BACK TRAUMA IN INDUSTRY

D.A. Stubbs and P.R. Davis
Department of Human Biology and Health
University of Surrey
GU2 5XH
(England)

SUMMARY

The incidence of industrial accidents and in particular back injuries attributed to manual handling will be considered in relation to the age and occupations at high risk in two large industries. That the risk of industrial accidents and back injuries in particular is greater in the lower age group (17-30 years of age) in the Building and Construction Industry, and in the middle age group (31-48 years of age) for the P.O. Telecoms Engineers will be discussed in relation to acute and cumulative trauma with particular reference to work experience and long-term employment following such trauma. The risk to occupations within each industry will be related to the manual efforts required by those occupations and these data considered in light of age.

The radio pill methodology which enables an indirect measure of truncal stress to be made during physical activities, will be considered briefly. The paper will describe two preventative approaches as applied to back injuries arising from manual materials handling, the first being amelioration of existing industrial problems, the second being the establishment of design guidelines for future working environments. Such safe industrial contours have now been established for forces which can be applied by the hands within the human reach envelope. Examples will be given of these industrial contours, together with age variation and these discussed in light of the industrial epidemiological data. The need for similar data for female industrial workers will also be discussed.

BACKGROUND

Back trauma in industry differs from those accidents reported here earlier in that they seldom involve matters of life or death. They are, however, still of great importance for many people and their socio-economic influence is vast. It has been estimated that in the United Kingdom back pain accounts for 13.2 million lost working days a year (Benn and Wood, 1975) and costs approximately £1.0 million a day, and is clearly a major concern, both for industry and those who suffer.

Where back trauma is similar to those papers previously presented is that in both, impacts are implicit. Indeed, Arvikar and Seireg (1978) using a musculoskeletal model to determine the distribution of spinal disc

pressures in the seated posture subjected to impact noted that in a 72Kg man the disc load at L4/L5 was greater when stoop-lifting 45.5Kg (441.2Kg) than when either subjected to a 1G forward or backward acceleration (278.8 and 354.8Kg respectively). With back trauma, for example when lifting a load, pushing your car or digging the garden, forces are generated over a relatively short time scale to move the object and simultaneously these forces are being applied to the lifter, and through the linkage system, including the spine, to the feet and the ground. It has been shown directly using intra-discal pressure measurements, (Nachemson and Elfstrom, 1970) and indirectly using intra-abdominal pressure measurements (Davis, 1956; Stubbs, 1975; and Davis, Stubbs and Ridd, 1977) that during such activities the load on the spine is increased, this increase being dependent on the magnitude of the load (Davis and Troup, 1964; Morris, Lucas and Bresler, 1961; and Stubbs, 1975), the acceleration applied to it (Eie, 1966; and Davis et al, 1965), the torque on the trunk (Davis and Stubbs, 1977, 1978; and Anderson et al, 1976), and the posture adopted (Davis et al, 1965; and Stubbs, 1975). More recently the effects of age in industrial populations have been considered in relation to safe working capacities when manual materials handling (Davis et al, 1979).

Of particular concern to the Materials Handling Research Unit (MHRU) at the University of Surrey has been the prevention of back trauma in industry arising from both acute and cumulative origins. The latter expression represents two groups of pathological conditions for primary consideration from the aetiological standpoint: a) those in which long-term effects of load handling are superimposed upon other factors and contribute to, or are associated with, the degenerative conditions of the musculo-skeletal system, and b) those in which the forces of insult are greater and produce immediate effects of acute trauma and industrial injury (Jackson, 1968). Thus, manual handling may result not only in acute accidents, but also in an incalculable, insidious decrease in work output, loss of earning capacity, and diminution of skilled abilities.

Of the industrial groups studied to date by the MHRU, two are included here to illustrate the complete methodology.

I Construction Industry

To identify those age and occupational groups at high risk, where safety input with regard to manual handling and back trauma are urgently needed, existing accident data have been re-examined.

Results

From the analysis (2,437 three-day-plus reports) it was noted that back trauma constituted 22.4% of all accidents, materials handling giving rise to 45.9% of these injuries. It was also noted, as shown in

Table I, that the younger population (16-30) and those occupations defined as involving heavy manual work (Table 2) had significantly higher rates ($p < 0.005$) of back injuries attributed to manual handling than the older population (31-46+) and light occupations.

TABLE I

BACK INJURIES ATTRIBUTED TO HANDLING BY AGE WITHIN THE CONSTRUCTION INDUSTRY, 1975-1977

Age Group	Sample Size	No. of Handling Back Injuries	Frequency No./1000 at risk
16 - 30[1]	16,046	116	7.2[x]
31 - 45[2]	20,787	99	4.8
46+[3]	16,833	76	4.5

1 > 2 and 3 x^2 = 8.9 and 9.8 respectively [x] $p < 0.005$

TABLE 2

BACK INJURIES ATTRIBUTED TO HANDLING BY LIGHT AND HEAVY OCCUPATIONS WITHIN THE CONSTRUCTION INDUSTRY, 1975-1977

Handling Group	Sample Size	No. of Handling Back Injuries	Frequency No./1000 at risk
Heavy[1]	31,090	240	7.7[x]
Light[2]	22,576	78	3.5

1 > 2 x^2 = 39.2 [x] $p < 0.001$

Further, the work of brick/blocklayers and labourers (both heavy occupations) require 1000 or more lifts per day of loads up to 70Kg, often in a stooping position, and laboratory studies have shown that a high proportion of these lifts in the observed postures induce peak intra-abdominal pressures in excess of 100mmHg (13.3KPa) (Stubbs, 1975). For the light occupations, similar observations show that the handling of their loads (most weighing less than 15Kg) rarely induce peak intra-abdominal pressures in excess of 60mmHg (8.0 KPa). Thus there appears to be an increased liability of back injury in those workers in the construction industry sustaining repeated, frequent, high trunk

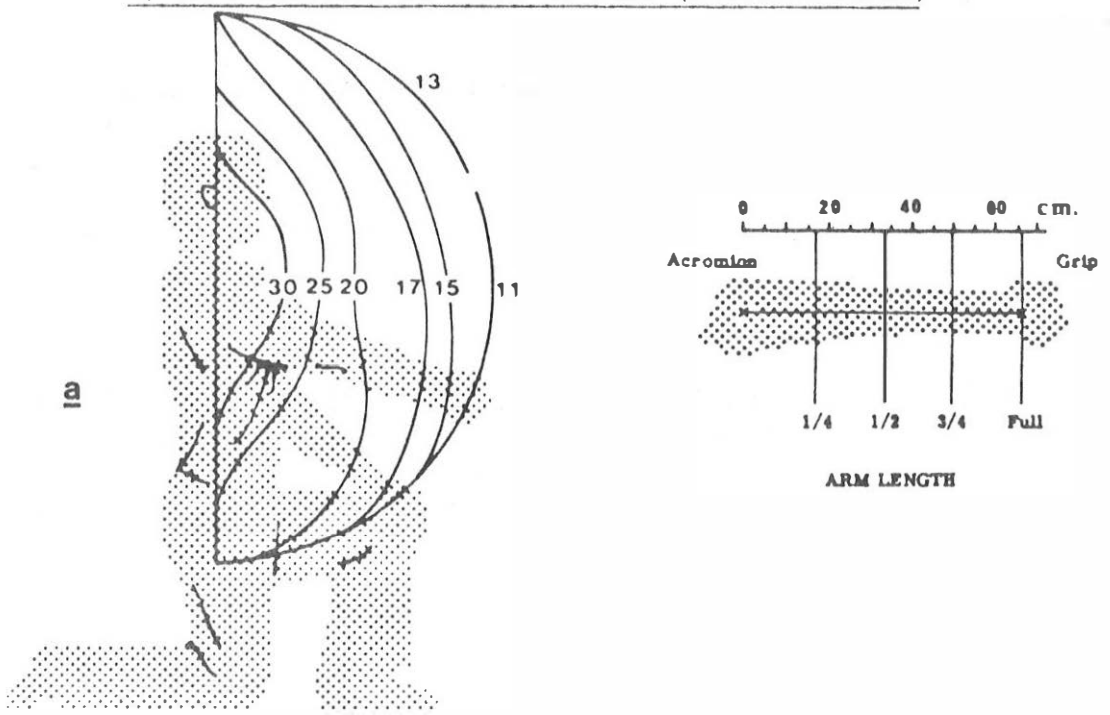
stresses inducing peak intra-abdominal pressures above 100mmHg (13.3 KPa) (Davis and Stubbs, 1978).

This level of intra-abdominal pressure has subsequently been used to establish designers' guidelines in the form of contours, part of an example of which is given in Figure 1, for young fit adult males (Davis and Stubbs, 1977, 1978). Such contours can be used in two ways, first to examine safety in existing handling tasks, and secondly when designing a new work environment. The effects of age in relation to these contours will be considered later (see III).

FIGURE 1

CONTOURS OF SAFE VALUES (KG) FOR ONE-HANDED VERTICAL LIFTS WHEN KNEELING

a) HAND DIRECTLY IN FRONT OF BODY (SAGITTAL PLANE)



II Telecommunications Industry

Accident records from the telecommunications industry (TI) covering some 100,000 engineers over a period of 12 months have been examined. Back injuries constituted one-quarter of all accidents, materials handling giving rise to two-thirds of the injuries (Davis and Sheppard, 1979) and a mean accident rate of 22.4 per 1000 men at risk was observed. When age and occupation are considered, however, a clearer picture emerges. It is noted, as shown in Table 3, that those under 30 years and over 48 years have a significantly lower ($p < 0.001$) back rate attributed to handling than those between 31 and 47 years of age.

TABLE 3

BACK INJURIES ATTRIBUTED TO HANDLING BY AGE WITHIN THE TELECOMMUNICATIONS INDUSTRY, MAY 1977 - APRIL 1978

Age Group	Sample Size	No. of Handling Back Injuries	Frequency No./1000 at risk
16 -30[1]	42,141	120	2.8
31 - 48[2]	39,673	201	5.0[x]
49+[3]	19,117	42	2.2

2 > 1 and 3 x^2 = 24.9 and 24.9 respectively [x] $p < 0.001$

Further, those occupations having significantly higher rates than the overall accident rate ($p < 0.05$) encompassed all occupations involving manual work performed outdoors, where work conditions are less controlled (Table 4). This group also had significantly higher rates of back injuries attributed to handling ($p < 0.001$). From the analysis it was noted that this high risk group (top 23 codes) which constitute 33% of the total population at risk, suffered 70% of all three-day-plus accidents. They also had a greater proportion of accidents caused by handling objects and they more frequently met problems involving manhole covers, digging, water pumps, gas bottles, ladders and compressors etc.

TABLE 4

BACK INJURIES ATTRIBUTED TO HANDLING BY DUTY CODE (OCCUPATION) WITHIN THE TELECOMMUNICATIONS INDUSTRY, MAY 1977 - APRIL 1978

Duty Codes	Sample Size	No. of Handling Back Injuries	Frequency No./1000 at risk
Top 23[1]	33,335	260	7.8[x]
Other 56[2]	67,596	103	1.5

1 > 2 x^2 = 241.2 [x] $p < 0.001$

From contour applications and direct intra-abdominal pressure measurements, it was observed that without exception all the activities noted above involved truncal stresses inducing peak intra-abdominal

pressures in excess of 90mmHg (12.0 KPa). In addition, it was noted that the greater the number of these activities and the frequency with which they are performed as part of that duty code, the greater is the risk of back trauma.

III Safe Handling Capabilities in Relation to Age

The methodology for the establishment of safe handling forces in working situations is presented elsewhere (Davis and Stubbs, 1978) and the contours for fit young adult males previously published (Davis and Stubbs, 1977, 1978). To investigate the effects of age, calibrated radio pressure pills (Davis, Stubbs and Ridd, 1977) were swallowed by 200 general industrial male workers between 18 and 61 years of age and intra-abdominal pressures monitored during a variety of standardised handling tasks when standing, sitting and kneeling. To give safe values to the contours, we have inserted for each age group those loads in relation to the trunk that result in a maximum intra-abdominal pressure of 90mmHg (12.0 KPa) in 90% of the population investigated. The new age corrected contour data are being published shortly and follow the trends outlined in Figure 2, which shows the percentage change from the original fit young adult male population (Army) for each age group. It is particularly noted that there is a significant decline in safe capacity after 50 years of age ($p < 0.001$).

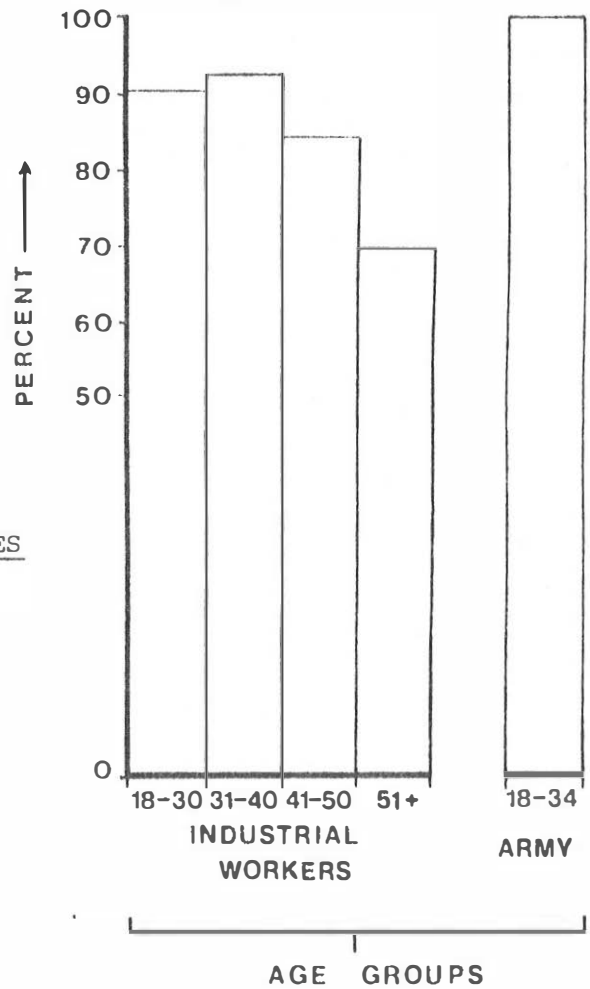


FIGURE 2

SAFE LOADING LEVELS FOR DIFFERENT AGE GROUPS: EXPRESSED AS PERCENTAGES OF THE ARMY CONTOUR WEIGHTS

DISCUSSION

An important observation of these analyses has been the high incidence of back injuries attributed to handling within both industries, but more particularly within certain occupations and age groups. For the construction industry the finding that back injuries attributed to handling occur most frequently in the younger population (16 - 30) supports directly and indirectly the evidence of Wilkins et al (1957); Kosiak et al (1968); Shepherd (1970); and Blow and Jackson (1971). In particular, Shepherd (1970) notes that 60% of incidents occurred during the first year of employment, suggesting inexperience as one of the probable causes of back trauma. This is supported by Blow and Jackson (1971) who noted a similar high risk group in the younger worker and add inadequate training and attitudes to manual handling in the younger age groups, whose members take pride in their muscular strength rather than their physical skill, to the inexperience noted by Shepherd (1970).

In relation to the aetiology of back trauma, the construction industry results would support the concept of acute trauma and industrial injury at an early age (16 - 30) (Stubbs and Nicholson, 1979). This frequently results in the fall-out of younger men from the construction industry due to back pain and the mature construction worker may be considered a survivor. Similar results have been observed for other heavy industrial worker groups (Partridge et al, 1968).

With the telecommunications industry the results in relation to age groups at high risk would support the accumulation of minor damage over a number of years, the peak at 31 - 48 arising from the superimposing, on the long-term effects of load handling of an acute incidence which of itself may not otherwise have caused an injury. It is noted from the study that only 7% of the back injuries observed occurred during the first year of employment. Further, of those who suffered trauma leading to a permanent disability, however slight, the majority were redeployed in lighter duties within the industry.

The observation from both industries of occupations with a higher risk from back trauma is typical of most industries studied by the MHRU and highlights the need for selective preventive measures. Related to the observation that for the telecommunication industry 65% of back injuries were associated with handling accidents, and for the construction industry that 45.9% of such injuries involved handling, is the further observation that both high risk groups within each industry perform frequent activities inducing high truncal stresses inducing peak intra-abdominal pressures in excess of 90mmHg (12.0KPa). Previous studies have highlighted the problem of handling heavy objects as one of the associated causes of back trauma. Roantree (1963) noted that in nearly 50% of 111 cases of back lesions with a clear history as to cause, lifting weights was implicated. Hence it would seem that one of the factors affecting accident incidence in the telecommunications industry top 23 codes is the number of specific handling problems encountered which expose the individual to a risk of back injury. Indeed, the observation that the greater the number of identifiable

stressful activities performed as part of a duty code the greater is the back risk, reinforces this hypothesis.

In relation to the preventive work of the MHRU once the high risk groups are identified, the tasks performed by those groups are evaluated either by contour or direct pill application. Once the stress caused by a given activity is known, this can be compared with standard measurements and the safety of any particular procedure with regard to possible hazard to the back can be assessed. If the activity appears hazardous, alternative procedures can be tested, and where a safe method is found it can be recommended for adoption. Of course, in many of the studies carried out be the MHRU there are activities where the nature of the environment or load is such that a particular handling task observed can only be carried out in a stressful manner, that is, the hazard is built into the system. In some, mechanical aids can be used, for example lift trolleys for manhole cover handling in the telecommunications industry. However, in some situations even these cannot be used because of the design, or lack of it, of the work place.

To be able to evaluate the safety of all existing manual tasks objectively, and to allow safety in future designs of working environments, contour data is now available and can have many uses. Two of which would seem important to industry, a) to designers of equipment, vehicles and to system designers in that where any force needs to be applied by the worker, the designer can readily see if it is within normal capabilities, and, if not, can adjust the position to bring it within that capability. b) when an existing task appears to be stressful, measurements of the force required and of the position relative to the trunk will allow a direct reading from the contour.

The present contours are applicable to 90% of the male industrial population and therefore tasks which fall outside the safe zone should either be redesigned or selection criteria applied to those who have to perform them either on the basis of physique or age. In relation to age when compared with 31 - 40 year olds, both 18 to 30 and 41 to 50 year olds had slightly reduced capacities but 51 to 61 year olds had significantly reduced capacities ($p < 0.005$).

This work is still proceeding to produce for females that which is now available and validated for males. This is particularly important in relation to the Health and Safety and Discrimination at Work Acts, as it has been shown that back trauma is not simply confined to male dominated industries (Stubbs and Osborne, 1979). This, together with further field application of the available male contour data and direct pill assessment of truncal stress in addition to further morbidity studies will give us more data that can be utilized to try and prevent some of the enormous man power wastage occurring through back trauma at work.

CONCLUSIONS

Industrial accidents and particularly back trauma attributed to manual handling occur frequently in the younger population in construction workers and in the middle age group of telecommunication engineers. These findings support the hypothesis that back trauma arise commonly either as a result of an acute incident as in the case of the CI or as the result of an accumulation of minor damage over a number of years, this being illustrated by the TI epediomiology. The earlier onset seen in industries with high accident rates suggest that stresses imposed on the trunk are greater or more frequent, and induce back trauma at an earlier age. This may lead to some workers leaving an industry, as in the case of the CI, or being redeployed within it (TI).

Industrial accidents also appear more frequently in certain occupations within an industry than others; those occupations having relatively more specific handling problems. Further from laboratory and field measurements there appears to be an increased liability of back trauma in those workers exposed to tasks inducing peak intra-abdominal pressures above 100 mmHg (13.3 kPa). Using a slightly reduced level from this (90 mmHg) safe contours have been established for male industrial workers between 18 and 61 years of age. In this it is noted that after 50 years of age there is a significant decline in safe capacity, this being important for safety analysis and task designing alike where manual handling inputs are required. The need for similar data for female workers is apparent.

ACKNOWLEDGEMENTS

The authors wish to express appreciation to both the PO and ECSC for funding part of this research and in providing volunteers without whose cooperation the establishment of the contour data would have been impossible.

BIBLIOGRAPHY

ANDERSON, G.B.J., ORTENGREN, R. and NACHEMSON, A. (1976) Quantitative studies of back load in lifting. Spine 1, 178-185.

ARVIKAR, R.J. and SEIREG, A. (1978) Distribution of spinal disc pressures in the seated posture subjected to impact. Aviation, Space and Enbironmental Medicine 49 (1): 168-169.

BENN, R.T. and WOOD, P.H.N. (1975) Pain in the back: An attempt to estimate the size of the problem. Rheum. and Rehab. XIV, 3, 121-128.

BLOW, R.J. and JACKSON, J.M. (1971) Rehabilitation of registered dock workers - an analysis of back injuries in registered dock workers. R. Soc. Med. Prac., 64, 7. 753-757.

DAVIS, P.R. (1956) Variations of the intra-abdominal pressure during weight-lifting in various postures. J. Anat., 90, 601 (p).

DAVIS, P.R. and TROUP, J.D.G. (1964) Pressures in the trunk cavities when pulling, pushing and lifting. Ergonomics, 7, 4, 465-474.

DAVIS, P.R., TROUP J.D.G. and BURNARD, J.H. (1965) Movements of the thoracic and lumbar spine when lifting; a chronocyclophotographic study, J. Anat., 13-26.

DAVIS, P.R., STUBBS, D.A. and RIDD, J.E. (1977) Radio pills: their use in monitoring back stress. J. Med. Eng. and Tech., 1, 4, 209-212.

DAVIS, P.R. and STUBBS, D.A. (1977, 1978) Safe levels of manual forces for young males. 1, 2 and 3. Applied Ergonomics 8, 141-150, 8, 4, 219-228 and 9, 1, 33-37.

DAVIS, P.R. and STUBBS, D.A. (1978) A method of establishing safe handling forces in working situations. DHEW (NIOSH) Pub. No. 78-185 pp 34-38.

DAVIS, P.R. and SHEPPARD, N.J. (1979) The pattern of accident distribution in the telecommunications industry. Brit. J. Ind. Med. (in press).

DAVIS, P.R. et al (1979) Determination of safe levels of loading for manual handling. ECSC Res. Pro. No. 7245-31-8-001.

EIE, N. (1966) Load capacity of the low back. J. Oslo City Hosp., 16, 73-98.

JACKSON, J.M. (1968) Biomechanical hazards in the dockworkers. Ann. Occup. Hyg. 11, 147-157.

KOSIAK, M., AURIELIUS, J.R. and HARTFIEL, W.F. (1968) The low back problem - an evaluation. J. Occup., Med. 10, 588-593.

MORRIS, J.M., LUCAS, D.B. and BRESLER, B. (1961) The role of the trunk in stability of the spine. J. Bone. Jt. Surg. 43A, 327-351.

NACHEMSON, A. and ELFSTROM, G. (1970) Intravital dynamic pressure measurements in lumbar discs. Scand. J. of Rehab. Suppl. 1, 5-40.

PARTRIDGE, R.E.H., ANDERSON, J.A.D., McCARTHY, M.A. and DUTHIE, J.J.R. (1968) Rheumatic complaints among workers in iron foundaries. Ann. Rheum., Dis., 27, 244-253.

ROANTREE, W.D. (1963) The mobilisation and use of heavy mining equipment as a cause of back stress. Med. Off. Broadsheet IV, 3.

SHEPHERD, P.M. (1970) Personnel communication.

STUBBS, D.A. (1975) Trunk stresses in construction workers. PhD Thesis, University of Surrey, England.

STUBBS, D.A. and NICHOLSON, A.S. (1979) Manual handling and back injuries in the construction industry: An investigation. J. Occup. Acc. 2, 3, 179-190.

STUBBS, D.A. and OSBORNE, C.A. (1979) How to save your back. A comparison between the nursing profession and construction industry. Nursing 3, 118-124.

WILKINS, G.F. and SCHILLING, J.W. and SCHOWALTER, E. (1957) Industrial back injuries - Bell system. Arch. Ind. Health, 15, 91-100.