

Implications of the study

It may be inappropriate to extrapolate from models for high income countries to poorer settings. We have developed a methodologically valid, simple, and accurate model that may help decisions about health care for individual patients. These prognostic models can also help in the design and analysis of clinical trials, and in clinical audit by allowing adjustment for case mix.

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- Murray LS, Teasdale GM, Murray GD, Jennett B, Miller JD, Pickard JD, et al. Does prediction of outcome alter patient management? *Lancet* 1993;341:1487-91.
- Perel P, Edwards P, Wentz R, Roberts I. Systematic review of prognostic models in traumatic brain injury. *BMC Med Inform Decis Mak* 2006;6:38.

- CRASH Trial Collaborators. Effect of intravenous corticosteroids on death within 14 days in 10 008 adults with clinically significant head injury (MRC CRASH trial): randomised placebo-controlled trial. *Lancet* 2004;364:1321-8.
- CRASH Trial Collaborators. Final results of MRC CRASH, a randomised placebo-controlled trial of intravenous corticosteroid in adults with head injury-outcomes at 6 months. *Lancet* 2005;365:1957-9.
- Maas AI, Marmarou A, Murray GD, Teasdale SG, Steyerberg EW. Prognosis and clinical trial design in traumatic brain injury: the IMPACT study. *J Neurotrauma* 2007;24:232-8.
- Maas AI, Hukkelhoven CW, Marshall LF, Steyerberg EW. Prediction of outcome in traumatic brain injury with computed tomographic characteristics: a comparison between the computed tomographic classification and combinations of computed tomographic predictors. *Neurosurgery* 2005;57:1173-82.
- Wardlaw JM, Easton VJ, Statham P. Which CT features help predict outcome after head injury? *J Neurol Neurosurg Psychiatry* 2002;72:188-92.
- Hukkelhoven CW, Steyerberg EW, Farace E, Habbema JD, Marshall LF, Maas AI. Regional differences in patient characteristics, case management, and outcomes in traumatic brain injury: experience from the trilazad trials. *J Neurosurg* 2002;97:549-57.
- Signorini DF, Andrews PJD, Jones PA, Wardlaw JM, Miller JD. Predicting survival using simple clinical variables: a case study in traumatic brain injury. *J Neurol Neurosurg Psychiatry* 1999;66:20-5.
- Hukkelhoven CW, Steyerberg EW, Habbema JD, Farace E, Marmarou A, Murray GD, et al. Predicting outcome after traumatic brain injury: development and validation of a prognostic score based on admission characteristics. *J Neurotrauma* 2005;22:1025-39.

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Effect of training and lifting equipment for preventing back pain in lifting and handling: systematic review

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ABSTRACT

Objectives To determine whether advice and training on working techniques and lifting equipment prevent back pain in jobs that involve heavy lifting.

Data sources Medline, Embase, CENTRAL, Cochrane Back Group's specialised register, CINAHL, Nioshtic, CISdoc, Science Citation Index, and PsychLIT were searched up to September-November 2005.

Review methods The primary search focused on randomised controlled trials and the secondary search on cohort studies with a concurrent control group. Interventions aimed to modify techniques for lifting and handling heavy objects or patients and including measurements for back pain, consequent disability, or sick leave as the main outcome were considered for the review. Two authors independently assessed eligibility of the studies and methodological quality of those included. For data synthesis, we summarised the results of studies comparing similar interventions. We used odds ratios and effect sizes to combine the results in a meta-analysis. Finally, we compared the conclusions of the primary and secondary analyses.

Results Six randomised trials and five cohort studies met the inclusion criteria. Two randomised trials and all cohort studies were labelled as high quality. Eight studies looked at lifting and moving patients, and three studies were conducted among baggage handlers or postal workers.

Those in control groups received no intervention or minimal training, physical exercise, or use of back belts. None of the comparisons in randomised trials (17 720 participants) yielded significant differences. In the secondary analysis, none of the cohort studies (772 participants) had significant results, which supports the results of the randomised trials.

Conclusions There is no evidence to support use of advice or training in working techniques with or without lifting equipment for preventing back pain or consequent disability. The findings challenge current widespread practice of advising workers on correct lifting technique.

INTRODUCTION

Heavy lifting at work increases the risk of back pain.¹ Optimal working techniques are encouraged to prevent back pain and injuries when lifting heavy loads or patients cannot be avoided.^{2,3} In addition, lifting equipment has been developed to relieve some of the workload. Back pain is highly prevalent. The resulting disability has enormous consequences in terms of distress and economic costs of absence from work and reduced productivity.⁴ Employers must ensure that workers receive proper training on how to handle loads correctly.⁵ Specific techniques have been advocated to reduce the load on the back.^{6,7}

Earlier reviews on occupational interventions have questioned the role of education in the prevention of work related back pain.^{8,9} Even though primary studies have found no effect of training on the incidence of back pain, this could be incidental or caused by small sample size. We carried out a review following the systematic and rigorous Cochrane methods in searching the literature, selecting interventions and study designs, and combining the results.

METHODS

Searching—With the primary focus on randomised controlled trials, we used the search strategy developed by the Cochrane back review group.¹⁰ From August to November 2005 we searched Medline, Embase, CENTRAL, the back group's specialised register, CINAHL, Nioshtic, CISdoc, Science Citation Index, and PsychLIT. We considered trials reported in any language. In a secondary analysis using relevant cohort studies with concurrent control groups, we applied the sensitive search strategy for occupational health intervention studies¹¹ in Medline until November 2005.

Selection, validity assessment, and data abstraction—Two authors screened the titles and abstracts for eligibility. Eligible studies were those that aimed to modify the participants' lifting techniques at work and measured back pain, consequent disability, or sickness absence as the main outcomes. Two other authors independently extracted the data and assessed methodological quality of the randomised trials using the criteria and classification recommended by the Cochrane back review group.¹⁰ Studies were considered as high quality if more than half of the criteria were fulfilled. For the appraisal of cohort studies we used another instrument validated for non-randomised studies.¹²

Study characteristics—Our primary analysis was based on evidence from randomised trials only. In the secondary analysis using the cohort studies, we summarised the results of each comparison in a qualitative manner.

Quantitative data synthesis—We categorised the length of follow-up as short term (less than three months), intermediate (three to 12 months), or long term (more than 12 months). For comparisons with dichotomous outcomes and sufficient data, we plotted the adjusted results of each trial as odds ratios. For comparisons with similar interventions but with both dichotomous and continuous outcome measurements, we calculated an effect size.¹³ We combined the odds ratios of studies that compared similar interventions and measured back pain or back injury at a similar follow-up time. We combined effect sizes of studies with similar interventions that measured sickness absence rate or disability score at a similar follow-up time.

RESULTS

Trial flow

With our primary search strategy we found 3547 titles in nine databases. The sensitive search strategy provided 47

additional titles and a manual search provided another 17. From these 3611 articles, we closely evaluated 101. Eighty nine articles did not meet the inclusion criteria. Two articles reported on the same study.^{w1 w2} Consequently, we included 11 studies in the review.

Study characteristics

Four of the included studies were cluster randomised,^{w3-w6} two were individually randomised,^{w7 w8} and five were cohort studies.^{w1 w9-w12} Three randomised trials^{w4 w6 w7} and all five cohort studies involved care of patients. One trial studied postal workers,^{w3} and two studied baggage handlers.^{w5 w8} The number of participants in randomised trials varied from 51 to 12 772, and the follow-up time from six months to 5.5 years. The numbers in the cohort studies varied from 45 to 345, and the follow-up times ranged from eight weeks to two years.

In all jobs studied, the participants had enough strain on the back such that effective interventions could result in alleviation of symptoms. The training interventions focused on lifting techniques, with duration varying from a single session^{w6 w8 w11} to training once a week for two years.^{w12} In three studies the training was supported by follow-up and feedback at the workplace.^{w1 w3 w12} The advocated lifting techniques were not described in detail. Three studies clearly indicated the involvement of supervisors,^{w3 w11 w12} and five studies encouraged participants to use available lifting aids.^{w1 w6 w10-w12} Most studies used a professional instructor.^{w1 w3 w5 w8 w10 w11} Five studies monitored compliance with the instructions and with the use of lifting equipment.^{w5 w6 w9 w11 w12} Two randomised trials and all cohort studies were classed as high quality.^{w3 w5}

Quantitative data synthesis

Comparison between the groups that received training or no intervention in two randomised trials indicated that there was no difference in back pain (odds ratio 0.99, 95% confidence interval 0.54 to 1.81) or related disability (effect size 0.04, -0.50 to 0.58) at intermediate follow-up (figs 2 and 3).^{w5 w6} The same result was obtained in another randomised trial,^{w8} which we did not include in the meta-analysis because insufficient data were reported. One randomised trial showed no effect on back pain at long term follow-up (odds ratio 1.07, 0.06 to 17.96).^{w4} The results of three cohort studies supported those of the randomised studies at short term^{w10 w11} and long term follow-up.^{w1}

One randomised trial found no effect of training on back pain compared with minor advice (video) at long term follow-up (odds ratio 1.08, 95% confidence interval 0.56 to 2.08).^{w3} This was supported by the results of two cohort studies that used in-house orientation or training as the control interventions.^{w9 w12} One randomised trial found no significant difference in back pain with training compared with use of back belts at intermediate follow-up.^{w8} Another randomised trial had similar conclusions at long term follow-up (1.04, 0.06 to 17.38).^{w4} One randomised trial that compared training with physical

WHAT IS ALREADY KNOWN ON THIS TOPIC

Training in correct working techniques and lifting equipment is widely used to manage the increased risk of back pain related to repeated heavy lifting and handling

The effectiveness of these interventions has been questioned

WHAT THIS STUDY ADDS

There is no evidence that advice on lifting and handling with or without lifting equipment prevents back pain or consequent disability

exercise found no difference in back pain at intermediate follow-up.^{w7} The results of one cohort study supported the conclusions at short term follow-up.^{w10}

A comparison of a group receiving training and lifting equipment with the groups receiving training only or no intervention at all in one randomised trial showed no difference in back pain at intermediate follow-up of either comparison (0.42, 0.04 to 4.99).^{w6} There was also no difference in back related disability.

DISCUSSION

In this systematic review we found no evidence that training with or without lifting equipment is effective in the prevention of back pain or consequent disability. Either the advocated techniques did not reduce the risk of back injury or training did not lead to adequate change in lifting and handling techniques.

Strengths and limitations

We included only studies with designs that are the least susceptible to bias. In addition, we compared these results with those of studies with less valid study designs. There were no differences in conclusions between the analyses from studies with different designs or with different types of lifting and handling.

The measurement of the outcomes in the primary studies varied, leading to considerable differences in the incidences of back pain. Another limitation was that we could not extract the data needed from all studies, limiting the possibilities of pooling data. In addition, we had to adjust the results of most of the studies for the effect of the cluster randomisation that was not taken into account by the authors.

Interpretation

The actual number of participants in the eligible randomised trials was 17 720. After adjustment for the unit of analysis error, the effective sample size was 2727. The confidence intervals show that we cannot exclude the possibility that the studies and the review lacked the power to detect a small but possibly relevant difference in incidence. It is, however, highly unlikely that pooling the results of more studies would have led to a significant beneficial effect. This is because almost all studies showed an odds ratio that was near to 1, and the applied comparisons were all quite similar, especially as use of a back belt can be considered equal to no intervention in the prevention of back pain.

One explanation for the lack of an effect could be that the intervention was not appropriate. According to Burke et al, as training methods become more engaging, workers acquire more knowledge and the number of injuries falls.¹⁴ Accordingly, we classified the training methods based on learners' participation, but we did not find a more positive outcome for studies that involved more intense training methods.

Many health professionals are involved in training and advising workers on lifting and handling. Even though there may be other reasons to continue this practice, this review does not provide evidence that it prevents back pain. There is a need for more and high quality research with standardised outcome measurement, appropriate power, and adjustment for the cluster effect.

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- Kuiper JJ, Burdorf A, Verbeek JH, Frings-Dresen M, van der Beek AJ, Viikari-Juntura ER. Epidemiologic evidence on manual handling as a risk factor for back disorders: a systematic review. *Int J Ind Ergon* 1999;24:389-404.
- Straker LM. A review of research on techniques for lifting low-lying objects. 1. Criteria for evaluation. *Work* 2002;19:9-18.
- Straker LM. A review of research on techniques for lifting low-lying objects. 2. Evidence for a correct technique. *Work* 2002;20:83-96.
- Maniadakis N, Gray A. The economic burden of back pain in the UK. *Pain* 2000;84:93-103.
- Minimum health and safety requirements for the manual handling of loads where there is a risk particularly of back injury to workers*. Council Directive 90/269/EEC of 29 May 1990.
- European Agency for Safety and Health at Work. *Hazards and risks associated with manual handling of loads in the workplace*. 2007. <http://osha.europa.eu/publications/factsheets/73>.
- National Institute for Occupational Safety and Health. Simple solutions for lifting, holding, and handling materials. Introduction. In: *Simple solutions: ergonomics for construction workers*. 2007. (NIOSH Publication No 2007-122.) www.cdc.gov/niosh/docs/2007-122/.
- Van Poppel MNM, Hooftman WE, Koes BW. An update of a systematic review of controlled clinical trials on the primary prevention of back pain at the workplace. *Occup Med* 2004;54:345-52.
- Bos EH, Krol B, van der Star A, Groothoff JW. The effects of occupational interventions on reduction of musculoskeletal symptoms in the nursing profession. *Ergonomics* 2006;49:706-23.
- Van Tulder MW, Furlan A, Bombardier C, Bouter L, editorial board of the Cochrane Collaboration Back Review Group. Updated method guidelines for systematic reviews in the Cochrane Collaboration back review group. *Spine* 2003;28:1290-9.
- Verbeek J, Salmi J, Pasternack I, Jauhiainen M, Laamanen I, Schaafsma F, et al. A search strategy for occupational health intervention studies. *Occup Environ Med* 2005;62:682-7.
- Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomised studies (MINORS): development and validation of a new instrument. *ANZ J Surg* 2003;73:712-6.
- Chinn S. A simple method for converting an odds-ratio to effect size for use in meta-analysis. *Stat Med* 2000;19:3127-31.
- Burke MJ, Sarpy SA, Smith-Crowe K, Chan-Serafin S, Salvador RO, Islam G. Relative effectiveness of worker safety and health training methods. *Am J Public Health* 2006;96:315-24.
- Martimo KP, Verbeek J, Karppinen J, Furlan AD, Kuiper PPFM, Viikari-Juntura E, et al. Manual material handling advice and assistive devices for preventing and treating back pain in workers. *Cochrane Database Syst Rev* 2007;(3):CD005958.

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