Magnitude and distribution of trunk stresses in telecommunications engineers

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ABSTRACT The incidence of back injuries has been shown to be greater in occupations defined as heavy manual work than light manual work. To plan a programme aimed at reducing the incidence of back injuries in industry those workers at high risk of incurring handling accidents and back injuries need to be identified and a knowledge of the specific occupational factors causing such injuries sought. This has been achieved for telecommunications engineers using epidemiological and radio pressure pill methodologies. The results verify the correlation between the back injury rates and physical work stresses of different occupational groups. The magnitude and relative frequency of trunk stresses in hazardous tasks has been determined and compared with those with lower incidences of back disorders. The study has confirmed that in examining manual handling hazards in industrial male populations a critical value of truncal stress can be applied and used to determine the safety of occupational factors in relation to their potential for causing or contributing to degenerative back disease.

It is widely recognised that low back ailments and disorders are a major source of disability, discomfort, and distress to a large proportion of the population. It has recently been estimated¹ that as a nation we lose 19.2 million working days each year because of back pain. Many studies have shown that the incidence of back disorders is greater in occupations defined as heavy manual work than in light industry and that hard physical work promotes the appearance of degenerative back disease.²⁻¹¹ It is because of these observations that there is an increasing demand in industry for training in safe and efficient methods of manual materials handling. Despite concerted efforts in certain industries to reduce the incidence of industrially related back injuries, it has remained remarkably constant. Probably general handling training is insufficient, and careful identification and consideration of those workers particularly at risk of incurring handling accidents and back injuries and a knowledge of the specific occupational factors contributing to such pathologies is necessary before any programme of preventive action can be effectively applied.

In a previous study¹² a detailed analysis of accident

morbidity in the British telecommunication industry was undertaken to determine those groups of workers in terms of their occupations, ages, and experience at greatest risk of incurring manual handling accidents, back injuries, and back injuries specifically attributed to handling accidents. Twenty-three duty codes or occupational groups were found to have accident rates significantly greater ($p < 0.05$) than the overall accident rate. Further it was found that these "top 23" duty codes, which constitute only 33% of the engineer's population, suffer 70% of all reportable accidents—that is, accidents causing absence from work for three days or longer. It was therefore concluded that in searching for the occupational factors giving rise to these accidents that most benefit could be obtained from studying the work methods of these top 23 groups.

Method

Detailed field observations of these 23 high risk groups were carried out over a 12-month period beginning in the summer months of 1978. A preliminary observation period of half a day of all the top 23 duties was carried out first to gain an understanding of the type of work and activities in which the engineers were engaged. The men were asked to carry out their

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normal duties and were questioned in order to provide information regarding other aspects of their job. For 12 of the top 23 duty codes—that is, those found to have back injury rates greater than the mean back injury rate of the top 23—a second observation period was carried out to quantify the truncal stresses incurred by the engineers while carrying out their normal duties. The duration of this observation was determined by the various activities that the engineer performed but generally lasted from one-half to one full day.

The methodology for measuring truncal stresses was developed by the materials handling research unit and is based on observations by Davis¹³ and Morris *et al*¹⁴ and others that during lifting and other manual handling activities there is a close correlation between the magnitude of stress on the trunk and the magnitude of intra-abdominal pressure (IAP) in men. The technique requires the engineer to swallow a calibrated radio pressure pill¹⁵ and to carry out his duties while his IAP is measured.

In some cases the measurement period did not adequately cover a sufficient range of all possible activities, and a third observation period was arranged and measurements made in the same manner to cover the occupational tasks performed. When those activities found to be inducing high IAPs were identified, a further observation and measurement period was arranged to study more closely the factors contributing to these stressful activities and to test alternative work procedures to reduce the truncal stresses incurred.

Results

During the 42 periods of observation IAP measurements were made of a wide variety of the occupational tasks performed throughout the duty codes. These measurements were accumulated into common activity groups (table 1). With tasks requiring repeated actions, such as digging, the frequency of actions was counted and is also presented in this

Table 1 Accumulated results of intra-abdominal pressure measurements for various occupational tasks recorded during field studies

Activity	Intra-abdominal pressure measurements (mm Hg)									
	Mean	STD DEV	No ≥ 30	No ≥ 50	No ≥ 90	No ≥ 120	No ≥ 150	Rate/min	No of men concerned	No of observation periods
Pole handling	76.56	19.36	41	38	11	—	—	—	1 or 2	1
Air bottle handling	75.40	40.32	50	35	15	9	1	—	—	3
Out of manhole	123.64	35.44	11	11	9	6	1	—	2	1
In and out of vehicle	61.79	30.04	39	24	6	3	—	—	1 or 2	3
Cover and joint box handling	74.31	33.41	129	92	41	11	3	—	—	6
"Silent Knights"	80.36	41.85	47	34	18	7	3	—	1 or 2	3
"Elkingtons"	71.29	25.54	14	11	3	1	—	—	2	1
Other types	70.63	27.85	67	47	20	3	—	—	1 or 2	4
All 2-man handling	77.40	33.82	113	85	39	11	3	—	2	5
All 1-man handling	52.50	20.10	16	7	2	—	—	—	1	2
Water pump handling	72.48	36.36	106	77	25	11	5	—	—	6
1 man field situation	89.46	39.88	56	49	23	11	5	—	1	4
2 man field situation	60.91	11.86	22	19	1	—	—	—	2	3
1 man stores situation	53.00	16.29	15	9	1	—	—	—	1	1
2 man stores situation	40.00	4.36	13	—	—	—	—	—	2	1
Handling cable drums	62.40	17.05	48	36	2	—	—	—	1 or 2	3
Generator handling	59.60	22.86	20	12	3	—	—	—	1	2
Gas bottle handling	58.56	20.64	37	23	4	—	—	—	1 or 2	6
Rodding and cabling	54.35	21.29	146	75	12	1	—	25	—	3
Stoop posture	56.78	21.37	129	74	12	1	—	24	1	3
Kneeling posture	36.00	6.82	17	1	—	—	—	26	1	1
Battery handling	52.24	18.78	29	13	2	—	—	—	1	2
Trailer handling	52.09	20.07	58	25	3	1	—	—	2+	2
Digging activities	45.06	13.85	697	196	9	—	—	22	—	4
Short-handled shovel	63.69	14.88	48	40	3	—	—	33	1	1
Long-handled shovel	58.29	16.21	45	29	2	—	—	17	1	1
Ordinary spade	47.11	15.91	108	35	4	—	—	20	1	3
Ordinary shovel	43.41	12.30	78	23	—	—	—	23	1	1
Other eg cutting turfs	42.00	12.01	37	8	—	—	—	15	1	2
Forking	41.65	10.36	382	70	—	—	—	19	1	2
Long-handled spade	39.65	7.99	63	9	—	—	—	29	1	1
Ladder handling	40.68	8.37	68	11	—	—	—	—	1	3
Wiring joints	25.55	5.45	3	—	—	—	—	—	1	1
Light bricklaying	20.84	5.41	3	—	—	—	—	—	1	1
Working up poles, masts etc	20.56	5.51	2	—	—	—	—	—	1	1
Light underground cabling	19.27	3.08	1	—	—	—	—	—	1	1

No activities caused peak IAP measurements under 30 mm Hg (4.0 kPa), therefore data under heading "No ≥ 30 " also refers to total number of measurements contributing to the means.

Table 2 Digest of occupational tasks performed by duty code

Duty code No	Back injury rate (per 1000 at risk)	Occupational tasks									
		Handling poles	Handling manhole covers	Handling mechanical aids	Handling cable drums	Rodding and cabling	Handling batteries	Handling trailers	Digging	Handling heavy loads	Driving and delivering
02	66.7		●	●	●	●	●	●	●		
13	51.9		●	●	●	●	●	●	●		
04	26.6		●	●	●	●	●	●	●		
07	25.0		●		●	●	●	●	●		
06	24.6	●							●		
61	22.9		●	●	●	●	●	●	●		
01	17.5		●	●	●	●	●	●	●		
65	16.8		●	●			●	●	●		
41	16.2								●		
03	15.7		●	●	●	●	●	●	●		
14	14.2		●	●	●	●	●	●	●		
26	14.2					●	●			○	
72	14.1										
53	12.8									○	
08	12.5									○	
79	14.1									○	
77	11.8								●	○	
64	10.5			●						○	
78	10.4								●		○
62	10.3			●				●		○	
05	10.3					●					
10	10.1		●								
07	9.5		●	●			●		●		
48	9.0					●	●			○	
63	8.6		●								
15	8.6		●								
39	8.5									○	
71	8.3										
76	7.0			●			●			○	
52	6.9										
58	6.5										
22	6.2		●								
60	5.0									○	
17	4.5										
16	4.4		●								
49	4.2										
24	4.0										
25	3.8									○	
69	3.5										
66	3.5										
32	3.3										
27	3.1										
40	3.0										
11	2.8		●								
44	2.6										
23	2.4									○	
59	2.1									○	
09	2.0		●								
31	2.0										
45	1.4										
57	1.4										
55	1.3										
37	1.1										
21	1.1										
51	1.0										
36	1.0										
18	1.0										
33	1.0										
80	0.8										
46	0.5										
28	0										
50	0										
42	0										
73	0										
47	0										
30	0										
56	0										
74	0										
12	0										
38	0										
29	0										
20	0										
19	0										
43	0										
75	0										
35	0										
68	0										

● Activities giving rise to intra-abdominal pressures ≥ 90 mm Hg (12.0 kPa).○ Activities giving rise to intra-abdominal pressures < 90 mm Hg (12.0 kPa).

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Table 3 Comparison between accident rates for light and heavy occupations within the telecommunications and construction industries

Accident category	Accident rate (per 1000 at risk)			
	Light occupations		Heavy occupations	
	Telecomms industry	Construction industry	Telecomms industry	Construction industry
All accidents	10.4*	32.3*	46.9	58.4
Handling accidents	3.0*	5.2*	16.0	15.6
Back injuries	2.3*	6.2*	12.3	13.2
Back injuries attributed to handling incidents	1.5*	2.7*	7.8	8.0

* Level of significance between occupational groups $p < 0.05$.

table. In addition, where the same activities were performed under different environmental conditions or where two or more items of equipment or different models were used, the IAP measurements have been grouped separately for comparative purposes.

From this information and a knowledge of the job descriptions and activities of each of the 79 duty codes, it was possible to compile a digest of occupational tasks performed by duty codes as shown in table 2. The duty code groups are ranked from top to bottom in order of decreasing back injury rate as calculated from the analysis of accident returns described elsewhere.¹² For each duty code the occupational tasks performed are marked by either a dot or a circle as explained in the footnotes to the table. The tasks listed are ranked from left to right in order of decreasing mean intra-abdominal pressure as presented in table 1. For simplicity, the tasks "water pump and generator handling" and "air bottle and gas bottle handling" have been regrouped in table 2 under the title "handling mechanical aids." Other tasks listed in table 2, but without corresponding data in table 1, have either been included based on the results of field studies in other industries or have been nominally assigned IAP values based on the physical labour content of the task in relation to the other activities.

The accident rates of all accidents, handling

accidents, back injuries, and back injuries attributed to handling incidents for the light and heavy occupations of the telecommunications and construction industries are presented in table 3. In this context heavy occupations in the telecommunications industry refer to the top 23 duty codes, and in the construction industry to such trades as roofing tilers and labourers.¹⁰ Light occupations refer to the remaining 56 duty codes in the telecommunications industry and trades, such as carpenters, painters, and drivers in the construction industry. When the industrial groups were compared, the accident rates of all four accident types for light, but not heavy, occupations were found to be significantly different.

Table 4 shows the 11 duty codes with the highest back injury rates. The 12th duty code with a back injury rate greater than the mean back injury rate of the top 23 was a low population group incurring very few back injuries, and was therefore excluded from considerations specific to these groups of high risk duties.

Discussion

In previous studies investigating manual handling hazards in the building and construction industry, Stubbs and Nicholson¹⁰ found that the trades defined as heavy manual work had significantly higher back injury rates ($p < 0.01$) than the light occupations. Stubbs¹⁶ and Davis and Stubbs¹⁷ found that the work of the operatives comprising the heavy occupations included a high proportion of frequent, heavy lifts giving rise to IAPs in excess of 100 mm Hg (13.3 kPa). Operatives in the light occupations were found to handle loads less frequently; those loads which were handled rarely resulted in IAPs exceeding 60 mm Hg (8.0 kPa). Thus there appears to be an increased liability to back injuries caused by load handling in those workers in the construction industry sustaining repeated, frequent high trunk stresses inducing peak IAPs in excess of 100 mm Hg (13.3 kPa). From later laboratory

Table 4 List of 11 duty codes with the highest back injury rates

Duty code	Back injury rate (per 1000 at risk)
Rodding and cabling (3-man party)	66.7
General purpose installation party	51.9
Rodding and cabling (2-man party)	26.6
Manhole box building	25.0
Pole erection unit	24.6
External general purpose maintenance	22.9
Cabling in ducts	17.5
Maintenance jointers	16.8
Maintenance transmission equipment	16.2
General purpose external party	15.7
Installation jointers	14.2

studies^{18 19} it was considered necessary to regard the value of IAP of 90 mm Hg (12.0 kPa) as "safe" for British male industrial workers.

Since it has been shown (table 3) that the trades defined heavy occupations in the construction industry cannot be distinguished from the top 23 duty codes of the telecommunications industry, the hypothesis that 90 mm Hg (12.0 kPa) can be regarded as a criterion for safe manual handling, and that repeated, frequent high trunk stresses give rise to an increased liability to back injury can be rigorously assessed.

Several observations may be made from table 2. It is first apparent that a relationship exists between the incidence of back injury and the manual handling content of the various duties. The 11 duties with the highest back injury rates (table 4) may be seen to carry out a high proportion of manual handling tasks, particularly those that are more physically demanding and which give rise to IAPs in excess of 90 mm Hg (12.0 kPa) and result in high mean IAPs. All 11 of these duty codes are included in the top 23.

The next group of 18 duty codes with back injury rates from 14.2 to 7.0 per 1000 at risk range from works control engineers and pole testing gangs to one-man telephone installers and maintenance gangs. These duties require a mixed range of handling activities. Fewer than 40% of the occupational tasks carried out by these duties gave rise to IAPs in excess of 90 mm Hg (12.0 kPa) compared with 71% for the first group. Seven of these duty codes are included in the top 23.

The remaining duty codes have back injury rates ranging from 6.9 to 0 per 1000 at risk. Of all the tasks performed, only four (4%) were found to give rise to high truncal stresses. These groups are predominantly of a sedentary nature, being largely supervisory staff, rarely required to perform manual handling tasks. Only five of these duty codes are included in the top 23.

The frequency with which the tasks are carried out can be summarised in the following manner. The manhandling of poles, cable drums, and trailers is performed by specific duty codes at infrequent intervals throughout the day except in exceptional circumstances. Rodding and cabling, although also performed by specific duty codes, are carried out much more frequently, tending to be undertaken in bursts of activity, the timing of which is governed by the engineers themselves. Handling covers and joint boxes, mechanical aids, and digging are tasks frequently carried out during the day, as are ladder handling and lifting light unspecified equipment. The remaining activities are all specific to certain duty codes. Except in the few instances where these activities are fundamental descriptions of the

occupation the engineers perform, these tasks are carried out infrequently during the day.

Clearly, therefore, those groups of workers with the highest back injury rates carry out the greatest proportion of handling tasks. Of these, most (71%) give rise to IAPs in excess of 90 mm Hg (12.0 kPa). Conversely, those groups with the lowest back injury rates carry out manual handling tasks less frequently, and a small proportion (4%) of these induce pressures greater than 90 mm Hg (12.0 kPa). By examining table 1 it can be seen that the remaining 96% of the tasks carried out in this group give rise to IAPs below 50 mm Hg (6.7 kPa). The middle group of 18 duty codes consists of duties demanding a mixed spread of activities with a correspondingly varied handling component and frequency.

These results confirm the observations made in the construction industry—that there appears to be an increased liability to back injury in workers performing a high proportion of frequent, heavy lifts inducing IAPs in excess of 90 mm Hg (12.0 kPa). In addition, they add support to the argument that there is a close correlation between the manual handling content of an occupation and the appearance of back disorders.

Davis and Sheppard¹² found that back injuries attributed to handling incidents in the telecommunications industry occur most frequently in the 31-45 year age group and that 93% of all accidents occur after the first year of employment. In the construction industry, however,¹⁰ the 28-39 year olds suffer less frequently from back injuries attributed to handling incidents than 16-18 year olds. These observations support the argument proposed by Jackson²⁰ and others^{21 22} that two types of back injury can occur. Firstly, those in which the forces of insult are great enough to produce acute trauma without the involvement of secondary predisposing factors and, secondly, those in which degeneration of the spine is hastened by the superimposition of long-term effects of load handling on other factors gradually leading to cumulative damage. Apprentices in the construction industry rarely receive any instruction in correct methods of manual handling and are at greatest risk of suffering acute back injuries.¹⁰ Apprentice telecommunications engineers, however, undergo a four-year training during which time they are carefully instructed and supervised. The pattern of accident distribution for telecommunications engineers tends to suggest that they suffer more from degenerative back disorders in their middle ages and survive early acute injury because of their training. Similarly, the 28-39 year olds in the construction industry are most probably those who have survived early acute injury but suffer from the cumulative effects of load handling leading to back

disorders through degeneration of the spine.

Davis and Sheppard¹² also found that in studying the age distribution of the top 23, the younger engineers have a relatively higher back injury rate. As discussed, the occupations comprising the top 23 carry out a high proportion of tasks giving rise to high levels of IAP. It would appear, therefore, that by carrying out these frequent manual handling tasks they are at risk of an earlier onset of degenerative disorders since the load handling is not so frequent or extreme as to cause acute injury but is sufficient to promote degeneration. An earlier onset of low back pain in occupations performing heavy manual work is also reported by Magora and Taustein,⁹ Hult,³ and Anderson *et al.*²³

In addition to heavy and frequent lifting and carrying, two other occupational factors were recognised during field studies as contributing to the degenerative processes in the spine.

Ten of the 12 duty codes found to incur back injury rates greater than the mean back injury rate of the top 23 work out of doors throughout the year, where they are exposed to both wet and cold conditions. Lawrence²⁴ and Kellgren *et al.*²⁵ reported that such conditions increase the incidence of symptoms of degenerative back disease. In considering the contradictory evidence that is also reported, Wickstrom¹¹ suggested that wet and cold work conditions may merely awake or aggravate existing degenerative and rheumatic symptoms.

Incorrect working postures were often encountered, particularly those associated with heavy lifting activities. The stoop lift, known to induce high trunk stresses, was commonly observed.¹⁵ In certain duty codes, notably jointers, prolonged periods of stooping were a common sight. Postural fatigue induced by this practice is recognised as an important element in the production of low back pain.²⁶⁻³⁰

In the eight occupational tasks identified as giving rise to IAPs in excess of 90 mm Hg (12.0 kPa) (table 2) it was found that the truncal stresses incurred while performing the tasks could be reduced by modifying lifting postures and techniques or by altering the design of certain tools and pieces of equipment. For example, in rodding and cabling activities, kneeling or squatting eradicates any necessity for stooping and substantially reduces the IAP (table 1); two men handling water pumps instead of one produces a similar reduction (table 1). Specific measures to reduce back strain can be simply made once the stressful occupational factors have been identified.

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