,965	35,956	↓51
LBP (corrected for MHI affect)			↓70			↓84			↓65			↓32
Non-MHI LBP	1,183	1,162	↓2	-	-	-	2,088	4,789	↑129	-	-	-

DISCUSSION

The following discussion will make reference for the purpose of comparison to several other published back belt intervention studies. It should be noted that this area of study is marked by a wide range of methodologies and definitions, as became apparent during the literature review. It should also be noted that all of the reviewed back belt intervention studies were conducted in North American workplaces. Therefore, direct comparison between the results of this study and the earlier studies is not possible. However, some rough comparison is necessary, if only to establish that the results of this study fall within the bounds of what could reasonably be expected and are therefore reasonably representative of the workplace in general.

Incidence

Manual handling injury resulting in a lost time injury occurred at a rate of 8.83 per million hours worked. This compares with data published for Western Australia for the 1998/99 financial year where the category 'personal and household goods retailing' resulted in 7.5 manual handling lost time injuries per million hours worked (WorkCover Western Australia, 2000).

The incidence frequency rate for low back pain claims during the pre-intervention period of 11.03 injuries per million hours worked is smaller than the 16.06 (based on 79.2% of claims being associated with manual handling injury) per million hours worked reported by Kraus et al. (1997) for a similar but larger workforce, agreeing more closely with the 14 injuries per million hours worked reported by Gardner et al. (1999) for retail merchandise material handlers. The pre-intervention incidence frequency rate for low back pain resulting in a lost time injury of 5.30 per million hours is again similar to the 4.1 per million hours worked reported by Gardner et al. It is not possible to make a comparison with the lost time injury data presented by Kraus et al. as the proportion associated with manual handling injury is not known. As a percentage of total pre-intervention claims low

back pain accounted for 15%, similar to the 17% US average previously reported (Hashemi et al., 1997), while low back pain lost time injuries accounted for 29%, somewhat higher than the Western Australian workforce average of 19.5% (WorkCover Western Australia, 2000) and the 13.5% reported for the Western Australian retail trade sector (Worksafe, 2002).

The above figures would suggest that the low back pain incidence frequency rate for the Bunnings cohort prior to the introduction of the back belt was slightly higher than the state average but it must be noted that the nature of the business exposed workers to greater manual handling hazards that would reasonably be expected to be the norm for the retail trade sector.

The non-significant 14% reduction in the incidence frequency rate for all low back pain cases was less than the significant 26% reduction reported by Kraus et al. (2002). However, the 33% reduction in low back pain lost time injuries with the introduction of back belts agrees very closely with the 34% reduction reported in the similar study performed by Kraus et al. (1996) although in the present study the decrease was not statistically significant. Interestingly, the earlier study by Kraus et al. appears to have included low back pain lost time injury cases from all causes while the present study only included low back pain arising from manual handling injury. If the small number of low back pain claims arising from causes other than manual handling injury then the trend towards a reduction in low back pain found in the present study would have been weakened.

The null result for low back pain incidence, despite the 33% reduction in low back pain lost time injuries, highlights the difficulty of performing workplace epidemiological studies where the dependent variable has an incidence frequency rate in the order of 10 per million hours worked. Based on the initial low back pain injury rates and cohort size, and by using the confidence interval equation presented in the methodology, a reduction in low back pain incidence frequency rate of approximately 58% was required to achieve statistical significance with 95% confidence intervals. Looked at in another way and again using the confidence interval equation, the cohort would need to be approximately 3.5 larger if the observed 33% decrease in low back pain lost time injury were to be significant. This study, with over 6.5 million man hours, must be regarded as a relatively large study.

In fact, only three studies (J. Kraus et al., 1996; J. Kraus et al., 2002; Wassell et al., 2000) have been published to date with cohorts of this size or larger and one of these (Wassell et al., 2000) suffered from a high drop-out rate and poor back belt compliance. Such difficulties must not only bring into doubt many of the previous back belt intervention studies but also other interventions aimed at reducing occupational low back pain. It also suggests that the design of the current study, and similarly those of Kraus et al. (1996, 2002), that is a non-experimental before-and-after design, is the most practical means of providing the large cohort sizes required. To perform a randomised controlled trial of sufficient size would be very difficult and is difficult to justify given the likelihood of poor compliance discussed earlier.

Based on the lack of statistical significance it would be reasonable to assume that the introduction of back belts to the Bunnings' workplace did not have a favourable effect on occupational low back pain incidence. However, given the very large and significant reductions in both low back pain duration and cost following the introduction of the back belt it seems far more reasonable to conclude that the lack of significance in the incidence frequency rate for incidence of low back pain is the result of a type II error, that is, the hypothesis is rejected based on the statistical analysis when, in fact, it is true. Considering the difficulty in achieving adequate power when dealing with low back pain incidence one is left with the possibility that many of the results in past studies have been dismissed due to a lack of statistical significance when there was, in reality, a true decrease in incidence due to the back belt, thus leading to a simple and cost effective control measure being discarded in error.

Care must be exercised in interpreting statistical significance. Sprent (2003) points out that a given level of statistical significance is "no more than a convenient and conventional yardstick" (p. 525) and that the clinician must also consider the practical importance of the result. Whitley and Ball (2002) go further and state that "the aim of hypothesis testing is not to 'accept' or 'reject' the null hypothesis. Rather, it is simply to gauge how likely it is that the observed difference is genuine if the null hypothesis is true." (p. 223) Burton, Gurrin and Campbell (1998) suggest that p values and confidence intervals are often misinterpreted, stating:

> Significance at the 5% level is commonly interpreted to mean that 'there is an effect (the null hypothesis is false)' while p>0.05 is taken to mean that 'there is no effect (the null hypothesis is true)'. These interpretations suggest that p values provide some direct quantification of the plausibility of the null hypothesis. However, a proper assessment of the plausibility of the null hypothesis requires the simultaneous consideration of the relative plausibility of other competing hypothesis. It cannot reasonably be based upon a single p value calculated assuming that the null hypothesis is true. (p.318)

The trend towards a reduction in all low back pain claims was larger than that occurring for all other manual handling injury claims but this was reversed for claims resulting in a lost time injury where other manual handling injury claims demonstrated a greater trend to reduction. In fact, excluding the low back pain lost time injury claims there was a significant 50% reduction in the remaining lost time injury claims, despite only a 2% reduction in all claims for this category. This may indicate a change in the management of injury claims resulting in lost time injury, either in the workplace or the medical management of the injured worker, resulting from a general drive to reduce lost time injury cases by providing early return to work on light or restricted duties, the latter type of claims not being included in the lost time injury count. Some of the drive behind this type of management is the fact that lost time injuries are often used as key performance indicators for workplace health and safety. There was also additional encouragement from Worksafe Western Australia and WorkCover Western Australia to provide for an early return to work to improve injury management, with a campaign being run on television and through brochures and guidelines provided to both injured workers and employers, although the overall effectiveness of the campaign must be questioned given the increase in both lost time injury duration and cost recorded for Western Australia and discussed in more detail in following sections (Knowles et al., 2000; WorkCover Western Australia, 2000). Such "claims management" may explain why there was only a 4% reduction in total claims but a 46% reduction in claims resulting in a lost time injury.

If claims management is operating in the case of the workplace used for this study then the results would suggest that low back pain lost time injuries are more difficult to manage in this fashion then other injuries as a 33% reduction in low back pain lost time injury claims was associated with an overall 46% decrease in lost time injuries.

Although the injury numbers were not large enough to allow meaningful statistical analysis it is worthwhile briefly discussing low back pain resulting from injuries other than manual handling. These claims would be the result of such mechanisms as slips and trips, falls and "struck by" incidents. Clearly, with these types of injuries it would appear appropriate to assume that there is no plausible casual link between the back belt and their incidence. For these injuries there was a 63% increase in incidence following the introduction of back belts. Although only a trend it does lend some support to the assumption that the decrease in manual handling injury low back pain incidence is the result of intervention rather than a changes in claims management or a general secular trend. This claim category is more significant when the cost of injury is discussed latter.

Duration

In contrast to the lack of a significant decrease in low back pain incidence frequency rate the effect of the introduction of back belts on low back pain duration, as measured by the number of days lost, was dramatic with a 79% decrease in days lost to low back pain per million hours worked and a 69% reduction in the average days lost per low back pain lost time injury.

During the pre-intervention period there were 3 very long duration low back pain claims which have the effect of skewing the results. Limiting the maximum days lost to 220 days (Standards Australia, 1990), which is the equivalent of 1 working year, reduces the size of an effect on duration but provides for a more realistic comparison so the adjusted days lost will be examined through this discussion. As was seen in the results, limiting the days lost to 220 had little effect on the very large reductions which followed the introduction of the back belts and the limitation will have little bearing on this discussion.

Prior to the introduction of back belts the average days lost per lost time low back pain claim was approximately 64 days which is close to the Western Australian average of 75.8 (Workcover, 2004) for the same period. Following the intervention the average duration reduced to 20 days while the state average had increased somewhat to 76.9 days. It should be noted the state figures have not been restricted to 220 days as discussed above; if the pre-intervention days had not been restricted they would have been approximately twice the state average.

When the total injury database was examined there were significant reductions in all the categories for the number of days lost from the pre-intervention to the intervention periods. However, the largest reduction by far occurred in low back pain claims, with the decrease of 79% being compared to the 64% for all other manual handling injury claims, and the difference between these two categories being statistically significant. This suggests that, despite the possibility of unidentified factors having an effect on manual handling injury, in general the significant difference between the reduction in low back pain duration and the reduction in other manual handling injury duration may be attributed to the back belt.

The results suggest that the effect of the back belt was somehow directed more at the severity of the injury, as measured by the number of days the injured worker required off work to recover and rehabilitate, rather than the injury incidence itself. This was further borne out when examining longer duration claims where the back belt effect was even more dramatic on long duration claims of 60 days lost or more, the total days lost per million hours worked being reduced by 86%. This concept will be discussed in more detail in following sections.

As with low back pain incidence there may be an underlying change in claims management affecting the number of days lost but the statistical difference between low back pain and other manual handling injury claims and the fact that low back pain lost time injury incidence was less affected than other categories would suggest that at least some of the reduction in the number of days lost per low back pain injury was as a result of the introduction of the back belt. That is, although the back belt did not significantly affect the overall incidence of low back pain it did reduce the severity of the injury, as measured by the number of days lost.

The effect on duration is all the more interesting bearing in mind that previous studies of back belt interventions have not examined the effect on the duration of injury. The possibility exists, therefore, that in many previous studies there was an underlying positive effect which the investigators failed to uncover.

Cost

The cost of a claim includes not only lost wages but also medical and rehabilitation costs. It is therefore a far better indicator of the severity of an injury than days lost and is less susceptible to the affects of claims management aimed at reducing days lost. Claims management will often be directed at the measures which are used as key performance indicators for safety performance. Two of the most commonly used key performance indicators are lost time injury incidence and days lost. The dollar cost of injuries is not a common key performance indicator as, unlike incidence and lost time injury data, this information would rarely be available at the middle management or store level as the data on cost is maintained by the insurer.

Overall there was an 80% reduction in the cost of low back pain on an hours worked basis compared to only a 15% reduction in other manual handling injury claims. This cost saving is even more apparent when the average cost of claims is examined with the average low back pain claim being over 3.5 times more expensive than other manual handling injury claims during the pre-intervention period. During the intervention period the average cost of a low back pain claim fell to become slightly less than that of other manual handling injury claims.

The cost of low back pain lost time injury claims on an hours worked basis was reduced by 83%. This was accompanied by a 51% reduction on the cost of other manual handling injury lost time injury claims. However, where there was a 74% reduction in the average cost of a low back pain lost time injury claim, the average cost of non-low back pain manual handling injury lost time injury claims actually increased by 10% so that the average cost of non-low back pain manual handling injury lost time injury was almost twice that of low back pain lost time injury. This result is quite surprising as manual handling injuries involving the lower back would normally be expected to be the most expensive of the manual handling injuries.

Similarly, when low back pain arising from injuries other than manual handling are examined there was a massive 129% increase in the cost of these injuries per million hours worked, further strengthening the decrease in manual

handling injury low back pain costs. This is an interesting result as many workplaces and, based on the literature review, researchers as well, do not distinguish between cases of low back pain arising from manual handling injury and those cases of low back pain claims arising from other causes. If these claims had been included in this analysis they would have diluted the effect of the back belt, masking the effectiveness of the back belt intervention.

The dramatic increase in cost for the non-manual handling injury low back pain category, as well as that for non-low back pain lost time injury discussed above, suggests that claims management was not being applied in the workplaces studied.

Clearly, there is a large and consistent reduction in the cost of low back pain and a sizable amount of this reduction is independent of any affect on other manual handling injury claims. Therefore, it seems reasonable to assume that the reduction in low back pain cost is associated with the introduction of back belts. The only published study that examines the effect of back belts on the cost of low back pain was that of Reddell et al. (1992), who reported no effect. However, as discussed previously the Reddell et al. study suffered from a high drop-out rate and poor compliance.

Although the large figures involved make statistical comparisons somewhat meaningless there is an obvious business advantage which appears to be related to the introduction of the back belt; there is no need to apply complex inferential statistical measures to dollar costs where the reductions are in the order of 70 to 80%. This advantage is even more commercially significant when the cost effectiveness of the intervention is taken into account, as discussed in a following section.

Severity of low back pain

For discussion purposes the duration of a claim, as measured in days lost, and/or the cost of a claim can be regarded as measures of the severity of the injury underlying the claim.

As discussed earlier, these measures of severity are more robust where there is a possibility of claims management as there is little that can be done from a management perspective, at least in the early stages of the injury, to affect the recorded outcome. This is probably more so for the direct cost of the injury as this can only be reduced slightly by a return to alternative or light duties while this same action immediately stops the recording of further lost time. If the overall incidence frequency rate for lost time injuries were being reduced by management of the injuries, such as incentives for reduced lost time injury incidence frequency rate, increased availability of "light duties" in the workplace or a perception by the workforce that minor complaints should not be reported, then this should lead to an increase in the average time lost and cost per lost time injury as it is only the less severe claims that can be managed in such a way. Regardless of how an injury is managed, a severe injury will still tend to be a severe injury.

From a risk management perspective workplace interventions should be targeted at those injuries with the highest risk, where the risk is a measure of the combination of severity and frequency or incidence of occurrence. There should be no argument regarding the unacceptably high incidence of workplace low back pain. As we have seen the severity of occupational low back pain has been shown to be heavily skewed with the costliest 10% of workers' compensation claims accounting for 86% of the total cost, and the lengthiest 10% accounting for 92% of total days lost (Hashemi et al., 1997) and these finding have been consistently supported in the literature (Clemmer et al., 1991; Dempsey, 1999; Knowles et al., 2000; Spengler et al., 1986).

An efficient and cost effective control measure would target these severe injuries but there appeared to be no means of identifying which risk factors are

associated this most severe 10% (Clemmer et al., 1991), that is, until the present study.

The earlier discussion relating to the risk factors associated with occupational low back pain literature examines the relationship between various factors and the *incidence* of low back pain; it is not clear from the literature whether there are any generally accepted risk factors for the severity of low back pain. One could argue that psychosocial risk factors impact on the cost of low back pain, particularly evident when compensation is available, but this does not explain why back belts should have such a large effect on the cost; the normal effect of the presence of workers' compensation insurance is to increase the cost of the injury, as any clinician who has dealt with injured workers covered by insurance will attest.

From the results of this study it is apparent that the back belt's main effect was on those more severe injuries. While there was no significant reduction in incidence measures there was a considerable decrease in the severity measures, in particular the cost. This is an effect that has not been identified in previous studies but it may explain the long standing anecdotal support for back belts despite what is often seen as equivocal incidence data.

An alternative explanation for this large decrease in cost without a significant decrease in incidence is that the back belt raises awareness of the lower back to such an extent that individuals are more likely to take note of and report occurrences of minor low back pain that previously were going unreported. This would have the effect of masking an overall decrease in incidence so that the only evidence remaining of an effect is the decrease in cost and duration. However, if this mechanism is acting, even to a small extent, it will only result in a weakening of the apparent effectiveness of the back belt on incidence rates, that is, the true effectiveness of the back belt would be stronger than the incidence results would suggest.

The reduction in severity observed in this study is the opposite to that reported in the general workforce from which the cohort was taken over the same period. In Western Australia between 1995/96 and 1998/99 long duration workers' compensation claims increased by 21.1% while the average cost of lost time injury

claims increased 13.6% between 1995/96 and 1997/98 (WorkCover Western Australia, 2000).

Cost Benefits

At the end of the study period the cost of supply of the back belts was approximately $15 (Bunnings Building Supplies, 2000). Training in the use of the back belt involved a short video supplied by the manufacturer and the instructions on the packaging. At the introduction of the back belt this required a brief training period to be set aside for all existing staff. Following this, new starts received training in the use of back belts as part of their normal manual handling induction training.

If it is assumed that the staff numbers at the time of introduction of the back belts were 1,244 and the cost of supply of the back belt and initial training was, say, $20 per person then the cost of introducing the back belts was approximately $24,880. If an annual staff turnover of 10% is assumed then the ongoing cost of maintaining the back belt program is 124 back belts at $15 or $1,860 per annum, or $4,960 for the 32 months of the intervention period. The total cost of the intervention was therefore approximately $30,000.

During the pre-intervention period the annual cost of low back pain claims was $294,010 reducing to $77,832 during the intervention period. This is despite a 28% increase in the hours worked. Allowing for the growth in the workforce and based on the projected cost from the pre-intervention period of low back pain claims per hours worked this represented a saving of approximately $793,852 over the duration of the intervention period. After the cost of the intervention is deducted the actual saving in the direct costs of low back pain claims is approximately $765,000 over the intervention period or over $286,000 per year and all for an outlay of less than $2,000 per year.

Even allowing for some cost reduction due to other causes, as reflected in the 15% cost reduction of other manual handling injuries, this still clearly indicates that the back belts represent a very cost effective workplace control measure for the prevention of manual handling injury involving the lower back.

Compliance

Clearly, compliance with back belt use is essential if an effect is to be measured; the Cochrane Back Group (Van Tulder et al., 2000) suggesting that an effect is "impossible" to determine without it. Compliance with back belt in the Bunnings cohort has been previously established as almost 90% during heavy lifting and 100% in workers performing regular heavy lifting (Merdith, 2000). Of the 7 larger studies previously reported only three (Anderson, Morris & Del Vechio. Cited in: Barron & Feuerstein, 1994; Kraus et al., 1996; Kraus et al., 2002) reported back belt compliance greater than 80% while one (Mitchell et al., 1994) did not report compliance and three (Reddell et al., 1992; van Poppel et al., 1998; Wassell et al., 2000) reported poor compliance. None of the smaller studies reviewed reported compliance.

If the results of studies with poor compliance are rejected, as was suggested (but not practised) by the Cochrane Back Group statement, only four studies, the present one and those of Anderson, Morris and Del Vechio (cited in: Barron & Feuerstein, 1994), Kraus et al. (1996) and Kraus et al. (2002) report good compliance and all four describe positive effects of back belts on the incidence or severity of occupational low back pain. Unfortunately reviewers in the past, including the Cochrane Back Group, have completely failed to take into consideration the effect of poor compliance when assessing the results of workplace interventions.

The poor compliance reported in the Wassell et al. (2000) is of particular concern as NIOSH has based its most recent policy statements relating to the use back belts in the workplace on the findings of this study. The negative findings of this NIOSH funded study have been reproduced extensively with NIOSH providing substantiation for what should be regarded as, at best, an inconclusive study.

The possible reasons for differences in compliance are many. Merdith (2000) found that back belt compliance was significantly greater in males, was negatively associated with length of employment, very strongly associated with positive attitudes towards the adequacy of training and, somewhat surprisingly, not affected by a past history of low back pain. Increased compliance has also been reported with

an increase in perceived lifting intensity (Merdith, 2000; Pan et al., 1999; Wassell et al., 2000).

Although not reported in the back belt literature, management and worker representative attitudes will also have significant effects on back belt compliance, as will general attitudes within the society. In the case of Bunnings' Building Supplies the author noted that there was considerable variation in attitudes to the back belt between store managers, despite a strong commitment to the back belt from upper management, and there was some variation in the level of compliance between stores. Unfortunately, although compliance data for individual stores was examined there was no measure of management attitudes to determine whether supervisory attitudes effect compliance in the earlier study. During the course of this study the author became aware of negative union attitudes towards the back belt based largely on the earlier NIOSH (1994) report. In fact, during the intervention period the back belt was withdrawn from mandated use in Bunnings' branches in another Australian state due to threatened industrial action by the union.

Poor choice of back belt design, such as occurred in the study of Reddell et al. (1992), where a leather weight lifting belt was used in the workplace, will do little to promote compliance. Weight lifting belts are designed for intermittent use while training or competing and are, of necessity, of very robust construction with no need for consideration of the comfort of the wearer over several hours or in postures other than sagittal flexion and extension. The difficulty with wearing a leather weight lifting belt for prolonged periods at work is attested to by the fact that Reddell et al. reported a high drop out rate despite a very positive attitude amongst the subjects towards the belts themselves. Similar difficulties could be reasonably expected with the moulded thermoplastic supports that have sometimes been promoted in the workplace and have been used in at least one workplace intervention study (Walsh & Schwartz, 1990).

A well designed back belt should be comfortable and easy to don. Back belts with shoulder braces, such as those used in the present study and by Kraus et al. (1996), allow the belt to be worn loosely when not required and quickly and easily tightened when performing manual handling duties. Back belts of this design are worn on the outside of clothing, simplifying monitoring by supervisors and

workmates of proper application in workplaces where their use is mandatory. The wearing of the back belt on the outside of clothing also means that the control measure has exposure to customers which further encourages its use.

One possible explanation for the poor compliance reported by Wassell et al. (2000) in stores where back belt use was mandated may be that the back belt used had no shoulder braces, allowing it to be worn under clothing. Monitoring of correct usage by colleagues and managers would, therefore, be difficult and the employee is not provided with the constant visual reminder. This design is somewhat more difficult to loosen and adjust than the back belt used in the present study which creates a further disincentive for the employee to wear properly.

The actual effect of anything less than complete compliance on outcome measures is not measurable as the voluntary non-compliance introduces a selection bias of unknown direction. Further complicating the inability to correct for poor compliance is the fact that there is no clear guidance or established standards in the literature on what should be regarded as an acceptable level of compliance when critically reviewing workplace interventions. It should be noted, though, that poor compliance with an intervention is not limited to back belt use; such interventions as manual handling training must still rely on the workers complying with accepted manual handling risk reduction techniques.

As the results of this study, and those other studies with similarly high compliance, demonstrate a positive effect of back belts in the workplace the introduction of back belts into the workplace as a control measure for low back pain must be accompanied by a policy of mandatory use and have the complete support of the workforce, management and employee representatives. Such a mandatory policy cannot be applied to the volunteers in randomised controlled trials (RCTs), or other less rigorous studies that rely on voluntary participation, and it is this weakness that is demonstrated in the literature through moderate, at best, compliance whenever back belt use is voluntary.

However, it is clear from the results of Wassell et al. (2000) that a 'mandatory policy' must be what it is states, in other words mandatory must mean full compliance, or at least as close to full compliance as is reasonably practicable. Despite the workplace studied by Wassel et al. requiring mandatory back belt use

they reported only 58% compliance, which on further examination, was even less than this. Other than the difficulty in monitoring back belt usage, as discussed above, the commitment from management in this workplace may have been less than adequate. A lack of commitment from top management appears to have been communicated to the workforce, at least inadvertently, by the fact that the mandatory introduction of back belt was not applied across all workplaces in the organisation. When an intervention is only introduced to some sites in an otherwise similar workforce it will be difficult to avoid giving the impression that management lacks total conviction in the effectiveness of the control measure, the assumption being that management is performing an experiment, and once this is the case then the intervention will no longer be regarded as truly mandatory.

When compared to many other forms of personal protective equipment (PPE), assuming that the back belt is personal protective equipment which is discussed in a later section, the effectiveness of a back belt requires more than just the wearing of the device. Once personal protective equipment such as a hardhat or safety boots is put on its protective function is automatic and does not rely on further user compliance and in many Australian workplaces compliance with hardhat and safety boot requirements is 100%. Even when back belts are 'worn' their effectiveness must still rely on the user complying with their correct application, that is, correctly tensioning the belt. This problem was acknowledged by Wassell et al. (2000) where the reported compliance with back belt use was weakened by a degree of uncertainty regarding the correct tension due to the fact that the back belt was worn under clothing.

Possible Mechanisms

Although it is not the purpose of this study to establish the mechanism involved in the reduction in the severity of low back pain by back belts some discussion is required, if only to establish the biological plausibility of the affect (see section on causation). As stated previously "Prevention of a disorder is contingent on an understanding of its causative mechanisms." (Leboeuf-Yde et al., 1997, p.877)

Comparing the known risk factors for occupational low back pain with the mechanisms of action of back belt that have been previously studied in the laboratory produces several likely candidates for a back belt mechanism(s) involved in the positive findings of this study. These are:

- Improved kinematics
    - Decreased range of motion
    - Decreased acceleration and/or velocity
- Improved proprioception due to feedback from the back belt
- Increased intra-abdominal pressure resulting in:
    - Increased stiffness of the trunk
    - Enhanced proprioception
    - Decreased compressive and/or tensile and/or shearing forces
- Psychosocial effects

It should be noted that, just as the cause of low back pain may be multi-causal, the back belt mechanisms involved in the reduction in low back pain duration and cost may be due to multiple factors. These mechanisms may have varying effects, either alone or in combination, of controlling the risk factors for occupational low back pain.

The generally accepted risk factors for occupational low back pain, as they relate to the possible mechanisms of action of back belts described above, are

summarised in a model developed by the author and shown in Figure 23 (for the purpose of this discussion a past history of low back pain is excluded).

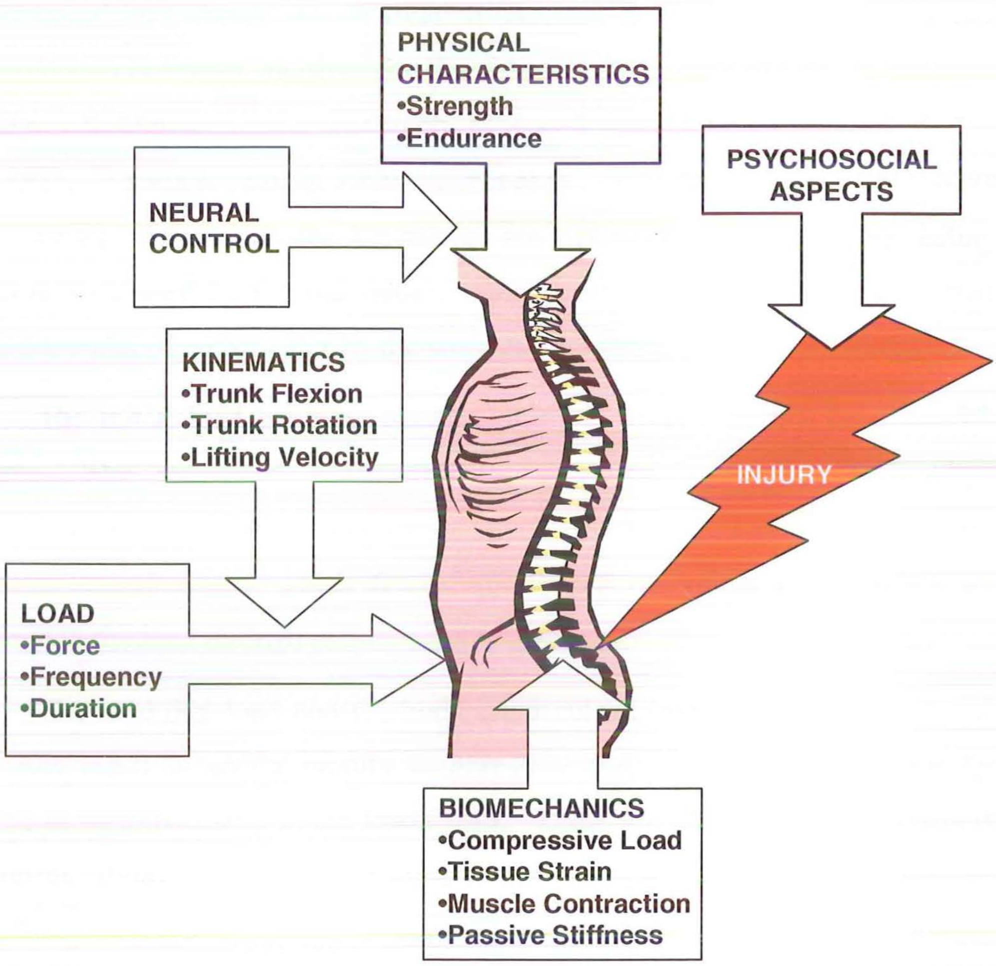

Figure 23. Factors contributing to occupational low back pain (Author's own model).

Based on this model, the basic or initiating risk factor of a manual handling injury causing low back pain is the load, which can be further divided into the force required to perform the manual handling task, and the characteristics of the task itself in the frequency and the duration of manual handling task. These are the external forces of the lifting activity described by Marras (1998).

The effect of the load is modified by the kinematics of the lift or activity. In particular, the amount of trunk flexion, which increases the load moment on the

lower back, and rotation (Andersson, 1981, 1997; Bernard & Fine, 1997; Burdorf & Sorock, 1997; Garg & Moore, 1992a; Gerr & Mani, 2000; Magnusson et al., 1990; Marras, 2000; Shelerud, 1998; Tubach et al., 2002). The effect of side flexion is difficult to distinguish from that of trunk rotation as side flexion will always be accompanied by a component of rotation (Bogduk & Taylor, 1987). The effect of these motions is further modified by the velocity and/or acceleration of the motions (K. Davis & Marras, 2000b; Fathallah, Marras & Parnianpour, 1998a; Fathallah et al., 1998b; Granata & Marras, 1999; Marras et al., 1995; Marras et al., 1993; Norman et al., 1998). Essentially the kinematics are determined largely by the lifting or handling style used by the individual, although some aspects may be governed by restrictions placed on the lifter by the work environment.

The initial load has now been modified by both task and kinematic/lifting factors. The individual deals with the resultant load using their physical characteristics of strength and endurance which are under the overall co-ordination of the neurological system which finely adjusts and co-ordinates the body's active response to the load through proprioceptive feedback.

The modified load and the body's musculoskeletal and neurological system responses result in and/or modify compressive and/or tensile and/or shear forces applied to various tissues in the lower back. These are the internal forces described by Marras (1998). Should any of these forces be greater than that which the tissues can tolerate then tissue failure and pain will result.

Once the injury has occurred the individual's response to the injury and subsequent recovery, or lack thereof, are dependent largely on psychosocial factors.

Although a back belt can not have an effect on the initial load characteristics it can potentially affect or modify all the remaining inputs to the system, as shown in Figure 24, thus resulting in a decreased output from the system, in the form of reduced incidence and/or reduced severity of the low back pain.

As demonstrated in the literature the most consistently reported effect of back belts is the reduction in the kinematics associated with an increased risk of occupational low back pain. In fact, back belts have been shown to reduce both range of motion and velocities during lifts (Buchalter et al., 1989; Fidler & Plasmans, 1983; Giorcelli et al., 2001; Granata et al., 1997; Grew & Deane, 1982; Jonai et al.,

1997; Lantz & Schultz, 1986a; Lavender et al., 2000; Marras, Jorgensen et al., 2000; S McGill et al., 1994; McGorry & Hsiang, 1999; Shah, 1993a; Sparto et al., 1998; Thomas et al., 1999; Thoumie et al., 1998; Willey, 2001; Woldstad & Sherman, 1998; Zink et al., 2001) and these factors have been suggested as having a significant bearing on the risk of low back pain (Andersson, 1981, 1997; Bernard & Fine, 1997; Burdorf & Sorock, 1997; Cohen et al., 1997; K. Davis & Marras, 2000a; Fathallah et al., 1998b; Garg & Moore, 1992a; Gerr & Mani, 2000; Granata & Marras, 1999; Luttmann et al., 2003; Magnusson et al., 1990; Marras, Jorgensen et al., 2000; Marras et al., 1995; Marras et al., 1993; Norman et al., 1998; Shelerud, 1998; Tubach et al., 2002; Worksafe Western Australia Commission, 2000). If this were the only reported effect of back belts then this action alone would be enough to provide physiological plausibility to the results of this study. In this case, the proposed action is that the back belt modified the kinematics of manual handling which therefore reduced the load applied to the lower back. Applying this process to the results of the current study, the modified kinematics did not result in a decrease in incidence but did reduce the severity of the injury.

The reductions in range of motion reported in the literature can be entered into the revised NIOSH lifting equation (Waters et al., 1994; Waters et al., 1993) to determine what affect a back belt should have on the recommended weight limit. Back belts have been shown to reduce flexion by 3 to 13^0 (Granata et al., 1997; M. Jorgensen & Marras, 2000; McGorry & Hsiang, 1999; Sparto et al., 1998; Thoumie et al., 1998) and rotation 2.5 to 4^0 (Granata et al., 1997; Woldstad & Sherman, 1998). Woldstad and Sherman had previously established that a 4^0 reduction in rotation only improved the recommended weight limit by 1 to 1.5%. If the trunk flexion is assumed to be reduced by 5^0 in a lift where the trunk was initially inclined at 45^0 and given a distance from the hips to shoulder of 50.5 cm (based on the 50th percentile British male (Pheasant, 1996)), using simple trigonometry, the horizontal multiplier increases from 0.69 to 0.78. If all other factors in the equation are given a value of one then this would increase the recommended weight limit from 15.9 kg to 18 kg, an increase of some 13%. It would therefore appear that increases in the recommended weight limit of 15% or so should be easily achieved by wearing a back belt. Of course, the NIOSH lifting equation does not take into account the velocity

or acceleration, both of which are reduced by back belts, and both of which should increase the weight limit.

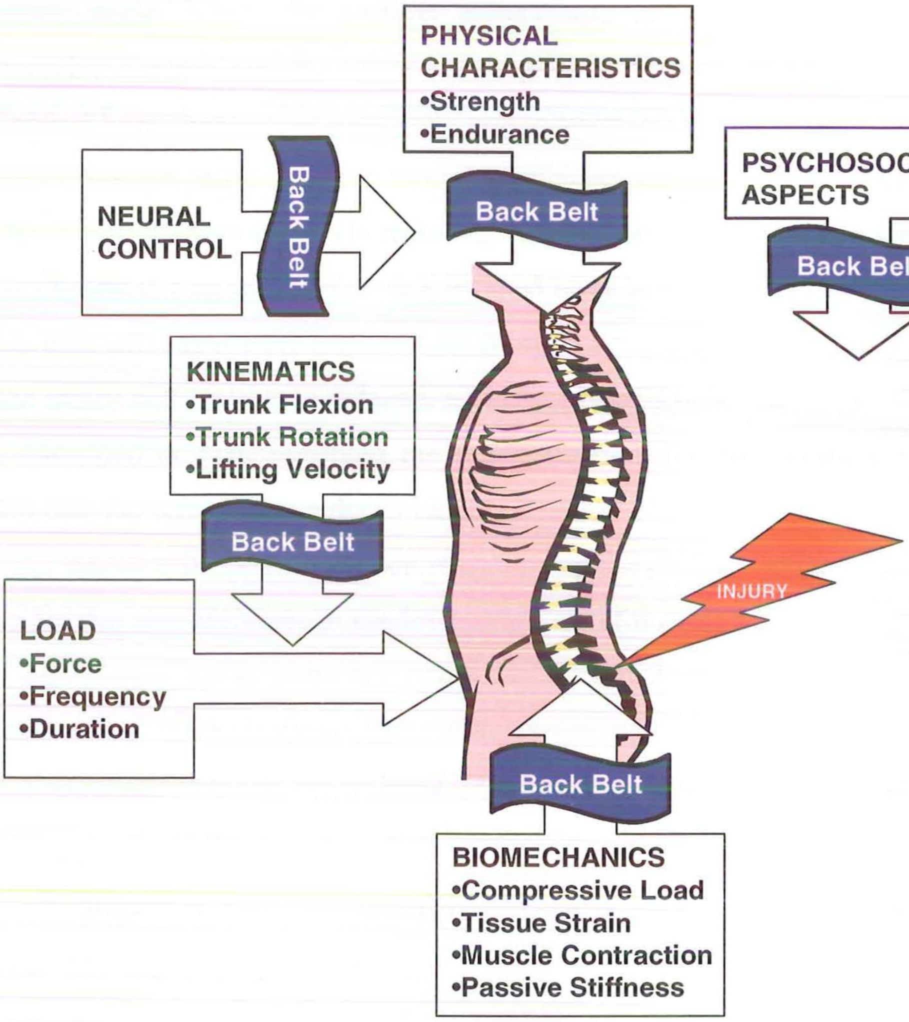

Figure 24. The potential effect of a back belt on the factors contributing to occupational low back pain (Author's own model).

However, it is difficult to immediately understand how a change in kinematics can have little overall effect on the incidence of low back pain, assuming that there is not a type II error discussed above, but have such a large affect on the direct cost/severity of the resulting injury, although this may simply be due to a general lack of understanding of the etiology of low back pain.

Another possible mechanism that is consistent with both the recognised low back pain risk factors and back belt mechanisms that may better explain the effect on severity rather than incidence is an improvement or alteration in the control mechanisms /proprioception/stability of the lower back during manual handling. To use a simple injury analogy, a common musculoskeletal complaint is the chronically unstable ankle, where the sufferer experiences recurrent ankle sprains. After undergoing a rehabilitation program of proprioceptive and strengthening training the individual later reports still going over on the ankle but not as severely as prior to the rehabilitation program; in effect, the injury incident has still occurred but the severity of the resulting injury is greatly reduced. Even closer to the back belt scenario is the same chronically unstable ankle that is taped prophylactically before sport; the taped ankle may still experience incidents resulting in symptoms but generally the severity of the injury will be largely reduced, a commonly held belief being that the strapping has enhanced or complemented the proprioception system (although it should be noted that the taping also reduces range of motion which is a function of back belts already discussed). If the back belt is enhancing the proprioceptive system it may be possible that the structures in the lower back are still placed under a degree of stress and the resultant tissue strain that equates to the threshold of injury but further strain is restricted by the neuromuscular system responding to proprioceptive feedback, and thus protecting the tissue under threat. The result is a low back pain incidence results but the severity of the incidence is reduced.

Based on the spinal stability model discussed earlier (Panjabi, 1992) (see Figure 25) the back belt could be functioning by enhancing any of the three subsystems. Passive musculoskeletal stability has been shown to be enhanced by wearing a back belt through increased stiffness of the lower back (Lavender et al., 2000; SM McGill et al., 1990; S McGill et al., 1994). The active musculoskeletal subsystem may be enhanced by the back belt as reflected in changes in electromyographic activity although, as seen earlier, the results of laboratory studies are on the whole inconclusive. As discussed above, it is the effects of the back belt on the neural & feedback subsystem, which includes motor recruitment patterns but is largely based on the proprioceptive system, that have been demonstrated in laboratory studies (Cholewicki, Juluru, Radebold et al., 1999; Ivancic et al., 2002; McGill et al., 1990; McGorry & Hsiang, 1999; McNair & Hine, 1999; Newcomer et

al., 2001; Wilders et al., 1999) that may offer the most plausible explanation for how back belt may reduce low back pain severity without having a large effect on low back pain incidence.

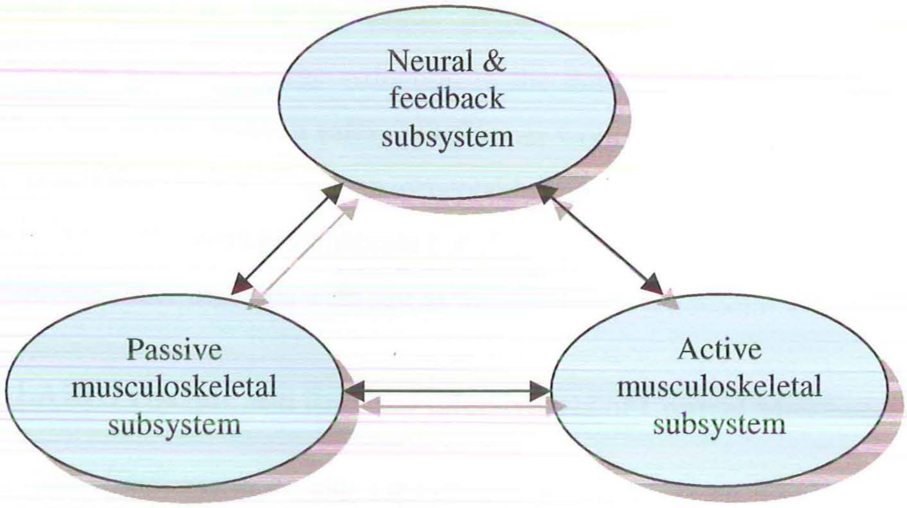

Figure 25. Spinal stability system. (Adapted from Panjabi (1992))

A similar mechanism of injury to a failure in Panajbi's neural and feedback subsystem is motor control error that has been proposed by Cholewicki and McGill (1996) who mathematically modelled lumbar spinal stability and found that stability increased under conditions of high compressive load/increased muscle activity. They suggested that this may explain why injuries often occur during activities requiring little effort and propose two mechanisms of injury; a momentary loss of stability resulting in injury due to strain of pain sensitive tissues or; a sudden muscular response to regain lost stability resulting in muscle spasm or strain. A similar over compensation was reported by Magnusson et al. (1996) who propose that injury may result where an individual has poor co-ordination or postural control. Again, it is plausible that back belts may function to reduce the motor error itself or the consequences of such error. Alternatively, the added passive stiffness provided by the back belt may protect the back during these momentary motor lapses.

Finally, and again quite plausibly, the back belt may be functioning on a psychosocial level, or even as a placebo. It is interesting to note that much of the literature, and much of the general occupational health and safety profession for that matter, treat a placebo effect as a negative effect, sometimes labelling an intervention as "just a placebo". However, one must ask whether a placebo effect should be discarded offhandedly. If the whole affect of back belts could be explained as placebo then, given the large reduction in the duration and cost of low back pain demonstrated in this study, a safety practitioner would be irresponsible to discount it. Many practitioners would say an acceptable intervention for reducing workplace injury is improving workplace morale but if this is truly effective and acceptable then why discount other methods with just as indefinable psychosocial affects.

The ALARP Principle and the Cost-effectiveness of Control Measures

The effectiveness of any intervention will depend on how much room for improvement exists. By their nature low back injuries cannot be eliminated completely where there is manual handling, which in reality is any physical activity, and this author's experience in low back pain injury management is that there will always be a certain level of random low back pain incidence regardless of control measures. This has led the author to develop a theory that the closer a workplace approaches the incidence rate expected from this 'random noise' then the more resistance to further reductions in incidence that will be encountered when introducing new control measures (see Figure 26). This is similar in concept to the 'As Low As Reasonably Practicable' (ALARP) principle (Standards Australia, 2004) used in risk management, where the law of diminishing returns finds that a continued reduction in the level of risk in the workplace requires ever increasing resources to achieve. Applying the as low as reasonably practicable principle to the control of workplace hazards suggests that control measures should only be applied to reduce risk or incidence up to the point where the expenditure justifies the reduction in incidence. A point will eventually be reached where it is not 'reasonably practicable' to expend ever increasing resources to achieve a minimal reduction in incidence.

From Figure 26 it can be seen that if the low back pain incidence frequency rate in a workplace is at point 'A' then investing resources in control measure should

result in a decrease in the incidence frequency rate. However, if the workplace is sitting at point 'B' then a similar investment will result in only a slight decrease in incidence frequency rate. There cannot be a truly risk free workplace as some level of risk is an unavoidable part of every day life and, as a result, there cannot be a true, long term zero incidence of occupational low back pain in the workplace where manual handling is performed. Workplaces do regularly report zero incidence of occupational low back pain but, unfortunately, this will either be due to simple normal, short term random variations or, more commonly, the claims management technique employed.

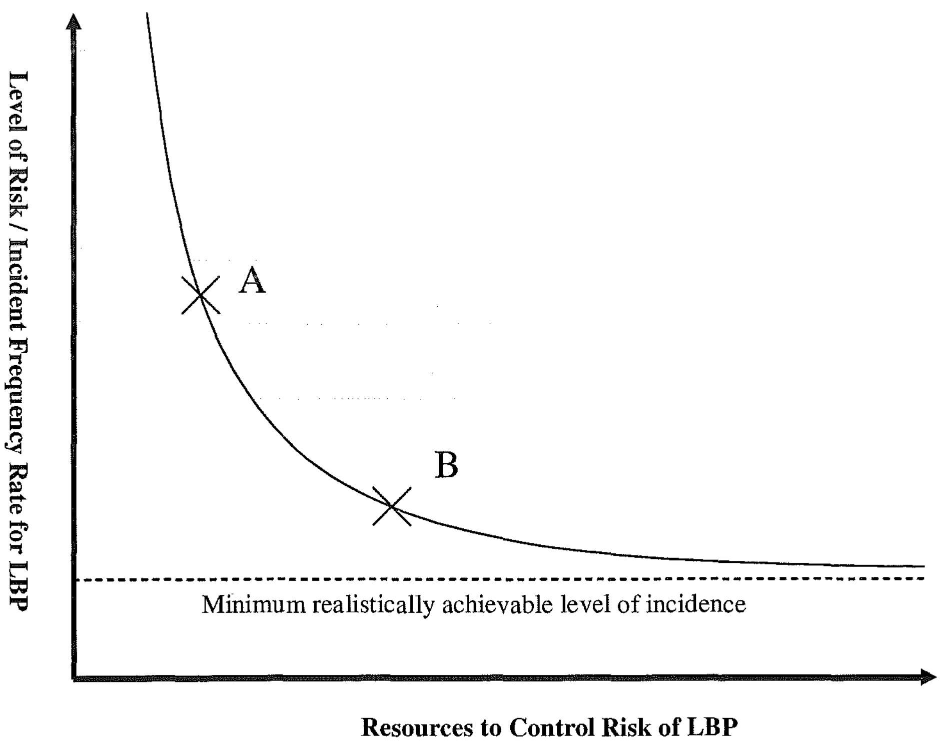

Figure 26.. The effect of diminishing returns of resources to control low back pain on the incidence of low back pain. The minimum realistically achievable level of incidence represents the level of 'random noise' below which low back pain incidence cannot be reduced despite increasing control measures. Expending resources to control the risk of low back pain at point 'A' results in a larger decrease in the incidence frequency rate of low back pain then the a similar expenditure of resources at point 'B'. (Author's own model)

Applying this concept to a back belt intervention in a workplace, the further above the expected random noise incidence frequency rate of low back pain that a workplaces pre-intervention low back pain incidence frequency rate is the larger the effect of the back belt is likely to be. The difficulty is measuring how far above the random noise incidence the workplace is currently sitting, that is, where on the incidence frequency rate curve the workplace is located. In other words, how much room for improvement there is? Additionally, the curve means comparing one workplace or study to another is problematic. In reality, there is probably no practical means of measuring at what point on the incidence frequency rate range a workplace is. That being said, the average cost of lost time low back pain claims, as discussed earlier, was twice the state average prior to the introduction of back belts and half the average following their introduction, which may be an indicator that there was considerable room for improvement.

Another effect of the random noise is that the expected incidence frequency rate distribution is no longer normal; the distribution is, in essence, negatively skewed (see Figure 27). Statistical analysis, including relative risk as used in this and similar intervention studies, assumes that a normal distribution is present when calculation of the confidence interval is performed. Due to the negative skewing of the distribution a decrease in incidence frequency rate may actually be statistically larger than the confidence interval suggest. In the case of this study, a 33% reduction in low back pain lost time injury incidence frequency rate was observed but this fell within the 95% confidence interval assuming a normal distribution so is not regarded as statistically significant. However, the resistance that will be encountered as the incidence frequency rate reduces suggests that this 33% decrease is actually stronger than the statical treatment would suggest.

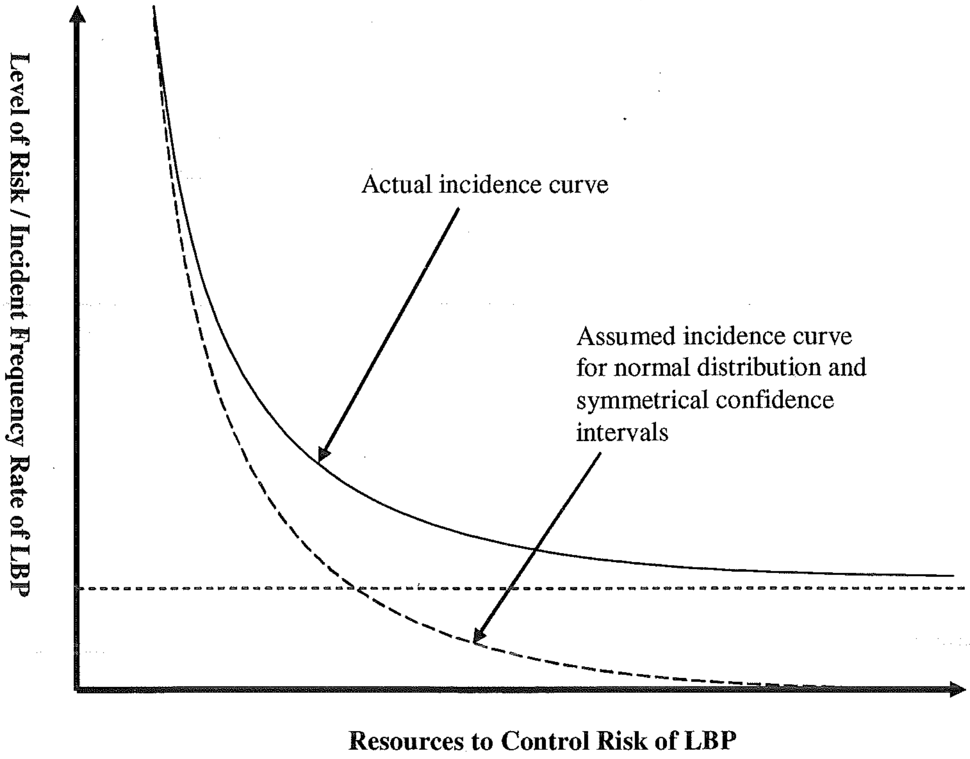

Figure 27. Actual incidence curve for real workplace and assumed incidence curve for a normal distribution. (Author's own model)

Back Belts as Personal Protective Equipment

There appears to be a tendency by Australian occupational health and safety legislators to avoid providing a specific definition for personal protective equipment (PPE). In fact, Division 2 of the Western Australian *Occupational Health & Safety Regulation 1996* (Western Australian Government, 2002), which deals specifically with PPE, is one of the few sections of the *Regulations* which is not accompanied by a list of definitions. Similarly, the Australian Standards handbook *Occupational Personal Protection* (Standards Australia, 1994) and the Western Australian *Code of Practice: Personal Protective Clothing and Equipment* (Worksafe Western Australia, 2002a) do not provide definitions.

Although most practitioners and workers will have an intuitive understanding of what constitutes personal protective equipment a definition is still needed to both sim[illegible] discussions and establish legislative requirements. A basic definition of personal protective equipment which is suitable for the discussion of back belts is "equipment worn by workers to reduce risk from occupational safety and occupational health hazards." (Altree-Williams, Altree-Williams & Marsh, 1998) Given this definition alone and the results of the present study it would seem reasonable to regard back belt as a form of personal protective equipment. However, a further examination of the application of the term personal protective equipment to back belts, and the implications of its application, is necessary, particularly, as will be seen, from a regulatory stand point.

The hierarchy of controls (Worksafe Western Australia Commission, 2000) (Table 18) describes where personal protective equipment falls in the scheme of workplace hazard controls. From this hierarchy of controls it is clear that the higher control measures either eliminate or reduce the hazard itself. However, personal protective equipment has no direct effect on the hazard; the personal protective equipment functions to modify or mitigate the effects of the hazard on the person. It is therefore seen as the last choice in the hierarchy, in effect acting as the last protective barrier between the hazard and the worker. For example, a worker may be exposed to a hazard of tools falling off a work bench onto their toes. Wearing steel

Table 18. Hierarchy of Controls (Worksafe Western Australia Commission, 2000)

Elimination	Removing the hazard or hazardous work practice from the workplace. This is the most effective control measure
Substitution	Substituting or replacing a hazard or hazardous work practice with a less hazardous one
Isolation	Isolating or separating the hazard or hazardous work practice from people involved in the work or people in the general work areas from the hazard. This can be done by installing screens or barriers or marking off hazardous areas
Engineering Control	If the hazard cannot be eliminated, substituted or isolated, an engineering control is the next preferred measure. This may include modifications to tools or equipment, providing guarding to machinery or equipment
Administrative Control	Includes introducing work practices that reduce the risk. This could include limiting the amount of time a person is exposed to a particular hazard
Personal Protective Equipment	Should be considered only when other control measures are not practicable or to increase protection. Includes all clothing and other work accessories designed to create a barrier against workplace hazards

capped safety boots does not prevent or reduce the likelihood the hazard from eventuating but it does mitigate the consequences by protecting the toes of the worker form the tool once it has fallen. Similarly, the function of back belts, as represented by the model in Figure 24, is not to affect the load or the characteristics of the load, but rather it modifies the effect the applied load has on the individual and, therefore, the injury itself. That is, the back belt functions to limit the consequences of the risk attached to the manual handling hazard, rather than eliminating or substituting the hazard.

Where back belts vary from other types of personal protective equipment is in the apparent lack of consistency of the protection provided to the wearer. With most forms of personal protective equipment, when used correctly, there is a certain level of minimum protection that can be relied on. Using the steel capped safety boot analogy the wearer's toes will be consistently protected from the kinetic energy of dropped objects up to a certain limit and this limit of protection can be established and measured by regulatory or standard setting authorities. Above the limit of protection injuries will result with rapidly increasing severity which is roughly proportional to the increasing kinetic energy but complicated by the structural failure of the personal protective equipment itself. As the applied k[illegible] energy can vary over a very wide range a limit of injury severity will also [illegible] reached where no further damage is physically possible, which in the case of the toes equates to amputation (see Figure 28).

On the other hand, the function of back belts, and the behaviour of low back pain for that matter, do not follow such a consistent or predictable pattern. Although increasing load is a known risk factor for low back pain, any clinician will attest that low back pain can result from seemingly petty loads, generally if other risk factors are present but sometimes for no apparent reason, probably related to the momentary losses of motor control described by Cholewicki and McGill (1996).

In a further departure from the safety boot analogy also, the load does not continue to increase but soon reaches a limit where manual handling is no longer possible; a worker is not going to experience a more severe injury by attempting to lift a 2,000 kg load compared to lifting a 200 kg as neither lift is possible. Figure 29 represents possible low back pain injury curves with and without a back belt. The slope and shape of the curves are purely conjectural and are used to illustrate the general concept rather than actual manual handling incidents.

As has been demonstrated by the current study the back belt functions to reduce the severity of the resultant injury without having a large affect on actual incidence. Therefore, regardless of the applied manual handling load the back belt cannot offer 100% protection, although, it should be noted, nor can any other

workplace low back pain intervention unless, that is, the manual handling hazard is eliminated all together.

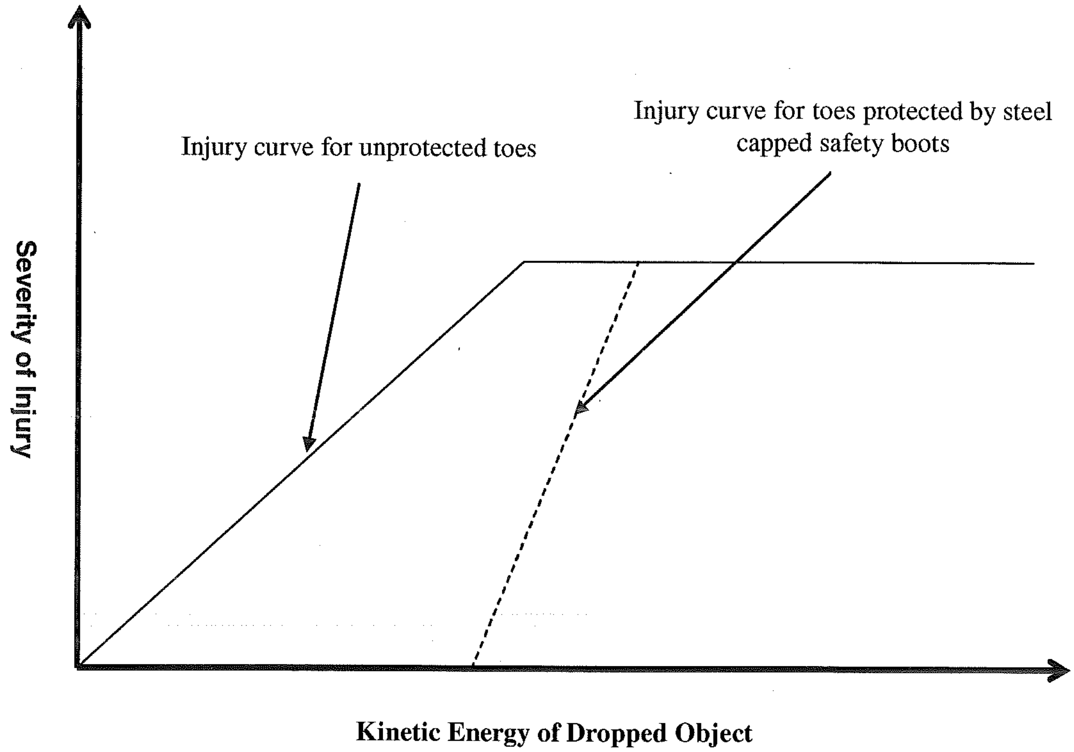

Figure 28. Injury curves for injuries to the toes from dropped objects (Author's own model).

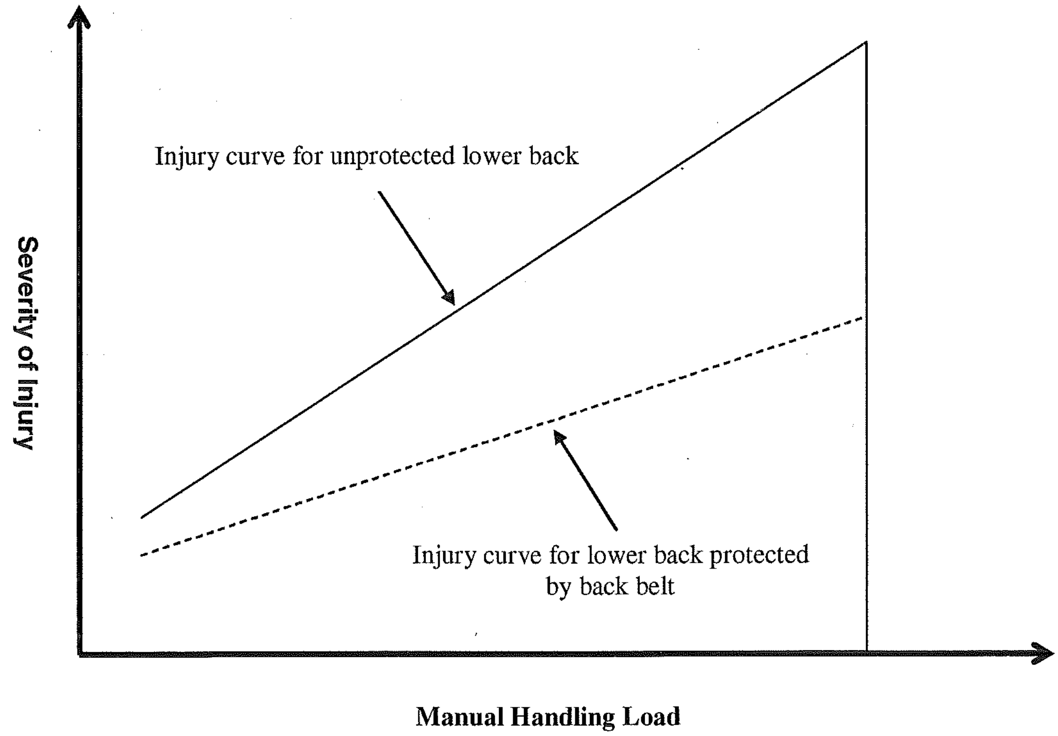

Figure 29. Proposed injury curves for low back pain from manual handling (Author's own model).

The debate regarding personal protective equipment is more than just academic when the legislation concerning personal protective equipment is examined. In Western Australia both the *Code of Practice for Personal Protective Clothing and Equipment* (Worksafe Western Australia, 2002a) and the *Regulations* (Western Australian Government, 2002) require mandatory use of personal protective equipment. The *Regulations* state that "if personal protective equipment has been identified as one of the control measures to minimise exposure to a risk, the employee must make sure such equipment is provided." (p. 34) Further to this requirement a worker who is provided with personal protective equipment "must use the protective clothing or equipment in a manner in which he or she has been properly instructed to use it." (p. 36) A consequence of this legislation is that once back belt are identified as personal protective equipment then employers will be compelled to provide back belt in all workplaces where there is an identified manual handling hazard and employees will be required to wear back belts. It is easy to see

why regulatory bodies and employers are reluctant to take the first step towards labelling back belts as personal protective equipment.

Another difficulty with introducing back belts as personal protective equipment is to establish performance standards for the level of protection provided. Where standards can and are set for the manufacture or design of other forms of personal protective equipment to meet a certain and measurable level of protection this is not possible for back belts, at least not presently given the current state of understanding of both their mechanism of action and the etiology and pathophysiology of low back pain.

Criteria of Causation

Even though this study has demonstrated a very strong association between the introduction of back belts and both the duration and cost of low back pain this, in itself, does not demonstrate a causal relationship. To establish a causal relationship further evidence is required. Given the very strong association between back belts and both duration and cost of low back pain there still needs to be established a causal relationship between the back belt and these two outcomes. Hill (Christie, 1988) established nine criteria to assist in the evaluation of causal relationships.

1. **Strength of association**. This is represented by the "strength" as measured by the appropriate statistical test. In the case of this study the relative risk or percentage change is an indication of the strength on which a judgement is based.

2. **Consistency**. To rule out accepting a casual relationship by chance the relationship must be demonstrated consistently in different samples and using different methods, that is, there must be evidence from independent studies supporting the findings.

3. **Specificity**. This criterion is met when it is established that the independent variable affects only the dependent variable. This is often the most difficult criteria to establish and, although its existence provides additional support for causation, its absence does weaken the argument. In this study an attempt to measure specificity (and validity) was made by examining additional effects that would not be reasonably expected to be a result of either manual handling injury or the introduction of the back belts.

4. **Temporal relationship**. The effect must follow the cause and the latency period between the case and effect must be biologically plausible. This study was a before and after design and a temporal relationship is implicit in this methodology.

5. **Biological gradient.** Otherwise known as the dose-response relationship. In many epidemiological studies it is difficult to accurately measure exposure, although for the purposes of this study the exposure is measured by compliance with the back belt and it is assumed that manual handling exposure remained constant through the course of the study.

6. **Biological plausibility.** The association should be able to be explained based on an understanding of the pathological processes involved. For this study, does the back belt have an effect or effects on the biomechanical factors generally agreed to be regarded as risk factors for low back pain. A difficulty exist in this case as the pathology of low back pain is not clearly understood, as discussed previously, and many of the commonly held "risk factors" for low back pain lack evidence themselves of causality and may be better regarded as "risk indicators". However, for the purpose of this discussion and to avoid venturing far outside of the scope of this examination it will be assumed that the biomechanical risk factors identified during the literature review are indeed risk factors and that a causal relationship between those risk factors and low back pain exists.

7. **Experiment.** Support for causality is provided where the effect can be demonstrated using appropriate experimental protocols. As has been discussed earlier and will again be examined during the discussion of the limitations of the study a double blinded randomised controlled trials is not a practical means of examining back belts in the workplace. Laboratory experiments may establish the relationship between back belts and risk factors, but by its nature, the effect on low back pain can not be measured in the laboratory. For obvious reasons animal studies are excluded. It is therefore difficult to provide true experimental evidence of the effect although the current study, and others of a similar design, have been described as quasi-experimental (Robson et al., 2001).

8. **Analogy.** If similar results have been demonstrated with similar controls than the causal relationship may be seen as stronger. When it comes to control measures for low back pain there is no analogy or parallel to the back belt for comparison.

9. **Coherence of evidence.** This criterion is based on a summing up of all the current theory and knowledge in the area.

Applying Hill's criteria to the present study the strength of the association, temporal relationship and biological plausibility criteria would all suggest strong evidence of causality. Consistency, specificity and coherence of evidence provide a medium level of evidence. The biological gradient is unclear, and there is no supporting evidence from experiment or analogy. For practical reasons the situation with these last three criteria is unlikely to change in the future. When the remaining criteria are examined as a whole there is medium to strong evidence of a causal relationship between the introduction of back belts and the reduction in low back pain duration and cost, given the assumptions discussed in point 7 above.

The meeting of each criterion by the present study is summarised in Table 19. On the whole there is medium to strong evidence that there is a causal relationship between the introduction of back belts in the workplace and the observed reduction in low back pain duration and cost.

Table 19. Hill's Criteria of Causality applied to the current study

Criteria	Strength	Comments
Strength of association	Strong	As represented by the relative risk and percentage changes the relationship between back belt and low back pain duration and cost was statistically strong
Consistency	Medium	Although the results from back belt intervention studies on the whole have been inconclusive, when only those studies with good compliance are examined there is consistent evidence that back belts reduce low back pain incidence. Although duration and cost have not been examined in the said studies it is reasonable to expect a relationship between incidence, duration and cost and it is likely that a Type II error relating to incidence has occurred in the current study
Specificity	Medium	The effect was not observed in those cases of low back pain resulting from injury other than manual handling injury and, in fact, there was a tendency in the opposite direction. In general, the effect was larger in low back pain compared to other manual handling injuries
Temporal relationship	Strong	To the level of statistical accuracy available the effects occur immediately on the introduction of the back belt (see Figure 21 and 22)
Biological gradient	Unclear	A dose-response relationship cannot be established until a better understanding of the causal factors of low back pain itself is established. For measurement purposes a back belt is either used, or assumed to be used, for 100% of manual handling tasks or not at all; there is no practical means of measuring the effect of partial usage of back backs
Biological plausibility	Strong	There is good experimental evidence that back belts effect kinematic measures and intra-abdominal pressure, both of which are used during biomechanical modelling of lifting forces and the former is an accepted risk factor for low back pain
Experiment	None	There is no experimental support
Analogy	None	There is no analogy available
Coherence of evidence	Medium to Strong	Within the practical limits of this area there is overall some evidence supporting a causal relationship but disagreement exists.

Internal Validity

A weakness in many of the previous studies has been a reliance on self reported low back pain as an outcome measure, with even the recent NIOSH backed study of Wassell et al. (2000) using self reporting as one measure. In the present study an incidence was any injury resulting in a medical attendance, whether it resulted in a lost time or not. As categorisation of the injury regarding both the injured area and immediate mechanism leading to the injury was provided by the attending medical practitioner using a standardised workers' compensation claim form, the recording of injury data was as objective as practicable. The likelihood of an injury being assigned to the wrong category is thus greatly reduced if not eliminated completely.

Another common weakness that is probably present in most of the previous back belt intervention studies, and certainly is not discussed in these studies, is the validity of assuming that any changes in low back pain outcome measures will be due to the back belt intervention, and not some other unidentified factor. Potential factors that may have a positive influence on low back pain outcomes include changes in manual handling practices in the workplace, the introduction of mechanical lifting aids, improvements in workplace layout, improved manual handling training and/or awareness, changes in injury management procedures and a general secular trend, that is, a general trend towards decreased incidence within the whole working community. All these factors could be expected to affect all manual handling injuries equally and the final two factors would be expected to affect all injuries, regardless of cause. Thus, by examining manual handling injuries that result in either low back pain or injuries to all other areas a means of measuring, at least qualitatively, the validity of the back belt effectiveness is provided.

Using manual handling injuries claims to ensure the internal validity is maintained relies on two assumptions:

1. If there is an unidentified factor affecting manual handling injuries then it will affect all manual handling injury claims, that is, low back pain and non-low back pain to the same extent.

2. The back belt effect will only be demonstrated in low back pain claims, that is, manual handling injuries involving areas other than the lower back will not be affected by the introduction of the back belt.

The first assumption should hold true for such factors as improved manual handling training, and elimination of reduction in overall manual handling due to increased mechanical assistance, changes in inventory and changes in general work practices. Such measures should result in a general reduction in manual handling injury rather than a specific reduction in manual handling injury to the lower back. In reality, it is not possible to predict how the various manual handling injuries will respond to control measures, particularly when the lack of understanding surrounding the pathophysiology of low back pain itself is considered.

Similarly, the second assumption would appear to be reasonable. However, like the first assumption it is based on an understanding of low back pain. If the mechanism of back belts is related to intra-abdominal pressure or to improvements in stability or proprioception then there should be little effect on injuries to other areas. If the mechanism of back belts is based on improvements in the kinematics of lifts then there may be some flow on effect that offers protection to other areas during manual handling. If the effect is one of reminding the wearer to lift safely this to would have a flow on to other areas. If the back belt mechanism is the result of a placebo effect then it is difficult to predict how this would affect other areas. On the whole, though, it seems likely that any back belt effect will be largely limited to the lower back.

Following these assumptions an examination of the data should establish internal validity. As the incidence data failed to reach statistical significance only the duration and cost data will be examined.

Lost time duration saw a decrease in both low back pain and other manual handling injury. However, the decrease was larger in the low back pain cases and the difference between the two categories was statistically significant ($z = -5.56$). The difference between the two categories is graphically quite dramatic as represented in Figure 21. When lost time duration was corrected for the overall affect on manual handling injury there remained a 15% reduction in low back pain duration that could not be attributed to a generalised reduction in manual handling injury. This would

suggest, that, although there may be some other factor influencing manual handling injury as a whole, that there was an effect that was primarily directed at low back pain, that is the back belt intervention resulted in a reduction in low back pain duration.

The cost of injuries saw very large and consistent decreases in the cost associated with low back pain claims, whereas the change in the cost of other manual handling injury claims was not as large, nor was there a consistent decrease, again this is graphically represented by Figure 22. On a dollar cost per million hours worked low back pain corrected for the manual handling injury effect still demonstrated a 65% decrease for all claims and 32% decrease in claims resulting in lost time.

The independence of the affect on low back pain claims cost is further strengthened when the cost of low back pain arising from injuries other than manual handling injury is examined. Where the cost of low back pain claims per million hours worked was reduced by 80% the dollar cost of non-manual handling injury low back pain actually increased by a massive 129%.

The results of the cost of injuries provides even stronger evidence that the back belt effect was primarily targeting low back pain resulting from manual handling injury.

It is important to note that although the above analysis appears to weaken the overall results relating to low back pain this is not the intent; this analysis is simply aimed at establishing internal validity. For the purposes of the general discussion on the effectiveness of back belts the low back pain results need not be corrected for other manual handling injury effects as the assumptions remain untested. There would also be little benefit as no comparison could be made with previous studies that have not made an adjustment for any unidentified factors.

Further to the internal validity issues discussed above Robson et al. (2001) describes an additional eight threats to the internal validity that specifically relate to of before-and-after studies, which are summarised in Table 20.

These threats can be addressed individually as follows:

1. **History.** Personal communication with Bunnings' Employee Relations Department found that there was no significant change to manual handling practices over the period of the study. That, other than the introduction of the back belt there were no other significant control measures introduced into the workplace. This was supported by the author's own observations.

2. **Instrumentation / Reporting.** As discussed above the outcome measures were based on the attending medical officer's completion of a standardised workers' compensation insurance claim form. Therefore, there was no change to this criterion through the course of the study.

3. **Regression-to-the-mean.** By extending the pre-intervention period to 21 months and the intervention period to 32 months the effects of one-time extreme values can be minimised.

4. **Testing.** Recording of the outcome measure should have no effect on the outcome itself.

5. **Placebo.** The placebo effect has been discussed in an earlier section.

6. **Hawthorne.** As this was a retrospective study the sample were not aware that the effectiveness of the back belt was going to be investigated so there can be no Hawthorne effect.

7. **Maturation.** The cohort studied was dynamic, with employees leaving Bunnings being replaced by new employees. Although the organisation is well established there may still have been an overall increase in employment experience as the study progressed. However, a maturation of the workforce cannot explain why low back pain duration and cost were reduced will other manual handling injury and non-manual handling injury low back pain exhibited an increase in cost.

8. **Dropout.** There may have been some affect arising from dropouts as some members of the pre-intervention sample were not members of the intervention sample and *visa versa.* This effect cannot be

quantified although it would be reasonable to expect that it would not be large.

On the whole, the design of this study established the internal validity of the results.

Table 20. Threats to Internal Validity (Robson et al., 2001p. 20)

Threat to Internal Validity	Description of Threat
History	Some other influential event(s), which could affect the outcome, occurs during the intervention
Instrumentation / Reporting	Validity of measurement method changes over course of the intervention
Regression-to-the-mean	Change in outcome measure might be explained by a group with one-time extreme value naturally changing towards a normal value
Testing	Taking measurement (e.g. test) could have an affect on outcome
Placebo	Intervention could have a non-specific effect on the outcome, independent of the key intervention component
Hawthorne	Involvement of outsiders could have an effect on the outcome, independent of the key intervention component
Maturation	Intervention group develops in ways independent of the intervention (e.g. aging, increase experience, etc,), possibly affecting outcome
Dropout	The overall characteristics of the intervention group change due to some participants dropping out, possible affecting the outcome

Limitations

Statistical power could have been increased by including employees from other states in the cohort. However, compliance data was not available for these states and this author was aware of negative attitudes towards the back belt from the industrial union representing Bunnings staff in the state with the next largest employment numbers after Western Australia. That same state's occupational safety and health authority had demonstrated the most negative attitudes to back belts in it's published documents (Victorian Worksafe Authority, 2000, 2002) compared to other Australian government authorities.

Non-experimental before-and-after designs, such as the present study, are often criticised for a lack of randomisation, blinding and controls. However, there are several reason this design was best suited for the Bunnings study.

Commercial realities, in particular, the influence of labour representatives, make large scale randomised controlled trials (RCTs) in the workplace extremely difficult. Randomised controlled trials will generally require a voluntary participation which immediately introduces the likelihood of bias, poor compliance and drop-outs, as demonstrated in the past studies. There will also be the issue of labour organisations views, whether well informed or not, which would likely negate any ethical clearance that was granted to perform a randomised control study in a workplace. As discussed earlier, an randomised controlled trial running for 12 months with an initial low back pain lost time injury incidence frequency rate of 5 per million hours worked and equal numbers in both experimental and control groups will require almost 15,000 full time equivalent subjects if a 30% improvement is to be statistically significant. The only large scale randomised controlled study reported is that of Kraus et al. (2002) and even their study was not truly randomised but rather relied on cluster randomisation by worksite.

In the case of the present study it could be argued that randomisation is not required when the whole available workforce is included in a before-and-after where the subjects act as their own controls. By including the entire potential population in the study the purpose of randomisation to reduce bias is made redundant.

Blinding of the members of an experimental group wearing back belts is not possible. Even if back belts where worn by a control group with no tension it is clear that this could not be hidden from the control subjects.

Finally the issue of cost must be considered. This study was performed without the benefit of a research grant or any private funding and the study design chosen enabled the production of meaningful research findings with minimal expenditure.

Recommendations for Future Research

Although the results of this study, at least regarding duration and cost of low back pain, are strong and certainly represent a large level of business significance, it is likely that the debate regarding the effectiveness of back belts will continue. It must be remembered that the two previous large studies reporting positive effects of back belts (Kraus et al., 1996; Kraus et al., 2002) did little to convince those with pessimistic views of the effectiveness of back belts. In fact, it was the negative findings of the Wassell et al.(2000) that attracted more attention, especially with the regulatory bodies, despite the obvious methodological difficulties encountered during that study.

For future studies to be of any use in contributing to our knowledge regarding back belts two key factors must be met:

1. Future studies must ensure high compliance with correct use of the back belt. Given that samples will be taken from the general workforce it appears that use mandated by the management, with a strong management commitment, is the only practical way to ensure compliance. The monitoring of mandatory use can be simplified by utilising a back belt with braces that is worn on the outside of clothing.

2. Sample numbers have to be larger than those seen in the majority of past studies, either through increased subject numbers or increased duration, both of which result in increased work hours of the study.

Future studies should also make use of the detailed computerised injury records that many organisations are now required to maintain. In particular, cost and duration should be examined to establish whether the effect observed in the present study is extended to other workplaces and populations. Care should also be exercised to ensure that the low back pain outcome is the result of manual handling, although this will require the cooperation of the insurer as well as the workplace.

An extension of the current study would be to examine the results of incidence frequency rate, duration and cost following the withdrawal of a back belt

from a workforce, in essence creating a before-and-after-and-before study. Shortly after the completion of this study, apparently as a result of union pressure interstate, the use of the back belt was no longer mandated. This may lead to some interesting results although the issue of compliance in a situation where use of the back belt is voluntary will lead to unknown bias that would make meaningful comparisons difficult and would need to be addressed before proceeding down this line of investigation.

CONCLUSION

The study of the effectiveness of the mandatory use of back belt as a control measure for low back pain arising from manual handling injury in the Bunnings' workforce in Western Australia proved to be one of the largest studies in this area attempted, at a total of 6,677,285 hours worked over a 53 month period. This study went further than previous studies by investigating not only low back pain incidence, but also the duration, measured in days lost, and the direct insurable cost associated with low back pain claims.

The results of the study are summarised as follows:

1. The introduction of mandatory back belt use did not result in a statistically significant decrease in the reported incidence of low back pain due to manual handling injury. However, there was a large trend towards a decrease in lost time injury incidence frequency rate of 33% and the strong results for the remaining main outcomes suggest that the nul result was due to a type II error, that is, there was an effect on incidence but the study lacked sufficient power to demonstrate a statistically significant relationship.

2. The introduction of mandatory back belt use resulted in a significant reduction in the number of days lost from low back pain due to manual handling injury, with a 69% decrease the average days lost per lost time injury and 79% decrease in days lost per million hours worked.

3. The introduction of mandatory back belt use resulted in a significant reduction in the direct cost of low back pain due to manual handling injury, with a 77% decrease in the cost of low back pain claims and an 83% decrease in cost due to low back pain per million hours worked.

The reduction in the direct cost of low back pain was very large and, given the small upfront costs of introducing the back belts into the workplace, demonstrates a massive cost benefit to the organisation.

The results also suggest the back belt effect was strongest on the more severe injuries, whether the severity is measured in days lost or direct cost.

This study presents strong evidence that back belts with braces that allow the device to be worn on the outside of clothing, when combined with a mandatory use policy to ensure high compliance, provide a simple, reliable and cost effective means of reducing the severity of low back pain resulting from manual handling in the workplace.

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APPENDIX 1: GROUP RISK MANAGEMENT REPORT

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2010* *Balcatta*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9612158	[redacted]	10.09.1996	STRAINED LEFT LUMBAR REGION. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	146	0	0	146
13-9710913	[redacted]	24.09.1997	LACERATION LEFT FOREARM. - HITTING STATIONARY OBJECTS	Y	0	0	0	0	0	0
13-9846072	[redacted]	27.05.1999	THORACIC SOFT TISSUE INJURY. - MUSCULAR STRESS WHILE HANDLING OBJECTS	Y	0	0	585	0	0	585
13-9842271	[redacted]	15.12.1998	MEDIAL & LATERAL EPICONDYLITIS - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	519	0	0	519
13-9846040	[redacted]	27.05.1999	SOFT TISSUE INJURY NECK & BACK - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	2	0	554	0	0	554
13-9818800	[redacted]	11.11.1998	FOREIGN BODY IN L/EYE - BEING HIT BY MOVING OBJECTS	Y	0	0	115	0	0	115
13-9819885	[redacted]	19.11.1998	FOREIGN BODY IN LEFT EYE - BEING HIT BY MOVING OBJECTS	Y	0	0	173	0	0	173
13-9825412	[redacted]	29.12.1998	LACERATION R HAND INDEX FINGER - HITTING STATIONARY OBJECTS	Y	0	0	444	0	0	444
13-9618914	[redacted]	14.11.1996	LACERATION TO RIGHT HAND. - HITTING MOVING OBJECTS	Y	0	0	71	0	0	71
13-9733150	[redacted]	12.03.1998	LACERATION TO BACK OF HEAD. - HITTING STATIONARY OBJECTS	Y	0	0	2,681	0	0	2,681
13-9637143	[redacted]	18.04.1997	LOWER BACK STRAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	401	0	0	401
13-9913515	[redacted]	06.10.1999	NECK & LEFT SHOULDER PAINS. - BEING HIT BY FALLING OBJECTS	Y	0	0	544	0	0	544
13-9921555	[redacted]	30.11.1999	SMOKE INHALATION FROM CAR FIRE - OTHER AND MULTIPLE MECHANISMS OF INJURY	Y	0	0	304	0	0	304
13-9902055	[redacted]	11.07.1999	STRAINED LEFT SHOULDER. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	188	0	0	188
13-9733155	[redacted]	07.03.1998	NECK LOW BACK ELBOW LEFT PAINS - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	182	0	0	182
13-9824961	[redacted]	28.12.1998	L/KNEE SPRAIN - MUSCULAR STRESS WITH NO OBJECTS HANDLED	Y	0	0	187	0	0	187

This Report Is Based On Information Provided By Wesfarmers Federation Insurance & Is Provided To Assist In The Management Of Outstanding Claims.
Please Contact Group Risk Management On (08) 9327 4260 For Clarification On Any Aspect Of This Information.
Printed On: 10-Mar-2000

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2010* *Balcatta*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9612625	[redacted]	27.09.1996	SPRAINED NECK. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	1	0	313	0	0	313
13-9604078	[redacted]	23.07.1996	LUMBAR BACK MUSCULAR STRAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	321	0	0	321
13-9532046	[redacted]	26.02.1996	BRUISED LEGS/STRAIN NECK - FALLS FROM A HEIGHT	Y	0	0	68	0	0	68
13-9625183	[redacted]	24.12.1996	LACERATED ABDOMEN. - UNSPECIFIED MECHANISMS OF INJURY	Y	0	0	110	0	0	110
13-9902072	[redacted]	12.07.1999	SOFT TISSUE PAIN NECK. - MUSCULAR STRESS WHILE HANDLING OBJECTS	Y	0	0	317	0	0	317
13-9616399	[redacted]	23.10.1996	FOREIGN BODY TO LEFT EYE. - UNSPECIFIED MECHANISMS OF INJURY	Y	2	0	338	0	0	338
13-9520303	[redacted]	28.11.1995	BRUIED (L) 4TH TOE - BEING HIT BY FALLING OBJECTS	Y	0	0	151	0	0	151
13-9830356	[redacted]	03.02.1999	LACERATION LEFT KNEE. - HITTING STATIONARY OBJECTS	Y	0	0	281	0	0	281
13-9520511	[redacted]	19.11.1995	CUT (L) THUMB - HITTING MOVING OBJECTS	Y	0	0	275	0	0	275
13-9530187	[redacted]	07.02.1996	STRAINED FINGERS & WRIST - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	685	0	0	685
13-9826551	[redacted]	28.12.1998	CHEMICAL BURN TO LEFT RING FIN - SINGLE CONTACT WITH CHEMICAL	Y	0	0	209	0	0	209
13-9901706	[redacted]	06.07.1999	LACERATION LEFT RING FINGER - HITTING MOVING OBJECTS	Y	0	0	246	0	0	246
13-9921551	[redacted]	29.11.1999	SUSPECTED SPIDER BITE TO NECK. - INSECT AND SPIDER BITES AND STINGS	Y	0	0	241	0	0	241
13-9720260	[redacted]	04.12.1997	LACERATION LEFT MIDDLE FINGER. - HITTING STATIONARY OBJECTS	Y	0	0	155	0	0	155
13-9823243	[redacted]	13.12.1998	STRAINED MUSCLE L/SHOULDER - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	391	0	0	391
13-9846043	[redacted]	21.05.1999	LEFT SHOULDER INJURY. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	273	0	0	273

Printed On: 10-Mar-2000

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: WBLBBS *Bunnings Building Supplies*

Centre: 2010 *Balcatta*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9744031	[redacted]	11.06.1998	LACERATION TO SIDE OF HEAD. - HITTING STATIONARY OBJECTS	Y	0	0	0	0	0	0
13-9849901	[redacted]	02.06.1999	LEFT KNEE SWELLING. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	312	0	0	312
13-9832640	[redacted]	10.02.1999	CUTS LEFT MIDDLE & RING FINGER - HITTING MOVING OBJECTS	Y	0	0	74	0	0	74
13-9507869	[redacted]	24.08.1995	LACERATION PALM (L) HAND - HITTING MOVING OBJECTS	Y	0	0	142	0	0	142
13-9618695	[redacted]	21.11.1996	LACERATION TO RIGHT HAND. - HITTING STATIONARY OBJECTS	Y	0	0	71	0	0	71
13-9926175	[redacted]	29.12.1999	FOREIGN BODY RIGHT EYE. - BEING HIT BY FALLING OBJECTS	Y	0	110	110	0	0	110
16-9458570	[redacted]	13.05.1995	LACERATED UPPER ARM - HITTING MOVING OBJECTS	Y	0	0	124	0	0	124
13-9901715	[redacted]	06.03.1999	LEFT HAND PALM LACERATION. - HITTING STATIONARY OBJECTS	Y	0	0	111	0	0	111
16-9458609	[redacted]	31.05.1995	SPRAINED HAND - FALLS ON THE SAME LEVEL	Y	0	0	62	0	0	62
13-9830348	[redacted]	05.02.1999	ABRASION LEFT FOREHEAD. - HITTING STATIONARY OBJECTS	Y	0	0	74	0	0	74
13-9633130	[redacted]	16.03.1997	CHEST LACERATION. - BEING HIT BY FALLING OBJECTS	Y	0	0	228	0	0	228
13-9846969	[redacted]	21.05.1999	RIGHT INDEX FINGER INJURY. - HITTING MOVING OBJECTS	Y	0	0	115	0	0	115
13-9715525	[redacted]	23.10.1997	PUNCTURE WOUND TO RIGHT FOOT. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	97	0	0	97
13-9603416	[redacted]	03.07.1996	LACERATION TO RIGHT CALF. - FALLS FROM A HEIGHT	Y	0	0	149	0	0	149
13-9605549	[redacted]	24.07.1996	FRACTURED RIGHT HAND - BEING HIT BY FALLING OBJECTS	Y	37	0	5,627	0	0	5,627
16-9458610	[redacted]	08.06.1995	SPRAINED KNEE - BEING HIT BY FALLING OBJECTS	Y	0	0	145	0	0	145

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2010* *Balcatta* *Page:* *4*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9816689	[redacted]	11.10.1998	CUT L/HAND INDEX FINGER - BEING HIT BY MOVING OBJECTS	Y	0	0	122	0	0	122
13-9816667	[redacted]	13.10.1998	CUT L/HAND INDEX FINGER - BEING HIT BY MOVING OBJECTS	Y	0	0	0	0	0	0
13-9849427	[redacted]	07.06.1999	FOREIGN BODY (R) INDEX FINGER - HITTING STATIONARY OBJECTS	Y	0	0	289	0	0	289
13-9827606	[redacted]	20.01.1999	DOG BITE TO RIGHT SIDE OF FACE - BEING BITTEN BY AN ANIMAL	Y	0	0	115	0	0	115
13-9815887	[redacted]	22.10.1998	LACERATED (L) MIDDLE FINGER - BEING HIT BY MOVING OBJECTS	Y	0	0	317	0	0	317
13-9911299	[redacted]	30.07.1999	LOW BACK PAIN. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	591	0	0	591
13-9835659	[redacted]	04.03.1999	SPIDER BITE TO RIGHT EAR. - INSECT AND SPIDER BITES AND STINGS	Y	0	0	74	0	0	74
13-9842832	[redacted]	13.04.1999	RIGHT SHOULDER PAIN. - MUSCULAR STRESS WHILE HANDLING OBJECTS	N	65	2,463	19,734	29,458	7,364	56,556
13-9840311	[redacted]	12.04.1999	SMALL LACERATION RIGHT FOREARM - BEING HIT BY FALLING OBJECTS	Y	0	0	74	0	0	74
13-9827621	[redacted]	27.11.1998	LOW BACK PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	94	4,504	22,244	0	0	22,244
13-9630621	[redacted]	21.02.1997	LUMBAR MUSCLE SPASM. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	187	0	0	187
13-9629899	[redacted]	18.02.1997	FOREIGN BODY IN RIGHT EYE. - HITTING MOVING OBJECTS	Y	0	0	238	0	0	238
13-9923831	[redacted]	29.11.1999	RIGHT KNEE STRAIN - BEING HIT BY FALLING OBJECTS	Y	0	56	205	0	0	205
13-9627087	[redacted]	27.01.1997	PARTIAL DISLOCATION (L) THUMB - BEING HIT BY MOVING OBJECTS	Y	0	0	232	0	0	232
13-9807935	[redacted]	23.08.1998	CUT TO R/HAND - BEING HIT BY MOVING OBJECTS	Y	0	0	197	0	0	197
13-9724686	[redacted]	07.01.1998	LACERATION TO RIGHT EYEBROW. - HITTING MOVING OBJECTS	Y	0	0	198	0	0	198

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2010* *Balcatta*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9516576	[redacted]	01.10.1995	UPPER BACK STRAIN - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	105	0	0	105
13-9830353	[redacted]	30.01.1999	SOFT TISSUE INJURY RIGHT WRIST - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	8	0	3,964	0	0	3,964
13-9644590	[redacted]	12.05.1997	LEFT UPPER BACK MUSCLE STRAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	433	0	0	433
13-9608881	[redacted]	30.08.1996	SOFT TISSUE INJ R LITTLE FINGE - HITTING STATIONARY OBJECTS	Y	0	0	151	0	0	151
13-9624425	[redacted]	27.12.1996	SOFT TISSUE INJURY LOWER BACK. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	2	0	668	0	0	668
13-9744002	[redacted]	03.06.1998	HIT IN THE MOUTH BY METAL STRA - HITTING MOVING OBJECTS	Y	0	0	2,121	0	0	2,121
13-9728130	[redacted]	01.02.1998	FB LEFT LOWER LEG. - FALLS FROM A HEIGHT	Y	0	0	264	0	0	264
13-9802053	[redacted]	20.06.1998	CRUSHED L/HAND INDEX FINGER - BEING TRAPPED BETWEEN OBJECTS	Y	0	0	111	0	0	111
13-9728131	[redacted]	20.01.1998	RIGHT ANKLE INJURY. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	407	0	0	407
13-9926667	[redacted]	18.11.1999	LEFT SHOULDER & NECK STRAIN. - MUSCULAR STRESS WITH NO OBJECTS HANDLED	N	0	123	193	37	11	241
13-9830343	[redacted]	05.02.1999	LOW BACK PAIN - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	389	0	0	389
13-9846079	[redacted]	21.05.1999	LEFT WRIST INJURY. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	227	0	0	227
13-9742703	[redacted]	10.03.1998	LEFT KNEE STRAIN. - UNSPECIFIED MECHANISMS OF INJURY	Y	0	0	9,024	0	0	9,024
13-9505795	[redacted]	01.08.1995	SOFT TISSUE INJ (L) SIDE HEAD - BEING HIT BY FALLING OBJECTS	Y	0	0	142	0	0	142
13-9828231	[redacted]	19.01.1999	LUMBAR SOFT TISSUE INJURY - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	4	0	2,109	0	0	2,109
13-9628973	[redacted]	14.02.1997	PULLED MUSCLES IN LEFT CALF. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	167	0	0	167

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2010* *Balcatta*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9738555	[redacted]	27.04.1998	SOFT TISSUE INJ 4TH LEFT KNUCK - HITTING STATIONARY OBJECTS	Y	0	0	181	0	0	181
13-9740225	[redacted]	05.05.1998	LOW BACK PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	31	0	9,098	0	0	9,098
13-9627694	[redacted]	20.01.1997	TISSUE INJ (R) WRIST - FALLS ON THE SAME LEVEL	Y	1	0	394	0	0	394
13-9507424	[redacted]	17.08.1995	LOWER BACK STRAIN - MUSCULAR STRESS WITH NO OBJECTS HANDLED	Y	0	0	218	0	0	218
Active Claim Totals:		**84**			**247**	**7,257**	**94,090**	**29,495**	**7,376**	**130,961**

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2036* *Bibra Lake*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9922064	[redacted]	25.11.1999	PAIN TO UPPER BACK LEFT ARM. - CONTACT WITH ELECTRICITY	Y	0	42	216	0	0	216
13-9708026	[redacted]	15.07.1997	LEFT WRIST STRAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	2,428	0	0	2,428
13-9910994	[redacted]	05.09.1999	LEFT ANKLE INJURY. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	338	0	0	338
13-9711141	[redacted]	23.09.1997	SOFT TISSUE INJURY RIGHT ELBOW - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	181	0	0	181
13-9711143	[redacted]	18.09.1997	MINOR LACERATION L 3RD FINGER - HITTING MOVING OBJECTS	Y	0	0	87	0	0	87
13-9527820	[redacted]	30.01.1996	STRAIN TO LOWER BACK - BEING HIT BY FALLING OBJECTS	Y	0	0	3,819	0	0	3,819
13-9732980	[redacted]	06.03.1998	LACERATION TO RIGHT LEG. - HITTING STATIONARY OBJECTS	Y	0	0	313	0	0	313
13-9718709	[redacted]	22.10.1997	LOWER BACK STRAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	4	0	780	0	0	780
13-9838732	[redacted]	23.03.1999	LACERATION TO RIGHT THUMB. - HITTING MOVING OBJECTS	Y	0	0	155	0	0	155
13-9629834	[redacted]	17.02.1997	INJURY R FACE, R MIDDLE FING, - FALLS FROM A HEIGHT	Y	0	0	160	0	0	160
13-9733163	[redacted]	24.02.1998	NECK PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	218	0	0	218
13-9629085	[redacted]	10.02.1997	LACERATION TO HEAD. - HITTING STATIONARY OBJECTS	Y	20	0	12,136	0	0	12,136
13-9736517	[redacted]	26.03.1998	STRAINED SHOULDER - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	434	0	0	434
13-9737102	[redacted]	07.04.1998	STRAINED LOWER BACK - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	6,348	0	0	6,348
13-9532941	[redacted]	13.03.1996	CUT TO LEFT HAND - BEING HIT BY MOVING OBJECTS	Y	0	0	96	0	0	96
13-9924232	[redacted]	10.10.1999	LEFT WRIST PAINS. - HITTING MOVING OBJECTS	Y	0	0	101	0	0	101

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2036* *Bibra Lake*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9736205	[redacted]	06.04.1998	STRAINED LOWER BACK - MUSCULAR STRESS WHILE LIFTING, CARRYING	N	6	217	14,639	27,620	5,524	47,784
13-9927421	[redacted]	21.12.1999	LEFT LEG INJURY. - BEING HIT BY FALLING OBJECTS	Y	0	0	74	0	0	74
13-9908825	[redacted]	30.08.1999	LACERATION TO RIGHT HAND. - HITTING STATIONARY OBJECTS	Y	0	0	248	0	0	248
16-9525294	[redacted]	20.04.1995	BROKEN TOOTH - HITTING STATIONARY OBJECTS	Y	0	0	101	0	0	101
13-9519571	[redacted]	23.11.1995	ABRASION TO CHEST - BEING HIT BY MOVING OBJECTS	Y	0	0	37	0	0	37
13-9922847	[redacted]	03.12.1999	LACERATION TO LEFT THUMB. - HITTING MOVING OBJECTS	Y	0	0	260	0	0	260
13-9805455	[redacted]	05.08.1998	ABRASIONS TO FINGERS L/HAND - BEING TRAPPED BETWEEN OBJECTS	Y	2	0	633	0	0	633
13-9823821	[redacted]	24.11.1998	STRAIN TO L/RIB CAGE - MUSCULAR STRESS WHILE HANDLING OBJECTS	Y	0	0	122	0	0	122
Active Claim Totals:		**24**			**32**	**259**	**43,925**	**27,620**	**5,524**	**77,069**

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2044* *Claremont*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9644179	[redacted]	12.06.1997	MUSCLE STRAIN R FRONT SHOULDER - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	122	0	0	122
13-9830357	[redacted]	04.02.1999	LACERATION LEFT HAND. - HITTING MOVING OBJECTS	Y	0	0	204	0	0	204
13-9539401	[redacted]	26.04.1996	BRUISED (L) LEG - FALLS FROM A HEIGHT	Y	2	0	253	0	0	253
13-9515984	[redacted]	18.08.1995	LACERATION (R) INDEX FINGER - HITTING STATIONARY OBJECTS	Y	0	0	111	0	0	111
13-9608547	[redacted]	21.08.1996	BRUISING TO BACK OF RIGHT HAND - HITTING STATIONARY OBJECTS	Y	2	0	846	0	0	846
13-9738926	[redacted]	20.04.1998	LEFT FOOT BRUISING. - HITTING MOVING OBJECTS	Y	0	0	203	0	0	203
13-9832323	[redacted]	22.02.1999	LACERATION TO RIGHT PALM HAND. - RUBBING AND CHAFING	Y	0	0	123	0	0	123
13-9919317	[redacted]	20.10.1999	RIGHT ANKLE INJURY. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	883	0	0	883
13-9703162	[redacted]	20.07.1997	PALM OF RIGHT HAND PUNTURE. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	113	0	0	113
13-9826413	[redacted]	26.12.1998	RIGHT THUMB INJURY. - HITTING STATIONARY OBJECTS	Y	0	0	2,636	0	0	2,636
13-9705928	[redacted]	13.08.1997	LEFT KNEE BRUISING. - HITTING MOVING OBJECTS	Y	0	0	203	0	0	203
Active Claim Totals:		**11**			**4**	**0**	**5,696**	**0**	**0**	**5,696**

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: WBLBBS *Bunnings Building Supplies*

Centre: 2078 *Joondalup Warehouse*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9840750	[redacted]	18.02.1999	LEFT SHOULDER PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	624	0	0	624
13-9807943	[redacted]	16.08.1998	5TH FINGER R/HAND STRAIN - BEING TRAPPED BETWEEN OBJECTS	Y	0	0	298	0	0	298
13-9723573	[redacted]	02.01.1998	RIGHT WRIST INJURY. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	1	0	5,854	0	0	5,854
13-9921089	[redacted]	23.11.1999	LACERATION TO RIGHT HAND. - HITTING MOVING OBJECTS	Y	0	0	419	0	0	419
13-9916853	[redacted]	26.09.1999	LACERATION TO FOREHEAD. - FALLS ON THE SAME LEVEL	Y	0	0	201	0	0	201
13-9801392	[redacted]	24.06.1998	SOFT TISSUE INJURY L/H THUMB - BEING HIT BY MOVING OBJECTS	Y	0	0	74	0	0	74
13-9923931	[redacted]	19.11.1999	RIGHT FOOT LIGAMENT STRAIN - MUSCULAR STRESS WHILE HANDLING OBJECTS	Y	0	0	74	0	0	74
13-9922842	[redacted]	27.11.1999	LACERATION TO LEFT THUMB. - BEING HIT BY FALLING OBJECTS	N	0	224	5,157	20,416	6,125	31,698
13-9807949	[redacted]	06.08.1998	STRAIN TO THUMB L/HAND - BEING TRAPPED BETWEEN OBJECTS	Y	0	0	110	0	0	110
13-9824459	[redacted]	06.12.1998	CUT TO L/HAND INDEX FINGER - HITTING MOVING OBJECTS	Y	0	0	171	0	0	171
13-9843072	[redacted]	26.04.1999	RIGHT LOW BACK STRAIN - MUSCULAR STRESS WHILE HANDLING OBJECTS	Y	0	0	590	0	0	590
13-9823332	[redacted]	28.11.1998	LOWER BACK STRAIN - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	256	0	0	256
13-9837414	[redacted]	04.03.1999	INJURY TO RIGHT BIG TOE. - BEING HIT BY FALLING OBJECTS	Y	0	0	74	0	0	74
13-9712107	[redacted]	30.09.1997	FB IN RIGHT EYE. - BEING HIT BY MOVING OBJECTS	Y	2	0	418	0	0	418
13-9723602	[redacted]	30.12.1997	RIGHT TOES LACEARTION. - HITTING MOVING OBJECTS	Y	0	0	74	0	0	74
13-9738548	[redacted]	22.04.1998	LACERATION TO LEFT HAND. - OTHER AND MULTIPLE MECHANISMS OF INJURY	Y	0	0	71	0	0	71

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Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2078* *Joondalup Warehouse*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9928360	[redacted]	02.11.1999	LUMBAR BACK PAIN. - FALLS ON THE SAME LEVEL	N	0	1,567	1,567	7,607	2,282	11,456
13-9803777	[redacted]	08.01.1998	CUTS TO FINGERS L/HAND - HITTING STATIONARY OBJECTS	Y	0	0	74	0	0	74
13-9836014	[redacted]	15.03.1999	SPIDER BITE TO LEFT HAND. - INSECT AND SPIDER BITES AND STINGS	Y	0	0	133	0	0	133
13-9726274	[redacted]	23.01.1998	INJURY TO LEFT BIG TOE. - FALLS FROM A HEIGHT	Y	0	0	1,152	0	0	1,152
13-9807961	[redacted]	13.08.1998	LOWER BACK STRAIN - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	1,124	0	0	1,124
13-9844127	[redacted]	01.04.1999	DERMATITIS RASH - OTHER AND MULTIPLE MECHANISMS OF INJURY	Y	2	0	290	0	0	290
13-9834162	[redacted]	16.02.1999	LEFT HAND & WRIST INJURY. - BEING HIT BY FALLING OBJECTS	Y	0	0	378	0	0	378
13-9840307	[redacted]	01.04.1999	FOREIGN BODY IN LEFT EYE. - HITTING MOVING OBJECTS	Y	0	0	630	0	0	630
13-9827279	[redacted]	01.01.1999	LACERATION RIGHT LITTLE FINGER - HITTING STATIONARY OBJECTS	Y	0	0	2,627	0	0	2,627
13-9731420	[redacted]	20.02.1998	# L WRIST & SPRAINED L ANKLE I - FALLS ON THE SAME LEVEL	Y	13	0	2,216	0	0	2,216
13-9836638	[redacted]	05.03.1999	LUMBAR & BUTTOCK PAIN. - FALLS ON THE SAME LEVEL	Y	0	0	604	0	0	604
13-9930747	[redacted]	19.12.1999	BRUISING TO RIGHT BIG TOE. - BEING HIT BY FALLING OBJECTS	Y	0	42	42	0	0	42
13-9826044	[redacted]	04.01.1999	FOREIGN BODY IN RIGHT EYE - BEING HIT BY FALLING OBJECTS	Y	0	0	172	0	0	172
13-9839952	[redacted]	21.01.1999	SWELLING TO LEFT MIDDLE FINGER - BEING TRAPPED BETWEEN OBJECTS	Y	0	0	74	0	0	74
13-9819819	[redacted]	20.10.1998	INFLAMMATION TO TAIL BONE - FALLS FROM A HEIGHT	Y	0	0	363	0	0	363
13-9842510	[redacted]	13.04.1999	LACERATION TO LEFT HAND. - BEING HIT BY MOVING OBJECTS	Y	0	0	239	0	0	239

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2078* *Joondalup Warehouse*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9924903	[redacted]	13.12.1999	LACERATION TO LEFT 2ND FINGER, - HITTING MOVING OBJECTS	Y	0	42	373	0	0	373
13-9844636	[redacted]	05.04.1999	SKIN RASH - OTHER AND MULTIPLE MECHANISMS OF INJURY	Y	0	0	739	0	0	739
Active Claim Totals:		**34**			**18**	**1,875**	**27,265**	**28,024**	**8,407**	**63,695**

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Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2094* *Kalamunda*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
16-9527206	[redacted]	24.06.1995	LEFT ANKLE INJURY - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	12	0	7,030	0	0	7,030
13-9622428	[redacted]	03.11.1996	PAIN IN LEFT GROIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	93	0	0	93
13-9621985	[redacted]	18.11.1996	RIGHT SHOULDER PAIN. - HITTING STATIONARY OBJECTS	Y	0	0	213	0	0	213
13-9705094	[redacted]	13.05.1997	PAIN LEFT CLAVICLE. - UNSPECIFIED MECHANISMS OF INJURY	Y	0	0	0	0	0	0
13-9707756	[redacted]	12.08.1997	PAIN IN LEFT LEG. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	776	0	0	776
13-9813208	[redacted]	03.10.1998	ABRASIONS TO HANDS & KNEES - FALLS ON THE SAME LEVEL	Y	0	0	113	0	0	113
13-9612143	[redacted]	19.09.1996	LOW BACK PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	975	0	0	975
16-9514240	[redacted]	28.06.1995	SPLINTER (R) THUMB - HITTING STATIONARY OBJECTS	Y	0	0	51	0	0	51
13-9535069	[redacted]	21.12.1995	LOW BACK PAIN - MUSCULAR STRESS WHILE HANDLING OBJECTS	Y	1	0	303	0	0	303
13-9524229	[redacted]	04.01.1996	SOFT TISSUE INJ.(R)KNEE/ANKLE - FALLS ON THE SAME LEVEL	Y	0	0	448	0	0	448
13-9613300	[redacted]	23.09.1996	LOWER BACK PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	400	0	154,048	0	0	154,048
13-9719389	[redacted]	06.10.1997	BACK PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	1,157	0	0	1,157
Active Claim Totals:		**12**			**413**	**0**	**165,205**	**0**	**0**	**165,205**

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: WBLBBS *Bunnings Building Supplies*

Centre: 2109 *Mandurah*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9838759	[redacted]	26.03.1999	LACERATION TO SCALP. - HITTING STATIONARY OBJECTS	Y	0	0	90	0	0	90
13-9616890	[redacted]	20.10.1996	LACERATED RIGHT RING FINGER. - UNSPECIFIED MECHANISMS OF INJURY	Y	0	0	257	0	0	257
13-9904530	[redacted]	20.07.1999	RIGHT ANKLE INJURY. - FALLS ON THE SAME LEVEL	Y	0	0	256	0	0	256
13-9627880	[redacted]	29.01.1997	MUSCLE STRAIN RIGHT SHOULDER. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	264	0	0	264
13-9712941	[redacted]	22.09.1997	LOWER BACK STRAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	3,804	0	0	3,804
13-9601376	[redacted]	20.06.1996	LACERATION TO L MIDDLE FINGER. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	71	0	0	71
13-9820014	[redacted]	17.11.1998	CORNEAL ABRASION - BEING HIT BY MOVING OBJECTS	Y	7	0	1,463	0	0	1,463
13-9624302	[redacted]	03.01.1997	RIGHT SHOULDER INJURY. - HITTING STATIONARY OBJECTS	Y	0	0	589	0	0	589
13-9822308	[redacted]	27.11.1998	LOWER BACK STRAIN - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	2	0	350	0	0	350
13-9634329	[redacted]	20.03.1997	LACERATIONS TO LEFT LEG. - HITTING MOVING OBJECTS	Y	0	0	78	0	0	78
13-9927050	[redacted]	20.12.1999	BURNS TO MOUTH. - BEING HIT BY FALLING OBJECTS	Y	0	0	239	0	0	239
13-9918168	[redacted]	10.10.1999	LEFT WRIST INJURY. - MUSCULAR STRESS WHILE LIFTING, CARRYING	N	0	650	5,155	34,417	10,325	49,897
13-9820971	[redacted]	16.10.1998	BRUISED LEFT FOOT - BEING HIT BY FALLING OBJECTS	Y	0	0	41	0	0	41
13-9819467	[redacted]	24.10.1998	CUT TO FOREHEAD - BEING HIT BY MOVING OBJECTS	Y	0	0	0	0	0	0
13-9514277	[redacted]	07.09.1995	LACERATION (R) THUMB - BEING HIT BY MOVING OBJECTS	Y	0	0	68	0	0	68
13-9712945	[redacted]	09.10.1997	RIGHT LOWER BACK STRAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	412	0	0	412

This Report Is Based On Information Provided By Wesfarmers Federation Insurance & Is Provided To Assist In The Management Of Outstanding Claims.
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Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2109* *Mandurah*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9901909	[redacted]	24.05.1999	LACERATION TO LEFT FACE. - HITTING MOVING OBJECTS	Y	0	0	90	0	0	90
13-9640384	[redacted]	12.05.1997	SCRATCH TO LEFT EYE. - HITTING MOVING OBJECTS	Y	2	0	202	0	0	202
13-9927027	[redacted]	19.12.1999	LOW BACK STRAIN. - MUSCULAR STRESS WHILE HANDLING OBJECTS	Y	0	0	74	0	0	74
13-9839976	[redacted]	26.03.1999	NECK STRAIN - MUSCULAR STRESS WITH NO OBJECTS HANDLED	Y	0	0	158	0	0	158
13-9836139	[redacted]	05.03.1999	INJURED BACK. - MUSCULAR STRESS WHILE HANDLING OBJECTS	N	32	0	11,921	4,404	1,101	17,425
13-9512160	[redacted]	15.08.1995	LACERATION (L) THUMB - HITTING MOVING OBJECTS	Y	0	0	117	0	0	117
13-9922469	[redacted]	16.11.1999	LEFT SHOULDER PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	398	0	0	398
13-9908335	[redacted]	05.05.1999	LEFT SHOULDER INJURY. - MUSCULAR STRESS WHILE LIFTING, CARRYING	N	0	1,427	2,685	6,614	1,653	10,952
13-9825727	[redacted]	09.12.1998	LASCERATION TO RIGHT THUMB - HITTING MOVING OBJECTS	Y	0	0	300	0	0	300
13-9901445	[redacted]	05.06.1999	LOW BACK PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	318	0	0	318
13-9917930	[redacted]	21.10.1999	HIT IN MOUTH BY WOOD. - HITTING MOVING OBJECTS	Y	0	0	101	0	0	101
Active Claim Totals:		**27**			**43**	**2,076**	**29,499**	**45,434**	**13,079**	**88,013**

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: WBLBBS *Bunnings Building Supplies*

Centre: 2117 *MADDINGTON (OLD CLOSED STORE)*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9710951	[redacted]	09.08.1997	FOREIGN IN LEFT EYE. - HITTING MOVING OBJECTS	Y	0	0	209	0	0	209
13-9617131	[redacted]	25.10.1996	PUNCTURE WOUND TO RIGHT FOOT. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	2	0	2,899	0	0	2,899
13-9637891	[redacted]	01.10.1996	FOREIGN BODY RIGHT EYE. - HITTING MOVING OBJECTS	Y	0	0	34	0	0	34
13-9713707	[redacted]	21.10.1997	LACERATION TO LEFT THUMB. - HITTING MOVING OBJECTS	Y	0	0	0	0	0	0
13-9632047	[redacted]	23.01.1997	PAIN IN RIGHT GROIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	136	0	0	136
13-9605177	[redacted]	04.07.1996	FB IN RIGHT EYE. - BEING HIT BY FALLING OBJECTS	Y	0	0	52	0	0	52
13-9805399	[redacted]	30.07.1998	CONCUSSION - HITTING STATIONARY OBJECTS	Y	0	0	74	0	0	74
13-9529492	[redacted]	27.10.1995	CUT TO RIGHT FOOT - HITTING STATIONARY OBJECTS	Y	2	0	294	0	0	294
13-9705648	[redacted]	23.06.1997	LACERATION TO L INDEX FINGER. - HITTING MOVING OBJECTS	Y	0	0	41	0	0	41
13-9809726	[redacted]	07.09.1998	CUT TO LEFT HAND - BEING HIT BY MOVING OBJECTS	Y	0	0	115	0	0	115
13-9529490	[redacted]	06.02.1996	CUT TO LEFT THUMB - BEING HIT BY MOVING OBJECTS	Y	2	0	569	0	0	569
13-9742621	[redacted]	02.06.1998	LOW BACK STRAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	4	0	761	0	0	761
13-9636271	[redacted]	24.02.1997	LACERATION TO SCALP. - HITTING MOVING OBJECTS	Y	0	0	39	0	0	39
13-9631167	[redacted]	16.02.1997	SOFT TISSUE INJURY TO BACK. - HITTING MOVING OBJECTS	Y	0	0	172	0	0	172
13-9703970	[redacted]	09.07.1997	RIGHT KNEE INJURY. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	78	0	0	78
13-9642320	[redacted]	05.05.1997	LEFT INDEX FINGER INJURY. - HITTING MOVING OBJECTS	Y	0	0	90	0	0	90

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2117* *MADDINGTON (OLD CLOSED STORE)*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9638865	[redacted]	29.04.1997	BRUISED TESTICLES. - HITTING STATIONARY OBJECTS	Y	0	0	239	0	0	239
Active Claim Totals:		**17**			**10**	**0**	**5,802**	**0**	**0**	**5,802**

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Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2125* *Midland*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9702244	[redacted]	15.07.1997	SPRAINED LEFT ANKLE. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	8	0	1,847	0	0	1,847
13-9725459	[redacted]	15.01.1998	SOFT TISSUE INJ LEFT SHOULDER - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	188	281	83,870	0	0	83,870
13-9640771	[redacted]	09.05.1997	RIGHT RIBCAGE STRAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	261	0	0	261
13-9625588	[redacted]	17.01.1997	LACERATIONS TO BOTH FOREARMS. - BEING HIT BY FALLING OBJECTS	Y	0	0	46	0	0	46
13-9802028	[redacted]	13.07.1998	LACERATION R/HAND FINGERS - HITTING STATIONARY OBJECTS	Y	0	0	203	0	0	203
13-9900538	[redacted]	30.06.1999	LACERATION RIGHT THUMB. - HITTING STATIONARY OBJECTS	Y	0	0	253	0	0	253
13-9524307	[redacted]	31.12.1995	SOFT TISSUE INJURY-UPPER BACK - MUSCULAR STRESS WHILE HANDLING OBJECTS	Y	0	0	294	0	0	294
13-9530124	[redacted]	15.02.1996	BRUISED NERVES IN FINGERS - HITTING MOVING OBJECTS	Y	0	0	331	0	0	331
13-9733852	[redacted]	10.03.1998	LEFT HAND INJURY. - BEING HIT BY FALLING OBJECTS	Y	0	0	164	0	0	164
13-9825114	[redacted]	08.12.1998	SPRAIN TO LEFT SHOULDER - REPETITIVE MOVEMENT, LOW MUSCLE LOADING	Y	0	0	229	0	0	229
13-9531398	[redacted]	08.02.1996	STRAIN TO ELBOWS - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	39	0	0	39
13-9604348	[redacted]	25.07.1996	RIGHT BICEP TENDON INJURY. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	8	0	1,198	0	0	1,198
13-9705309	[redacted]	11.08.1997	DISLOCATED RIGHT LITTLE FINGER - BEING HIT BY FALLING OBJECTS	Y	22	0	6,093	0	0	6,093
13-9908370	[redacted]	24.08.1999	MILD CONCUSSION. - HITTING STATIONARY OBJECTS	Y	5	0	694	0	0	694
13-9807541	[redacted]	10.08.1998	SOFT TISSUE INJURY R/HAND - BEING TRAPPED BETWEEN OBJECTS	Y	0	0	2,688	0	0	2,688
13-9924610	[redacted]	09.12.1999	LACERATION LEFT INDEX FINGER - HITTING MOVING OBJECTS	Y	0	0	264	0	0	264

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Printed On: 10-Mar-2000

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2125* *Midland*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9540685	[redacted]	18.05.1996	LACERATION (R) WRIST - HITTING MOVING OBJECTS	Y	0	0	199	0	0	199
13-9619689	[redacted]	21.11.1996	ACUTE LUMBAR SPINE STRAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	208	0	0	208
13-9903351	[redacted]	20.07.1999	CUT TO LEFT INDEX FINGER. - HITTING MOVING OBJECTS	Y	0	0	281	0	0	281
13-9530192	[redacted]	17.02.1996	SPIDER BITE TO LEFT LEG - INSECT AND SPIDER BITES AND STINGS	Y	1	0	95	0	0	95
13-9632788	[redacted]	07.03.1997	PROLAPSED LUMBAR. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	505	0	141,831	0	0	141,831
13-9538675	[redacted]	29.04.1996	BACK STRAIN TO LOWER BACK - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	682	0	173,890	0	0	173,890
13-9509415	[redacted]	06.09.1995	PULLED MUSCLE (L) SHOULDER - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	295	0	0	295
13-9537155	[redacted]	07.11.1995	STRAINED LOWER BACK - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	1	0	92	0	0	92
13-9814871	[redacted]	13.10.1998	STRAINED (R) SHOULDER - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	122	0	0	122
13-9902975	[redacted]	13.07.1999	EPICONDYLITIS BOTH ELBOWS. - REPETITIVE MOVEMENT, LOW MUSCLE LOADING	Y	0	0	359	0	0	359
16-9458560	[redacted]	23.04.1995	UPPER BACK STRAIN - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	434	0	0	434
13-9544444	[redacted]	14.06.1996	LACERATION RIGHT 5TH FINGER. - HITTING STATIONARY OBJECTS	Y	0	0	160	0	0	160
13-9638738	[redacted]	24.04.1997	FOREIGN MATTER IN MIDDLE FINGE - HITTING STATIONARY OBJECTS	Y	0	0	156	0	0	156
13-9828209	[redacted]	20.01.1999	LACERATION TO LEFT THUMB. - HITTING MOVING OBJECTS	Y	0	0	261	0	0	261
16-9514332	[redacted]	31.05.1995	LOW BACK STRAIN - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	566	0	0	566
13-9503031	[redacted]	04.07.1995	LOW BACK INJURY - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	1,447	0	0	1,447

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2125* *Midland*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9522689	[redacted]	14.12.1995	LACERATION (R) ELBOW - HITTING STATIONARY OBJECTS	Y	0	0	92	0	0	92
13-9505151	[redacted]	26.07.1995	MUSCULAR NECK STRAIN - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	2	0	681	0	0	681
13-9638834	[redacted]	29.04.1997	FOREIGN BODY IN RIGHT EYE. - UNSPECIFIED MECHANISMS OF INJURY	Y	0	0	74	0	0	74
13-9912855	[redacted]	22.09.1999	LEFT ANKLE INJURY. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	206	0	0	206
13-9628241	[redacted]	10.02.1997	FRACTURED RIGHT FEMUR. - FALLS ON THE SAME LEVEL	N	131	0	40,496	68,943	10,341	119,780
13-9837886	[redacted]	29.12.1998	RIGHT SHOULDER MUSCLE STRAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	158	0	0	158
13-9900530	[redacted]	30.06.1999	RIGHT SHOULDER INJURY. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	219	0	0	219
Active Claim Totals:		**39**			**1553**	**281**	**460,793**	**68,943**	**10,341**	**540,077**

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2130* *Maddington Warehouse*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9715781	[redacted]	16.10.1997	LACERATION TO LEFT HAND. - HITTING MOVING OBJECTS	Y	0	0	118	0	0	118
13-9815623	[redacted]	15.10.1998	LACERATED (L) THUMB - BEING HIT BY MOVING OBJECTS	Y	0	0	41	0	0	41
13-9901434	[redacted]	02.07.1999	LEFT KNEE SWELLING. - HITTING STATIONARY OBJECTS	Y	0	0	4,593	0	0	4,593
13-9828912	[redacted]	01.02.1999	LACERATION RIGHT RING FINGER. - HITTING MOVING OBJECTS	Y	0	0	243	0	0	243
13-9801425	[redacted]	25.06.1998	LOWER BACK STRAIN - FALLS FROM A HEIGHT	Y	0	0	115	0	0	115
13-9927757	[redacted]	02.12.1999	LACERATION TO HEAD. - HITTING STATIONARY OBJECTS	Y	0	0	287	0	0	287
13-9719502	[redacted]	17.10.1997	LOWER BACK PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	68	0	0	68
13-9825209	[redacted]	29.12.1998	LACERATION TO SCALP - BEING HIT BY FALLING OBJECTS	Y	0	0	227	0	0	227
13-9738107	[redacted]	20.04.1998	SOFT TISSUE INJURIES. - FALLS FROM A HEIGHT	Y	11	0	3,027	0	0	3,027
13-9625895	[redacted]	02.01.1997	LOWER BACK PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	79	0	14,364	0	0	14,364
13-9736952	[redacted]	09.04.1998	TWISTED RIGHT KNEE - FALLS ON THE SAME LEVEL	Y	20	0	7,249	0	0	7,249
13-9838562	[redacted]	20.03.1999	LEFT FOREARM BITE. - INSECT AND SPIDER BITES AND STINGS	Y	0	0	233	0	0	233
13-9713543	[redacted]	12.10.1997	INHALING LPG & FELT DIZZY. - UNSPECIFIED MECHANISMS OF INJURY	Y	0	0	1,209	0	0	1,209
13-9908380	[redacted]	23.07.1999	LACERATION TO LEFT THUMB. - BEING HIT BY MOVING OBJECTS	Y	0	0	42	0	0	42
13-9924953	[redacted]	20.12.1999	INSECT BITE - INSECT AND SPIDER BITES AND STINGS	Y	0	0	149	0	0	149
13-9815610	[redacted]	12.10.1998	STRAINED (R) WRIST - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	92	0	0	92

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2130* *Maddington Warehouse*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9840826	[redacted]	12.04.1999	SPILL OF CHEMICAL ON UPPER LEG - SINGLE CONTACT WITH CHEMICAL	Y	0	0	115	0	0	115
13-9643642	[redacted]	27.05.1997	HIGH BLOOD PRESSURE. - OTHER AND MULTIPLE MECHANISMS OF INJURY	Y	199	0	34,477	0	0	34,477
13-9831345	[redacted]	11.02.1999	LEFT LEG CHEMICAL BURNS. - SINGLE CONTACT WITH CHEMICAL	Y	0	0	125	0	0	125
13-9901063	[redacted]	07.06.1999	ABDOMINAL MUSCULAR PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	212	0	0	212
13-9839124	[redacted]	05.04.1999	LEFT SHOULDER INJURY. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	350	0	0	350
13-9732983	[redacted]	25.02.1998	PAIN IN LEFT CHEST DUE TO FALL - FALLS ON THE SAME LEVEL	Y	0	0	343	0	0	343
13-9834173	[redacted]	28.02.1999	LACERATION TO RIGHT FOREHEAD. - HITTING MOVING OBJECTS	Y	0	0	200	0	0	200
13-9708785	[redacted]	20.08.1997	LACERATION TO LEFT MIDDLE FING - HITTING MOVING OBJECTS	Y	0	0	425	0	0	425
13-9711398	[redacted]	25.09.1997	UPPER LEG SOFT TISSUE RIGHT. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	26	0	5,966	0	0	5,966
13-9827473	[redacted]	14.01.1999	SOFT TISSUE INJURY TO BACK. - FALLS ON THE SAME LEVEL	Y	0	0	5,579	0	0	5,579
13-9728681	[redacted]	03.02.1998	LACERATION TO RIGHT OUTER EAR. - BEING HIT BY FALLING OBJECTS	Y	0	0	74	0	0	74
13-9729620	[redacted]	26.11.1997	SOFT TISSUE LOW BACK. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	193	0	0	193
13-9803928	[redacted]	10.05.1998	LOWER BACK STRAIN - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	0	0	0	0
13-9802905	[redacted]	05.01.1998	LEFT HAND AND FOREARM PAIN - REPETITIVE MOVEMENT, LOW MUSCLE LOADING	Y	31	0	6,454	0	0	6,454
13-9720658	[redacted]	01.12.1997	SOFT TISSUE INJURY R SHOULDER. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	322	0	0	322
13-9713700	[redacted]	12.10.1997	STRAINED LOWER BACK INJURY. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	3	0	389	0	0	389

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2130* *Maddington Warehouse*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9806753	[redacted]	10.08.1998	LOWER BACK STRAIN - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	1	0	834	0	0	834
Active Claim Totals:		**33**			**370**	**0**	**88,114**	**0**	**0**	**88,114**

This Report Is Based On Information Provided By Wesfarmers Federation Insurance & Is Provided To Assist In The Management Of Outstanding Claims.
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Printed On: 10-Mar-2000

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: WBLBBS *Bunnings Building Supplies*

Centre: 2167 *Osborne Park, Hector St.* *Page:* 1

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9626341	[redacted]	08.11.1996	TRAUMA/STRESS - EXPOSURE TO MENTAL STRESS FACTORS	Y	0	0	405	0	0	405
13-9616393	[redacted]	17.09.1996	FOREIGN BODY IN LEFT EYE. - UNSPECIFIED MECHANISMS OF INJURY	Y	0	0	71	0	0	71
13-9738519	[redacted]	29.04.1998	RIGHT SHOULDER PAIN. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	740	0	0	740
13-9514252	[redacted]	11.07.1995	SOFT TISSUE INJURY (R) FOOT - BEING HIT BY MOVING OBJECTS	Y	0	0	37	0	0	37
13-9625900	[redacted]	17.01.1997	PUNCTURE WOUND TO L MID FINGER - HITTING MOVING OBJECTS	Y	0	0	252	0	0	252
13-9536418	[redacted]	11.04.1996	FRACTURED (R) RIB - FALLS FROM A HEIGHT	Y	7	0	1,013	0	0	1,013
13-9805487	[redacted]	06.08.1998	MEDIAL MENISCUS TEAR L/KNEE - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	516	0	0	516
Active Claim Totals:		**7**			**7**	**0**	**3,034**	**0**	**0**	**3,034**

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2183* *Trade Plumbing CLOSED LOCATION*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9605112	[redacted]	24.07.1996	SOFT TISSUE INJURY NECK. - FALLS FROM A HEIGHT	Y	0	0	39	0	0	39
Active Claim Totals:		**1**			**0**	**0**	**39**	**0**	**0**	**39**

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Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: WBLBBS *Bunnings Building Supplies*

Centre: 2206 *Willetton*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
16-9507104	[redacted]	21.06.1995	LACERATION (R) LITTLE FINGER - HITTING STATIONARY OBJECTS	Y	0	0	154	0	0	154
13-9643229	[redacted]	17.05.1997	PAIN TO LEFT SHOULDER & HAND. - FALLS ON THE SAME LEVEL	Y	0	0	279	0	0	279
13-9903326	[redacted]	29.06.1999	LPG BURN TO BOTH EYES. - CONTACT WITH COLD OBJECTS	Y	0	0	169	0	0	169
13-9627092	[redacted]	15.01.1997	SPRAINED (L) ANKLE - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	173	0	0	173
13-9839958	[redacted]	22.09.1998	LOW BACK STRAIN. - MUSCULAR STRESS WHILE HANDLING OBJECTS	Y	0	0	82	0	0	82
Active Claim Totals:		**5**			**0**	**0**	**858**	**0**	**0**	**858**

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2214* *Rockingham*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9712100	[redacted]	01.10.1997	LACERATION TO FINGERS LEFT. - HITTING MOVING OBJECTS	Y	0	0	415	0	0	415
13-9711395	[redacted]	27.09.1997	BACK & LEFT LEG PAIN. - HITTING STATIONARY OBJECTS	Y	0	0	360	0	0	360
13-9712406	[redacted]	29.09.1997	SOFT TISSUE INJURY LEFT KNEE. - HITTING STATIONARY OBJECTS	Y	0	0	52	0	0	52
13-9802736	[redacted]	08.06.1998	LOWER BACK STRAIN - MUSCULAR STRESS WITH NO OBJECTS HANDLED	Y	10	0	2,270	0	0	2,270
13-9822237	[redacted]	20.11.1998	SOFT TISSUE INJURY R/HAND - BEING TRAPPED BETWEEN OBJECTS	Y	0	0	77	0	0	77
13-9916939	[redacted]	12.10.1999	LEFT KNEE PAIN. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	964	0	0	964
13-9603460	[redacted]	21.07.1996	ABRASION TO LEFT KNEE. - HITTING STATIONARY OBJECTS	Y	0	0	110	0	0	110
13-9633132	[redacted]	25.02.1997	TINNITUS BOTH EARS. - OTHER AND MULTIPLE MECHANISMS OF INJURY	Y	4	0	8,527	0	0	8,527
13-9817421	[redacted]	28.10.1998	LOWER BACK STRAIN - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	1,319	0	0	1,319
13-9722312	[redacted]	10.09.1997	FB, LACERATION TO LEFT EYE. - HITTING STATIONARY OBJECTS	Y	0	0	318	0	0	318
13-9908363	[redacted]	25.08.1999	FB IN LEFT EYE. - UNSPECIFIED MECHANISMS OF INJURY	Y	0	0	101	0	0	101
13-9843077	[redacted]	01.05.1999	LACERATION TO LEFT KNEE. - HITTING MOVING OBJECTS	Y	0	0	0	0	0	0
13-9612621	[redacted]	26.09.1996	MUSCULAR STRAIN THORACIC LEFT. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	237	0	91,333	0	0	91,333
13-9825768	[redacted]	07.01.1999	LACERATION RIGHT LITTLE FINGER - BEING TRAPPED BETWEEN OBJECTS	Y	0	0	122	0	0	122
13-9637637	[redacted]	19.04.1997	SOFT TISSUE CERVICAL SPINE. - FALLS FROM A HEIGHT	Y	0	0	757	0	0	757
13-9532042	[redacted]	29.02.1996	LOW BACK PAIN - MUSCULAR STRESS WHILE HANDLING OBJECTS	Y	10	0	1,830	0	0	1,830

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2214* *Rockingham*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9620064	[redacted]	28.11.1996	LACERATION LEFT MIDDLE FINGER. - OTHER AND MULTIPLE MECHANISMS OF INJURY	Y	0	0	39	0	0	39
13-9624784	[redacted]	31.12.1996	RIGHT WRIST INJURY. - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	2	0	2,273	0	0	2,273
13-9537465	[redacted]	02.04.1996	BRUISED (L) ANKLE - FALLS ON THE SAME LEVEL	Y	0	0	106	0	0	106
Active Claim Totals:		**19**			**263**	**0**	**110,972**	**0**	**0**	**110,972**

Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: WBLBBS *Bunnings Building Supplies*

Centre: 2222 *South Perth* *Page:* 1

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9712112	[redacted]	30.09.1997	LACERATION TO LEFT INDEX FINGE - HITTING STATIONARY OBJECTS	Y	0	0	86	0	0	86
13-9724128	[redacted]	29.12.1997	LACERATION LEFT MIDDLE FINGER. - HITTING MOVING OBJECTS	Y	0	0	41	0	0	41
13-9634085	[redacted]	12.03.1997	LEFT KNEE INJURY. - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	857	0	0	857
13-9628970	[redacted]	20.01.1997	LACERATION TO LEFT MIDDLE FING - HITTING MOVING OBJECTS	Y	0	0	167	0	0	167
13-9643235	[redacted]	22.05.1997	LACERATION TO LEFT THUMB. - HITTING STATIONARY OBJECTS	Y	0	0	41	0	0	41
13-9544907	[redacted]	07.06.1996	TWISTED RIGHT ANKLE & LOW BACK - STEPPING, KNEELING OR SITTING ON OBJECTS	Y	0	0	415	0	0	415
Active Claim Totals:		**6**			**0**	**0**	**1,606**	**0**	**0**	**1,606**

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Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2230* *Victoria Park CLOSED LOCATION* *Page:* *1*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9519799	[redacted]	29.10.1995	STRAIN-THORACIC/LUMBER SPINE - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	394	0	0	394
Active Claim Totals:		**1**			**0**	**0**	**394**	**0**	**0**	**394**

This Report Is Based On Information Provided By Wesfarmers Federation Insurance & Is Provided To Assist In The Management Of Outstanding Claims.
Please Contact Group Risk Management On (08) 9327 4260 For Clarification On Any Aspect Of This Information.
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Wesfarmers Group Risk Management Report - Workers Compensation

All Claims For All Periods From 1 April 1995 to 31 December 1999 As At 28 February 2000

Company: *WBLBBS* *Bunnings Building Supplies*

Centre: *2260* *Homebase Wembley* *Page:* *1*

Claim Ref:	Employee Name	Date Of Injury	Injury Details - Cause of Injury	Closed Y/N	Days Lost	Paid Month Inc. Fees	Total Paid Inc. Fees	O/Standing Estimate	IBNR Calc	Total Incurred
13-9514262	[redacted]	12.10.1995	LACERATION (R) MIDDLE FINGER - BEING HIT BY MOVING OBJECTS	Y	0	0	117	0	0	117
13-9913901	[redacted]	11.10.1999	LACERATION TO LEFT PALM. - HITTING MOVING OBJECTS	Y	0	0	41	0	0	41
13-9915257	[redacted]	09.10.1999	MUSCLE STRAIN LOW BACK. - MUSCULAR STRESS WITH NO OBJECTS HANDLED	Y	0	0	101	0	0	101
13-9603488	[redacted]	16.07.1996	BROKEN SPECTACLES ON FACE. - HITTING MOVING OBJECTS	Y	0	0	39	0	0	39
13-9807725	[redacted]	19.08.1998	ABRASION R/EYE - HITTING STATIONARY OBJECTS	Y	0	0	41	0	0	41
13-9920912	[redacted]	23.11.1999	LACERATION TO CORNEAL R EYE. - OTHER AND MULTIPLE MECHANISMS OF INJURY	Y	0	0	83	0	0	83
13-9804793	[redacted]	23.07.1998	LACERATED/BRUISED (R) KNEE - FALLS ON THE SAME LEVEL	Y	0	0	174	0	0	174
13-9908310	[redacted]	26.08.1999	DOG BITE TO RIGHT HAND. - BEING BITTEN BY AN ANIMAL	Y	0	0	304	0	0	304
13-9514421	[redacted]	01.08.1995	STRAIN TO (L) FOREFINGER - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	226	0	0	226
13-9740224	[redacted]	11.05.1998	CONTUSION TO RIGHT REAR EAR. - HITTING MOVING OBJECTS	Y	0	0	2,125	0	0	2,125
13-9804795	[redacted]	28.07.1998	LACERATED FOREHEAD - BEING HIT BY MOVING OBJECTS	Y	0	0	1,022	0	0	1,022
13-9728945	[redacted]	11.02.1998	SOFT TISSUE INJURY TO LOW BACK - MUSCULAR STRESS WHILE LIFTING, CARRYING	Y	0	0	400	0	0	400
Active Claim Totals:		**12**			**0**	**0**	**4,674**	**0**	**0**	**4,674**

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