2011

The effectiveness of back belts in reducing the incidence, duration and cost of low back pain claims associated with manual handling injury in a retail hardware chain

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Last reviewed: 22 March 2011

Introduction

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Abstract

The objective of this intervention 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 in Western Australia. The pre-intervention period extended for 21 months and included 2,265,933 work hours or 647 full-time equivalent positions, while the intervention period was 32 months for 4,411,352 hours worked or 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. The introduction of the back belts was followed by 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.

Relevance to industry

The mandatory use of back belts was associated with a reduction in both the days lost and cost of occupational low back pain resulting from manual handling, and back belts may provide a cost-effective control for occupational low back pain if high compliance is maintained.

Keywords: manual handling, low back pain, back belt, prevention, cost.

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Introduction

Back belts have been used for many years in competitive weightlifting 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 (MHI) to the lower back. There are some biomechanical indications to support their use, particularly in reducing range of motion during manual handling[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12] and improving lumbar stability and/or proprioception.[13, 14, 15, 16, 17, 18, 19] However, the evidence from clinical trials on their effectiveness in an industrial setting is often regarded as inconclusive.[20, 21, 22, 23, 24, 25]

Walsh and Schwartz[26], in a six-month follow-up study of grocery warehouse workers, found a significant decrease in lost time injuries (LTIs) among subjects using a custom moulded back support. Reddell et al[27], in a study of 896 baggage handlers using a leather weight lifting belt, found no significant difference in incidence frequency rate (IFR), days lost or cost with belt use. Mitchell et al[28] studied 1,316 US Air Force warehouse personnel wearing back belts and reported a significant decrease in lower back pain (LBP) incidence. In none of these studies was compliance reported but the study by Reddell et al suffered a 58% dropout amongst belt users.

Kraus et al[29] performed a retrospective study of 36,000 employees in a large home improvement retail chain from 1989 to 1994. In 1990 mandatory back belts were introduced with all stores using them by 1992. The IFR for all reported acute LBP associated with work, regardless of mechanism, decreased from 30.6 to 20.2 per million hours worked. This produced a statistically significant prevented fraction, defined as 1 — relative risk (RR)[30], of 34%, that is, 34% of potential cases were prevented from occurring. Compliance was reported to be 98%.

van Poppel et al[21] examined self-reported LBP and days lost among 312 cargo handlers and found that a back belt did not result in a significant change. In a NIOSH supported study by Wassel et al[31], a retail merchandise chain with 160 stores mandated flexible elastic belts to be used in 89 of its stores. Self-reported LBP, back belt use and workers' compensation claims data was recorded over an average of 6.5 months for each store. Of the 9,377 subjects recruited, 6,311 (67%) completed the final follow-up. Self-reported episodes of LBP and workers' compensation claims were not significantly affected by back belt use. Both these studies suffered from poor compliance, 43% and 58% respectively, and high dropout rates.

Kraus et al[32] examined the effect of back belts on back injuries among female home carers where 12,772 workers were followed for 28 months (44,922,000 hours worked). The IFR, using the control group as the reference gives a RR for the back belt group of 0.74 (95% CI = 0.55–0.95). Initial compliance was 92.2%, increasing to 97%.

A Cochrane systematic review[22] of five randomised and two non-randomised controlled studies of back belts in the workplace found moderate evidence that back belts were not more effective than other, or no intervention. The reviewers note poor compliance as an issue and they suggest that future trials need to ensure adequate compliance.

A hardware retail chain, which in Western Australia (WA) had 21 metropolitan branches, required all employees to wear a back belt in the workplace from April 1997. This provided an opportunity to conduct a large scale retrospective study of the effectiveness of back belts as a control measure for reducing the risk of MHI-related LBP.

Methods

All WA employees of the 21 metropolitan stores where enrolled in a retrospective cohort.[30, 33] The cohort was followed from 1 July 1995 through to 31 December 1999 and a mandatory back belt intervention was introduced during April 1997. The workforce prior to the introduction of the back belt acted as historical controls.[34]

Data on person–hours worked by store was supplied by the hardware chain and workers' compensation insurance claims data was supplied by the workers' compensation insurer. All workplace injuries requiring medical attendance, regardless of whether an LTI occurred, were included in the claims data.

The cause of injury and body part injured were used to separate LBP resulting from MHI from MHI that did not result in LBP.

The back belt supplied to all employees was a Rooster™ Back Support Belt which is an elastic type with semi-rigid stays, adjustable elastic straps with Velcro® closures and shoulder suspenders (see Figure 1).

Rooster Back Support Belt.

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 could be adjusted or loosened when not required without the need to remove clothing. Compliance with back belt use had been previously established[35] at 62.2% for normal duties and 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.

The maximum number of days lost per injury were restricted to 220 days, representing 12 months off work, according to Australian Standard.[28]

During the course of the study management reported that there were no other major changes made to occupational health and safety practices within the organisation.[36]

Results

Cohort details

The pre-intervention period extended from 1 July 1995 to 31 March 1997 (21 months). Over this period 2,265,933 work hours occurred for a yearly average of 1,294,819 work hours. The hours worked during the pre-intervention period equates to 647 average full-time equivalent (FTE) positions. 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 1 May 1997 to 31 December 1999 (32 months). During the intervention period 4,411,352 hours were worked, at an average of 1,654,247 hours a year or 827 FTEs.

Incidence

During the pre-intervention period 25 of 29 injuries to the lower back were due to MHI. These 25 LBP cases (for the purpose of this discussion the term LBP relates to LBP due to a MHI unless otherwise stated) represented an IFR of 11.03 injuries per million hours worked. During the intervention period 43 of 56 injuries to the lower back were due to MHI equating to a LBP IFR of 9.53. This represents a 14% reduction in IFR which was not statistically significant (RR = 0.86. 95% CI = 0.53−1.41). The pre-intervention period saw 12 LBP injuries resulting in an LTI, for an IFR of 5.30, compared to 16 LBP LTIs, and an IFR of 3.55 during the intervention period. This difference represented a 33% reduction in the IFR although the decrease was not statistically significance (RR = 0.67. 95% CI = 0.32−1.42).

MHI other than those resulting in LBP accounted for 29 cases (IFR = 12.80) in the pre-intervention period and 53 (IFR = 11.75) in the intervention period, giving a RR of 0.92 (95% CI = 0.58−1.44). Of these cases 9 (IFR = 3.97) resulted a LTI in the pre-intervention period and 8 (IFR = 1.77) during the intervention period. This represented a 55% decrease but failed to reach statistical significance (RR = 0.45. 95% CI = 0.17−1.16. χ^2 = 2.91) (see Table 1).

Table 1: LBP incidence

		Cases	IFR	LTI Cases	LTI IFR
LBP	Pre-intervention	25	11.03	12	5.30
	Intervention	43	9.53	16	3.55
	RR (95% CI)		0.86 (0.53−1.14)		0.67 (0.32−1.42)
Other MHI	Pre-intervention	29	12.80	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)

Duration

The average days lost per LBP LTI prior to the intervention period was 64.3 (SD = 96.3) reducing by 69% to 19.81 (SD = 33.62) during the intervention period. When the days lost were examined by hours worked there was a 79% reduction (RR = 0.21. 95% CI = 0.18−0.24) in days lost due to LBP.

All other MHI averaged 47 days lost (SD = 85.64) per LTI claim during the pre-intervention period and 37.38 lost days (SD = 64.84) per lost time injury claim. On an hours worked basis this was a significant reduction of 66% (RR = 0.34. 95% CI = 0.29−0.40) (see Table 2).

Table 2: LTI duration

		Days lost (average)	Days lost IFR
LBP	Pre-intervention	772 (64.3)	340.7
	Intervention	317 (19.8)	70.3
	RR (95% CI)		*0.21 (0.18−0.24)*
Other MHI	Pre-intervention	423 (47)	186.68
	Intervention	299 (37.38)	66.28
	RR (95% CI)		*0.36 (0.31−0.41)*

Cost

During the pre-intervention period the total direct or insurable cost of LBP claims was $514,517 (in December 1999 dollars) at an average of $20,581 (SD = 53,530) per claim. The intervention period saw a reduction in total LBP cost to $207,551 and the average cost per LBP claim fell to $4,827 (SD = 12,588), a decrease of 77% per claim. When examined per hours worked LBP 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. For LBP claims resulting in an LTI 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), representing a 74% reduction. On an hours worked basis this represents an 83% reduction in the cost of LBP LTIs, from $223,863 per million hours worked to $38,627 per million hours worked.

MHI claims other than LBP accounted for $168,768 in claims costs 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. χ^2 = 2,701). During the pre-intervention period all other MHI LTIs cost a total of $165,533 or $72,965 per million hours worked at an average of $18,370 (SD = 34,046) per LTI claim. During the intervention period the total cost of these LTIs was $162,209, at $35,956 per million hours worked representing a 55% reduction (RR = 0.49. 95% CI = 0.49–0.50. χ^2 = 42,746). However the average cost per LTI increased by 10% to $20,276 (SD = 32,925) (see Table 3).

Table 3: Direct cost per injury claim

		Average $ cost per claim	Average $ cost per LTI claim	Claims $ cost per million hours worked	LTI claims $ cost per million hours worked
LBP	Pre-intervention	20,581	42,272	227,006	223,863

Intervention	4,827	10,909	47,049	38,627
% change	⊠ 77	⊠ 74	⊠ 80	⊠ 83
Other MHI Pre-intervention	5,820	18,370	74,481	72,965
Intervention	5,393	20,276	63,360	35,956
% change	⊠ 7	⊠ 10	⊠ 15	⊠ 55

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 ($z = -237.21$)

Discussion

Incidence

The IFR for LBP 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 MHI) per million hours worked reported for a similar but larger workforce[37] , agreeing more closely with the 14 injuries per million hours worked reported for retail merchandise material handlers.[38] The pre-intervention IFR for LBP resulting in an LTI of 5.3 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 LTI data presented by Kraus et al as the proportion associated with MHI is not known. As a percentage of total pre-intervention claims LBP accounted for 15%, similar to the 17% US average[39] , while LBP LTIs accounted for 29%, somewhat higher than the WA workforce average of 19.5%[40] and the 13.5% reported for the WA retail trade sector.[41]

The null result for LBP incidence, despite a 33% reduction in LBP LTI and a relatively large cohort with over 6.5 million man hours, 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.

Duration and cost as a measure of severity

In contrast to the lack of a significant decrease in LBP incidence the effect of the introduction of back belts on LBP duration, as measured by the number of days lost, was more marked. 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.

That being said, total insurable cost of a claim maybe a better indicator of the severity of an injury than days lost as it is less susceptible to the effects of “claims management” aimed at reducing days lost. Safety performance in the workplace is often measured in lost time injury incidence and days lost. In contrast, the dollar cost of injuries is not a common key performance indicator as, unlike incidence and LTI data, this information would rarely be available at the middle management or store level as the data on cost is maintained by the insurer.

There was an 80% reduction in the cost of LBP on an hours worked basis compared to only a 15% reduction in other non-LBP MHI claims. This cost saving is even more apparent when the average cost of claims is examined with the average LBP claim being over 3.5 times more expensive than other MHI claims during the pre-intervention period. During the intervention period the average cost of a LBP claim fell to become slightly less than that of other MHI claims. For injuries resulting in LTI LBP was more than twice as expensive per claim then other MHI in the pre-intervention period while it was close to half the cost during the intervention period.

There is the possibility of confounding factors affecting the results. However, any effect of the back belt should be largely limited to the lower back while other workplace manual handling controls, and recall that management reported no other significant change during the study period, should have a more even affect across all manual handling injuries. The larger decrease in LBP cost compared with the change in other MHI costs, with the average cost of MHI LTI actually increasing, provides support that the improvement in LBP severity measures was as a result of the introduction of the back belt.

From a risk management perspective priority should be given to 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 LBP. The severity of occupational LBP 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[39] with similar results being reported elsewhere.[42, 43, 44] An efficient and cost-effective control should target these high-cost injuries 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".[42] 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.

The reduction in severity observed in this study is the opposite of that reported in the general workforce from which the cohort was taken over the same period. In WA 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.[40]

Compliance

Clearly, compliance with back belt use is essential if an effect is to be measured; the Cochrane Back Group[22] suggest that an effect is "impossible" to determine without it. Compliance with back belt use in this cohort had been established at almost 90% during heavy lifting and 100% during regular heavy lifting.[36] If the results of previous studies with poor compliance are rejected, as was suggested by the Cochrane Back Group, then this study and the two performed by Kraus et al[37, 40] with good compliance all describe positive effects of back belts on the incidence or severity of occupational LBP.

A well-designed back belt should be comfortable and easy to don. Back belts with shoulder braces, such as those used in this study, allow the belt to be worn loosely when not required and it can be tightened easily before lifting. Back belts of this design are worn on the outside of clothing, simplifying monitoring by supervisors and workmates in workplaces where use is mandatory. The wearing of the back belt on the outside of clothing also means that this control measure has exposure to customers which further encourages compliance.

The actual effect of anything less than complete compliance on outcome measures is not quantifiable as the voluntary non-compliance introduces a selection bias of unknown direction. Further complicating this issue is the fact that there is no standard of what an acceptable level of compliance is. It should be noted that poor compliance is not limited to back belt use but also encompasses accepted good manual handling practices.

To achieve positive results the introduction of back belts into the workplace must be accompanied by a policy of mandatory use and have the complete support of the workforce, management and employee representatives.

Conclusions

The results of the study are summarised as follows:

1. The back belt did not result in a statistically significant decrease in the incidence of LBP due to MHI. However, the strong results for the remaining main outcomes suggest that the null result may

be 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 use of back belts was associated with a significant reduction in the number of days lost from LBP due to MHI.
3. The use of back belts was associated with a significant reduction in the direct cost of LBP due to MHI.

The reduction in the direct cost of LBP was large and, given the relatively small upfront costs of introducing the back belts into the workplace, demonstrates a substantial cost benefit to the organisation. This study presents 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, provides a simple, reliable and cost-effective means of reducing the severity of LBP resulting from in the manual handling in the workplace.

Footnotes

1 Grew, N and Deane, G. The physical effect of lumbar spinal supports. *Prosthetics and Orthotics International* 1982, 6:76–87.

2 Fidler, M and Plasmans, C. The effect of four types of support on the segmental mobility of the lumbosacral spine. *The Journal of Bone and Joint Surgery*1983, 65-A(7): 943–7.

3 Lantz, S and Schultz, A. Lumbar spine orthosis wearing: I. Restriction of gross body motions. *Spine* 1986, 11(8): 834–7.

4 Buchalter, D, Kahanovitz, N, Viola, K, Dorsky, S and Nordin, M. Three-dimensional spinal motion measurements. part 2: a noninvasive assessment of lumbar brace immobilization of the spine. *Journal of Spinal Disorders* 1989, 1(4): 284–6.

5 Granata, K, Marras, W and Davis, K. Biomechanical assessment of lifting dynamics, muscle activity and spinal loads while using three different style of lifting belt. *Clinical Biomechanics* 1997, 12(2): 107–15.

6 Thoumie, P, Drape, J, Aymard, C and Bedoiseau, M. Effects of a lumbar support on spine posture and motion assessed by electrogoniometer and continuous recording. *Clinical Biomechanics* 1998, 13(1): 18–26.

7 Sparto, P, Parnianpour, M, Reinsel, T and Simon, S. The effect of lifting belt use on multijoint motion and load bearing during repetitive and asymmetric lifting. *Journal of Spinal Disorders* 1998, 11(1): 57–64.

8 Woldstad, J and Sherman, B. The effects of a back belt on posture, strength and spinal compressive force during static lift exertions. *International Journal of Industrial Ergonomics* 1998, 22: 409–16.

9 McGorry, R and Hsiang, S. The effect of industrial back belts and breathing technique on trunk and pelvic coordination during a lifting task. *Spine* 1999, 24(11): 1,124–30.

10 Marras, W, Jorgensen, M and Davis, K. Effect of foot movement and an elastic lumbar back support on spinal loading during free-dynamic symmetric and asymmetric lifting exertions. *Ergonomics* 2000, 43(5): 653–68.

11 Giorcelli, R, Hughes, R, Wassell, J and Hsiao, H. The effect of wearing a back belt on spine kinematics during asymmetric lifting of large and small boxes. *Spine* 2001, 26(16): 1,794–8.

12 Willey, M. The effects of back belts and load on selected lifting kinematics during a simulated patient transfer. *Work* 2001, 17(1): 31–8.

13 Thomas, J, Lavender, S, Corcos, D and Andersson, G. Effect of lifting belts on trunk muscle activation during a suddenly applied load. *Human Factors* 1999, 41(4): 670–6.

14 Lavender, S, Shakeel, K, Andersson, G and Thomas, J. Effects of a lifting belt on spine moments and muscle recruitments after unexpected sudden loading. *Spine* 2000, 25(12): 1,569–78.

15 McGill, S, Seguin, J and Bennett, G. Passive stiffness of the lumbar torso in flexion, extension, lateral bending and axial rotation: effect of belt wearing and breath holding. *Spine* 1994, 19(6): 696–704.

16 Cholewicki, J, Juluru, K, Radebold, A, Panjabi, M and McGill, S. Lumbar spine stability can be augmented with an abdominal belt and/or increased intra-abdominal pressure. European *Spine Journal* 1999, 8: 388–95.

17 McNair, P and Hine, P. Trunk proprioception: enhancement through lumbar bracing. *Archives of Physical Medicine and Rehabilitation* 1999, 80: 96–9.

18 Wilders, D, Lee, J, Pope, M, Magnusson, M and Goel, V. Do lumbar supports alter the erector spinae response to sudden loads? In: Hansom M, (ed). *Contemporary Ergonomics*, 1999, p 255–8.

19 Newcomer, K, Laskowski, E, Yu, B, Johnson, J and An, K. The effects of a lumbar support on repositioning error in subjects with low back pain. *Archive of Physical Medicine and Rehabilitation* 2001, 82(7): 906–10.

20 Karas, B and Conrad, K. Back injury prevention interventions in the workplace: an integrative review. *American Association of Occupational Health Nurses Journal* 1996, 44(4): 189–96.

21 van Poppel, M, Koes, B, Smid, T and Bouter, L. A systematic review of controlled clinical trials on the prevention of back pain in industry. *Journal of Occupational and Environmental Medicine* 1997, 54: 841–7.

22 Van Tulder, M, Jellema, P, van Poppel, M, Nachemson, A and Bouter, L. Lumbar supports for prevention and treatment of low-back pain. *The Cochrane Library* 2000, Issue 4.

23 Jellema, P, van Tulder, M, van Poppel, M, Nachemson, A and Bouter, L. Lumbar supports for prevention of low back pain: a systematic review within the framework of the Cochrane back review Group. *Spine* 2001, 26(4): 377–86.

24 Gatty, C, Turner, M, Buitendorp, D and Batman, H. The effectiveness of back pain and injury prevention programs in the workplace. *Work* 2003, 20: 257–66.

25 Canadian Task Force on Preventive Health Care. Use of back belts to prevent occupational low-back pain. *Canadian Medical Association Journal* 2003, 169(3): 213–4.

26 Walsh, N and Schwartz, R. The influence of prophylactic orthoses on abdominal strength and low back injury in the workplace. *American Journal of Physical Medicine & Rehabilitation* 1990, 69(5): 245–50.

27

Reddell, C, Congleton, J, Huchingson, R and Montgomery, J. An evaluation of a weightlifting belt and back injury prevention training class for airline baggage handlers. *Applied Ergonomics* 1992, 23(5): 319–29.

28 Standards Australia. *The Workplace Injury and Disease Recording Standard*. Report No: AS 1885.1 – 1990. Sydney: Standards Australia, 1990.

29 Kraus, J, Brown, K, McArthur, D, Peek-Asa, C, Samaniego, L and Kraus, C. Reduction of acute low back injuries by use of back supports. *International Journal of Occupational and Environmental Health* 1996, 2(4):2 64–73.

30 Rothman, K. *Modern Epidemiology*. Boston: Little Brown & Co, 1986.

31 Wassell, J, Gardner, L, Landsittel, D, Johnston, J and Johnston, J. A prospective study of back belts for prevention of back pain and injury. *Journal of the American Medical Association* 2000, 284(21): 2,727–32.

32 Kraus, J, Schaffer, K, Rice, T, Maroosis, J and Harper, J. A field trial of back belts to reduce the incidence of acute low back injuries in New York City home attendants. *International Journal of Occupational and Environmental Health* 2002, 8(2): 97–104.

33 Hernberg, S. *Introduction to Occupational Epidemiology*. Boca Raton, 1992.

34 Zwerling, C, Daltroy, L, Fine, L, Johnston, J, Melius, J and Silvertein, B. Design and conduct of occupational injury intervention studies: a review of evaluation strategies. *American Journal of Industrial Medicine* 1997, 32: 164–79.

35 Merdith, N. *An evaluation of the effectiveness of back belts as a control measure for occupational low back injury in a retail home improvement chain: compliance and workers' attitudes*. Unpublished masters dissertation. Perth: Edith Cowan University, 2000.

36 Personal communication. Bunnings Building Supplies, 2000.

37 Kraus, J, Schaffer, K, McArthur, D and Peek-Asa, C. Epidemiology of acute low back injury in employees of a large home improvement retail chain. *American Journal of Epidemiology* 1997, 146(6): 637–45.

38 Gardner, L, Landsittel, D and Nelson, N. Risk factors for back injury in 31,076 retail merchandise store workers. *American Journal of Epidemiology* 1999, 150(8): 825–33.

39 Hashemi, L, Webster, B, Clancy, E and Volinn, E. Length of disability and cost of workers' compensation low back pain claims. *Journal of Occupational and Environmental Medicine* 1997, 39(10): 937–45.

40 WorkCover Western Australia. *Workers' Compensation Statistical Report 1995/96–1998/99*. Perth: WorkCover Western Australia, August 2000.

41 Worksafe Western Australia. *Manual Handling: Handy back belts are not the answer to manual handling problems*. Report No.: Safetyline 10. Perth, March 2000.

42 Clemmer, D, Mohr, D and Mercer, D. Low-back injuries in a heavy industry: I. Worker and workplace factors. *Spine* 1991, 16(7): 824–30.

43 Knowles, J, Glass, N and Lord, T. *Report of the Review of Medical and Associated Costs in the Western Australian Workers' Compensation System*. Perth: Government of Western Australia, 2000.

44 Spengler, D, Bigos, S, Matin, N, Zeh, J, Fisher, L and Nachemson, A. Back injuries in industry: a retrospective study. I. Overview and cost analysis. *Spine* 1986, 11(3): 241–5.