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Technical Note

Training for lifting; an unresolved ergonomic issue?

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The paper describes a nine year project on lifting training which included nine trans-Australia consensus conferences attended by more than 900 health professionals. Major outcomes were: (1) The essence of lifting work is the need for the performer to cope with variability in task, environment, and self, and the essence of lifting skill is therefore adaptability; (2) the semi-squat approach provides the safest and most effective basis for lifting training; (3) for lifting training to be effective, the basic principles of skill learning must be systematically applied, with adaptability as a specific goal; (4) physical work capacity (aerobic power, strength, endurance, joint mobility) is a decisive ingredient of safe and effective lifting and, in addition to skill learning, should be incorporated in the training of people engaging regularly in heavy manual work; (5) if effective compliance with recommended skilled behaviour is to be achieved, then training must apply the principles and methods appropriate to adult learning and behaviour modification. © **1998 Elsevier Science Ltd. All rights reserved.**

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Introduction

Lifting, a hazardous activity, has been studied extensively in an effort to identify safe and effective methods of performance and training. However, despite that interest, there appear to be no widely accepted guidelines for training. Accordingly, the authors initiated a project, 'Safe and Effective Lifting', with the aim of developing such guidelines and which comprised study of the literature, observation in industry and sport, training courses, and consensus meetings for health professionals with interests in manual handling. The project is briefly outlined here; full details, including free papers, discussion notes, consensus analysis, and literature review are available (Sedgwick, 1994). The authors' interest in the project was aroused initially by two conflicting observations: the widespread convention that the so-called 'leg-lift' (*Figure 1*) is the 'correct technique' for lifting, and our impression that manual workers rarely, if ever, use the leg-lift when lifting low lying objects (Gormley *et al*, 1989).

Focus and assumptions

The project focussed exclusively on the most hazardous kind of manual handling, that is the lifting and lowering of low-lying objects, grasped or released at or below knee height; it was not concerned with manual handling in general or with ways of avoiding lifting, and attention was confined to the able-bodied. Consideration was given to the three approaches to lifting illustrated in *Figure 1*, and major objectives were to identify which approach best matches criteria of safe and effective lifting (*Table 1*) while facilitating learning in able-bodied adults, and to establish principles for the management of training, using that approach. Underlying assumptions were that manual handling is ubiquitous, cannot be engineered out of life, and that training (as in all physical activities) improves safety and effectiveness providing it is appropriate to task and performer and applies the basic principles of motor skill learning.

Research literature

An extensive review showed that the majority of studies, laboratory-based and dealing with highly stylised lifting performance, had little bearing on the everyday realities of lifting or the training process, and therefore contributed little to the aims of this project. More specifically: (a) research had concentrated mainly on bio-mechanics, neglecting other factors which have profound effects on performance — cognition, motor skill learning, and behaviour modification, (b) it had focused mainly on the back, paying scant attention to the dynamic interaction between the back and the rest of the body during lifting, (c) it had not accounted for variability of force and

Table 1 Criteria of a safe and effective lifting process

Throughout any lift/lower action and for any individual:
Vision of object, destination, and environment is clear
'Base' stability is optimal
The movement sequence permits postural adjustments which maintain dynamic stability
The movement sequence permits the load to follow a trajectory close to the vertical line above the feet (i.e. 'close to the body')
Joint/muscle complexes operate in optimal ranges
Forces are distributed so as:
To be within the tolerance limits of all anatomical structures
To prevent one or more joint/muscle complexes from unduly limiting potential through localised weakness or fatigue associated with mechanical disadvantage
To permit economical expenditure of available energy, in turn permitting long term work if required
The lift is performed in reasonable comfort

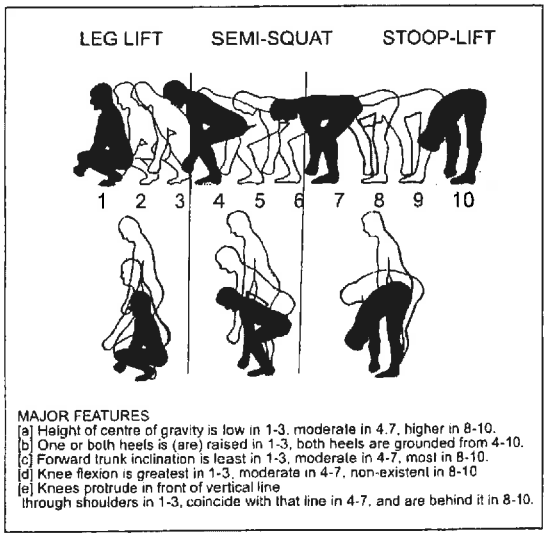

Figure 1 A continuum of lifting starting positions and related lifting movements

movement patterns within and between lifting tasks, or for the complementary role of the lifter's adaptability (to accommodate variability) and (d) it had not adequately investigated the effectiveness of training, using different approaches to lifting.

Consensus process

Having recognised the limitations of past research for purposes of this project, it was decided to conduct a series of consensus meetings designed first to sample Australia-wide opinion among people with professional interests in manual handling, secondly to promote discussion among all participants, and thirdly to seek consensus about training. It was thought that this approach would play a crucial role in the development of training guidelines and would also indicate future research requirements.

Nine meetings were held in five states and were attended by 940 health professionals — physiotherapists, ergonomists, occupational therapists, occupational health and safety personnel, bio-mechanists, exercise scientists, weight-lifting coaches, etc. At the outset, we found that 80–90% of the participants saw the leg-lift as an appropriate model for lifting training, less than 10% were prepared to recommend the stoop-lift, 25% claimed they were users of the semi-squat approach, and 25% claimed to be already using that approach for training purposes. While these findings highlighted the wide acceptance of the leg-lift, many of those who approved it expressed uneasiness with respect to compliance with the leg-lift and the apparent lack of workplace-based research to substantiate its efficacy.

Each meeting included formal presentations by the authors, free papers on specific issues related to lifting, workshops (theory and practical), and discussion. The first two meetings had a bio-mechanical emphasis (Sedgwick *et al*, 1989) reflecting the literature on lifting. The limitations of that emphasis were quickly recognised by participants, and as a result the remaining seven meetings were arranged to include all components seen as vital to the understanding of lifting and management of the training process — bio-mechanics, motor skill learning, functional anatomy, physical work capacity, and behaviour modification — topics which were addressed by appropriate specialists. Shortly after each meeting questionnaires were sent to participants to elicit their current perspectives on lifting training.

Major outcomes

There was consensus on the following items among the 643 participants (68% of the total 940) who completed follow-up questionnaires.

1. *The essence of lifting work is the need for the performer to cope with variability in task, environment, and self, and the essence of lifting skill is therefore adaptability (92% agreement).* Adaptability was defined as 'the ability to adjust lifting movements during a lift, and from one kind of lift to another, so as to suit variations in task, environment, and self, while maintaining work output and safety'.
2. *The semi-squat approach provides the safest and most effective basis for lifting training (84% agreement)* for reasons summarised as follows: (a) it most closely matches the criteria of 'good' lifting practice (*Table* 1), (b) it most favours adaptability within and between performers, and (c) it is readily learned. 'Approach' is used advisedly to emphasise that semi-squat lifting should not be conceived as a single "correct technique", but as a set of movement principles embodied in a "skill framework" which facilitates variation of movement pattern within the bounds of safe and effective musculo-skeletal function.

Practical experience during the consensus process showed that the advantages of semi-squat lifting are easily demonstrated by comparing performance outcomes (work output, precision, stability) when using leg-lift, stoop-lift, or semi-squat in difficult and varied circumstances — e.g. in prolonged work on slippery, uneven, sloping, or moving surfaces with heavy and/or awkward objects. We recommend that readers make such comparisons (illustrated in *Figure 2*, traced from movies) as a realistic way of perceiving differences

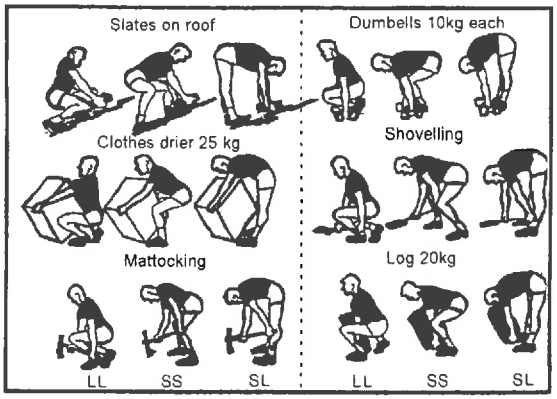

Figure 2 Three approaches to lifting applied to six tasks

between the three approaches to lifting. It is our firm impression, based on such trials, that the greater the task demands the more conspicuous are the advantages of applying semi-squat principles. Theoretical considerations (including the important issues of spinal configuration, shear forces, etc.) are discussed in detail elsewhere (Sedgwick 1994).

The leg-lift, despite the theoretical advantage of maintaining an upright posture ('sparing the back'), was seen as an unsuitable model for training owing to instability, inefficiency of knee action in full-squatting, and poor adaptability. Furthermore, it was agreed that the high-energy cost and inefficient knee action of the leg-lift together undermine the capacity for repetitive work, even with very light loads.

It was recognised that stoop-lifting is used widely and spontaneously for 'bent-over work' such as potato picking and weeding, and for the occasional lifting of light loads. Its advantages in such circumstances were discussed, namely energy efficiency and minimisation of knee extensor fatigue, together with the suggestion that the spine can operate safely when flexed as a function of support from passive trunk tissues (Twomey and Taylor, 1994). Nevertheless, a consistently held view throughout the consensus series was that stoop-lifting should not be used for training purposes owing to poor adaptability and potential hazards for the lumbar spine; two common perceptions among participants were that many people experience low back pain during or after stoop-lifting, and that spine pathology is very prevalent among habitual stoop-lifters — e.g. sheep shearers, brick-layers.

3. *For lifting training to be effective, the basic principles of skill learning must be systematically applied, with adaptability as a specific goal (90% agreement).* Principles of skill learning include (a) the cognitive element — understanding the nature of the skill, (b) a 'skill framework' is introduced and practised to initiate the skill learning process, (c) the skill is practised intensively, with training sessions distributed over several weeks, and with progressive demands on work-output and task complexity, (d) practise is accompanied by constant feedback (video, mirror, verbal), peer review, and discussion, and (e) learning is reinforced by showing the learner objective indications of progress.

There was strong agreement that training in industry (irrespective of the approach used, though mostly featuring the leg-lift) is often limited to a demonstration followed by brief practise of a single task, and that such procedures, ignoring the fundamentals of skill learning, are unlikely to achieve more than 'awareness raising'. It was also thought that inadequate training methods might do much to explain the failure of training to improve manual handling, sometimes reported in the literature (Gracovetsky, 1990; St. Vincent *et al*, 1989).

4. *Physical work capacity (aerobic power, strength, endurance, joint mobility) is a decisive ingredient of safe and effective lifting and, in addition to skill learning, should be incorporated in the training of people engaging regularly in heavy manual work (82% agreement).*
5. *If effective compliance with recommended skilled behaviour is to be achieved, then training must apply the principles and methods appropriate to adult learning and behaviour modification (71% agreement).* Training should therefore: (a) foster awareness and understanding of the reasons for training and the nature of the training process, (b) develop readiness for change, where awareness and understanding are converted into motivation to change, (c) develop lifting capacity (skill and physical work capacity), (d) actively involve the knowledge and experience (whether 'good' or 'bad') which trainees bring to the learning situation, and (e) include regular 'refreshing' of factors (a)–(c) so as to maintain compliance while minimising relapse. It was agreed that currently little effort is being made to apply these principles in industry or elsewhere in the community, such as schools.

Training courses

Six 'Lifting for Adaptability' courses were conducted for 69 trainees, average age 40 yrs, operating in groups of 10–14, with each course comprising 6–8 one and a half hour sessions distributed over 3–6 weeks; application of semi-squat principles was the sole basis for training. Video recordings were used extensively as a means of feedback and to evaluate training effects. The last course included pre and post 'isotrak' measurements to evaluate changes in lumbar spine configuration. Participants progressed from unloaded practise of the semi-squat framework to barbell lifts, to lifting a great variety of objects, to lifting in difficult work environments, to high-speed and fatiguing work, and to 'lifting-like' tasks — digging, forking, shovelling, mattocking. Sixty-four out of 69 trainees became proficient in applying semi-squat principles and no injuries were reported in 300 person/h of intensive lifting. Muscle stiffness was common in the early stages of all courses but was uncommon at the end despite greatly increased workloads. Stiffness was usually reported in the 'lifting muscles' (quadriceps, hamstrings, gluteals) and very rarely in 'trunk stabilising muscles' (abdominals, spine extensors). These courses demonstrated that the skills of semi-squat lifting can be readily acquired by able bodied adults, a not surprising outcome considering that semi-squat principles are universally applied to weight training and competitive weight lifting. What is surprising, perhaps, is that these principles have not as yet been effectively applied to manual handling training.

Conclusions

Based on the experience of this project, and in the context of the lifting of low-lying objects, the authors recommend the application of semi-squat principles for purposes of training in lifting, and the avoidance of the leg-lift and stoop-lift. At the same time it is acknowledged that the issue of training remains unresolved in scientific terms, especially where safety is concerned, and that only long-term research can achieve such resolution. In the interim, until appropriate research becomes available, the need for credible training guidelines remains. In an effort to meet that need a set of guidelines has been formulated, based on the project reported here (Sedgwick and Gormley, 1996).

The consensus process served to draw attention to the limitations (notably the bio-mechanics bias) of research into lifting, the shortcomings of training in industry, and the need for an holistic approach to the management and study of lifting. Some urgent topics for research were identified: the long-term effects of applying semi-squat principles on compliance, accidents, and injury; optimal durations and content of training programmes; the effects of general versus job-specific training on adaptability; and individual variations in use and mastery of semi-squat principles as a function of age, physique, work capacity, and training. In retrospect, the consensus process showed itself to be a valuable method for promoting multi-disciplinary examination of current practise (of many kinds), and for integrating diverse professional interests within a defined operational context. It is difficult to imagine a more productive way of initiating thorough examination of complex issues, like lifting, and for promoting change on a rational basis.

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