

A Comparative Assessment of the Impact of Different Occupations on Workers' Static Musculoskeletal Fitness

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An ergonomic assessment of the involvement of static muscular forces like back strength, grip strength and pinch strength in different occupations was made. A study was conducted on 45 normal adult males (15 subjects per group) which included video display terminal (VDT) operators, industrial workers and safety inspectors. Their maximum back strength, handgrip strength and pinch strength were measured with dynamometers. The observed values of back strength were significantly lower in VDT operators while significantly higher in safety inspectors and moderate in industrial workers. The values of grip strength and pinch strength of all sample groups were more or less similar. The findings clearly indicate that static muscular strength varies significantly in different occupations. Heavy static muscular load might lead to an accumulation of metabolic waste and toxins on the back resulting in lower back strength in VDT operators and industrial workers.

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1. INTRODUCTION

Strong evidence of a causal relationship between several occupational factors and musculoskeletal symptoms has been shown in a large numbers of previous studies. The factors identified include heavy lifting, vibration, awkward postures, static work postures and repetitive work tasks, which led to an overall increase in musculoskeletal symptoms

despite mechanization and automatization in work. Musculoskeletal disorders (MSDs) such as work-related neck and upper limb disorders and work-related back disorders are widely recognized for their adverse impact upon employees' productivity and well-being. MSDs cover a large percentage of occupational diseases every year. There are many jobs, e.g., process work (assembly line, sorting, packing and press operation), piece work (clothing

machinists at home or in a factory), office work (keyboard, typing, clerical work), construction work (bricklayers, carpenters, plumbers), which require an application of different body parts, e.g., hand, shoulder, finger, back, leg. In favorable circumstances, these kinds of work contribute to good health and economic achievements. But these types of jobs can affect people's general health condition if the workplace setting is not properly designed as they have to spend several hours in the workplace. A poor work environment with repetitive tasks and static muscular load is also common among many industrial and service occupations and can lead to injuries and MSDs.

Work-related MSDs constitute about half of all MSDs [1] and account for some 15–22% of all instances of sick leave across industry in general (Çakir, 1988, as cited in Roelofs and Straker [2]). Straker [3] reported 44% of compensation cases were for "sprains and strains" and that these cost an average of AUS \$7 400 per case. Whilst MSDs have traditionally been associated with physically strenuous or intensive occupations, there is increasing evidence that sedentary office work and other work requiring constrained sitting or standing postures are associated with a high incidence of MSD [4, 5].

Risk factors relating to MSD development amongst VDT (video display terminal) operators involve different physical factors which include the work environment, equipment layout and furniture characteristics. These physical factors often lead to constrained body postures that are associated with musculoskeletal complaints and employees' reports of discomfort ([6, 7, 8, 9, 10], McPhee, 1993, as cited in [2]).

Cummins, Essig, Glick, et al. [11] reported that in 1990 repetitive strain injury was a hot topic: individuals were spending an increased amount of time at their desk working on computer terminals. They also reported that according to the Bureau of Labor Statistics (BLS) report in 1994 approximately 705 800 cases (32%) resulted from overexertion or repetitive motions. Over 367 000 injuries were associated with overexertion in lifting (65% affected the back), 93 000 were associated with overexertion in pushing/pulling objects (52% affected the back)

and close to 69 000 injuries were caused by over-exertion in holding, carrying or turning objects (58% affected the back).

Another common problem related to occupation is back discomfort. Its exact contributing factors are still not clear. They may be sustained or prolonged postures, and awkward or non-neutral postures of the spine [12]. Holding a position for a long time (sustained or prolonged postures) reduces blood flow, depletes nutrients and leads to a build-up of metabolic waste. On the other hand, twisting, bending or flattening the lower back (awkward or non-neutral postures of the spine) can cause back pain by contributing to stretched, overworked muscles and ligaments.

When back muscles or ligaments are injured from repetitive pulling and straining, the back muscles, disks and ligaments can become scarred and weakened and lose their ability to support the back, making additional injuries more likely. Back disorders are frequently caused by the cumulative effects of faulty body mechanics: excessive twisting, bending and reaching; carrying, moving, or lifting loads that are too heavy or too big; staying in one position for too long; poor physical condition; and poor posture. Prolonged sitting stresses the body, particularly the lower back and the thighs, and it may cause the lower-back (lumbar) region to bow outward if there is inadequate support. This abnormal curvature (called kyphosis) can lead to painful lower back problems, a common complaint among office workers [13].

Thus, in order to protect workers from the risk of developing MSDs, there is always a need to evaluate the level of their musculoskeletal fitness. All musculoskeletal problems generated during occupational activities may be solved with ergonomic interventions. Because the relationship between musculoskeletal injuries and lack of strength has been repeatedly demonstrated by ergonomists and also scientists from other fields, they have concluded that a stronger and fitter person is more healthy and productive. Ridgley and Wilkins [14] showed that the measurement of muscular strength was essential in the field of ergonomics to select suitable workers for

a specific job and to design jobs according to workers' needs.

Thus, we must consider people's optimum ability before organizing their working schedule. It has been shown that selecting workers through an isometric strength test is a means of controlling medical incidents on strenuous jobs in manufacturing tyres [15].

Various methods have been used to identify the functional capacity of a human being, e.g., a questionnaire study, a structured interview, musculoskeletal examination and maximum voluntary effort testing [16].

The best and easiest way to determine a person's maximum voluntary effort is by administering a safe and reliable strength test. A strength test plays an important role in permitting a selection of individuals most likely to be able to perform a job without undue risk of injury to themselves, and in replacing people who do not possess sufficient physical strength to perform a task. It can also help to redesign any work or materials so that they do not produce any muscular stress.

The concept of strength measurement and voluntary muscle contraction has now been explained to all. In previous literature [17] it was clearly stated that maximum voluntary contraction can only be said to be voluntary if a person makes the effort willingly at the time strength is measured. Thus, when people's maximum strength is measured, it should be kept in mind that the value of their actual strength cannot be measured; instead some lower value is achieved which they have given at the time of the experiment with the existing equipment (with the existing equipment at a particular environmental condition) and which may be different if the environmental conditions change.

Isometric strength is defined as the capacity to produce force with a voluntary isometric (muscles maintain a constant length) contraction. The key thing to understand about this type of contraction and strength measurement is that the whole body should be at a fixed position (no movement) during the whole measurement period. The other definitions to bear in mind are (a) isometric back strength is the maximum static force that can be

exerted by back muscles; (b) isometric or static hand grip strength is the maximum static force that can be exerted by hand muscles; (c) isometric or static pinch strength is the maximum static force that can be exerted by squeezing together the pad of the thumb in opposition to the pads of the index, middle, ring, or little finger or all of the fingers of the hand.

The present investigation was done to compare some important static muscular strength, such as hand grip strength, pinch grip strength and back strength of individuals coming from different occupations, since these kinds of strength are useful indices of overall muscular fitness due to their functional importance in occupational tasks. The subjects selected for this study were VDT operators and industrial processing workers (involved in processing glass fiber) as both of these jobs involve highly repetitive movements, awkward body postures and they can affect the workers' musculoskeletal fitness. Their strength values were compared with the strength values of safety inspectors (as a reference group), whose work does not require repetitive movement of hands or fingers and there is no continuous static load on the back muscles.

2. MATERIALS AND METHODS

2.1. Selection of Subjects

The subjects were selected on the basis of their occupation. Three groups of normal adult individuals, viz., safety inspectors, industrial workers and VDT operators were chosen at random from their populations. From each group 15 subjects were selected for the experiment. Grip strength, pinch strength and back strength were measured in standing postures using standard protocol. Grip strength and pinch strength were measured for both hands. All the subjects selected in this study had working experience of no less than 5 years.

The age, height and weight of the chosen sample groups are given in tabulated form in Table 1.

TABLE 1. General Information About Workers in Three Groups

Subjects	Age (years)		Height (cm)		Weight (kg)	
	<i>M</i> ± <i>SD</i>	Range	<i>M</i> ± <i>SD</i>	Range	<i>M</i> ± <i>SD</i>	Range
VDT operators	30.9 ± 1.8	28.0–34.0	166.8 ± 4.4	157.1–173.4	65.7 ± 7.3	50.0–76.0
Industrial workers	29.9 ± 1.1	28.0–32.0	169.9 ± 4.5	164.0–176.9	69.8 ± 4.9	63.0–76.0
Safety inspectors	30.4 ± 2.1	27.0–33.0	169.8 ± 5.1	163.0–179.5	70.7 ± 6.9	53.0–78.0
Probability (<i>P</i>)	.265		.299		.091	

Notes. VDT—video display terminal.

Three testing dynamometers were used to measure static muscular force: (a) a Jamar (Sammons Preston Rolyan, USA) handgrip dynamometer, a hand-held device for measuring maximum static force exerted by the hand. When hand grip strength is measured, the subjects stand erect with the hand at a 30° angle to the body; (b) a Jamar pinchgrip, a hand-held device for measuring static force of the thumb and finger contact. The pinch grip strength of all the fingers of both hands was measured in opposition to the thumb in standing posture with the standard protocol; (c) a back dynamometer (TKK 5402, Takei Scientific Instruments, Japan), a digital instrument designed to measure back strength of individuals. Back strength was measured with the subjects standing in a slightly forward-bent position. All the measurements were taken three times and the maximum values were recorded.

2.2. Statistical Analysis

All the data were statistically analyzed with Kruskal-Wallis non-parametric one-way ANOVA [18].

3. RESULTS AND DISCUSSIONS

Kruskal-Wallis non-parametric one-way ANOVA was performed with all the strength scores. The significant differences in the scores are shown in Tables 2–7.

In this study, an analysis of the experimental results revealed that there were differences in the maximal static forces as well as in the level of muscular fitness among the different occupational workers. The observed values of hand grip strength, pinch grip strength and back strength showed that the safety inspectors were

TABLE 2. Hand Grip Strength (kg)

Subjects	Right Hand		Left Hand	
	<i>M</i> ± <i>SD</i>	Range	<i>M</i> ± <i>SD</i>	Range
VDT operators	43.6 ± 5.9	32.0–56.0	42.8 ± 7.1	32.0–53.0
Industrial workers	42.6 ± 4.1	36.0–50.0	42.9 ± 5.6	35.0–56.0
Safety inspectors	48.4 ± 5.5	40.0–60.0	45.2 ± 4.0	40.0–54.0
Probability (<i>P</i>)	.008		.380	

Notes. VDT—video display terminal.

TABLE 3. Pinch Strength for Index Finger (kg)

Subjects	Right		Left	
	<i>M</i> ± <i>SD</i>	Range	<i>M</i> ± <i>SD</i>	Range
VDT operators	5.0 ± 1.3	3.5–7.3	5.1 ± 1.0	4.0–7.0
Industrial workers	4.1 ± 0.6	3.0–5.5	4.1 ± 0.7	3.0–5.5
Safety inspectors	5.8 ± 0.6	4.8–7.0	5.5 ± 0.7	4.8–7.0
Probability (<i>P</i>)	.001		.001	

Notes. VDT—video display terminal.

TABLE 4. Pinch Strength for Middle Finger (kg)

Subjects	Right		Left	
	<i>M ± SD</i>	Range	<i>M ± SD</i>	Range
VDT operators	4.6 ± 1.5	2.5–7.5	4.7 ± 1.4	2.8–7.0
Industrial workers	3.9 ± 0.8	2.5–5.5	4.1 ± 0.9	2.3–5.3
Safety inspectors	5.1 ± 1.2	3.0–7.5	5.3 ± 1.2	4.0–7.5
Probability (<i>P</i>)	.022		.046	

Notes. VDT—video display terminal.

TABLE 5. Pinch Strength for Ring Finger (kg)

Subjects	Right		Left	
	<i>M ± SD</i>	Range	<i>M ± SD</i>	Range
VDT operators	3.1 ± 1.3	1.0–5.5	3.4 ± 1.1	1.5–5.3
Industrial workers	2.6 ± 0.7	1.8–4.0	2.6 ± 0.7	1.0–3.5
Safety inspectors	4.0 ± 1.1	2.3–6.5	4.1 ± 0.9	2.5–6.3
Probability (<i>P</i>)	.003		.001	

Notes. VDT—video display terminal.

TABLE 6. Pinch Strength for Little Finger (kg)

Subjects	Right		Left	
	<i>M ± SD</i>	Range	<i>M ± SD</i>	Range
VDT operators	2.2 ± 0.8	1.0–3.5	2.0 ± 0.8	0.5–3.3
Industrial workers	1.8 ± 0.5	1.0–2.8	2.0 ± 0.6	0.5–2.8
Safety inspectors	2.8 ± 0.8	2.0–4.5	3.0 ± 0.9	2.0–4.5
Probability (<i>P</i>)	.001		.007	

Notes. VDT—video display terminal.

TABLE 7. Back Strength (kg)

Subjects	<i>M ± SD</i>	Range
VDT operators	108.6 ± 3.9	102.5–114.5
Industrial workers	120.2 ± 6.1	112.5–133.5
Safety inspectors	130.6 ± 5.3	123.0–138.5
Probability (<i>P</i>)	.001	

Notes. VDT—video display terminal.

less affected (i.e., suffered from lower static muscular stress) in comparison with the other two occupational groups.

The maximal forces exerted by humans are important in many aspects of life, mainly in occupational work. People whose occupations involve spending prolonged periods at an improperly designed workstation are exposed to muscular stress that may lead to the development of MSDs. The major health-related problems associated with industrial and VDT operators

are MSDs in hand, back and neck and shoulder areas. Thus measurement of static strength and analysis of some of these sites are used here for an ergonomic evaluation of the level of physical fitness.

A significant decrease in hand grip strength was detected in metal industrial workers who used hand-held grinders, in a 4-year follow-up study, indicating that prolonged occupational exposure should be considered as a risk for work-related MSDs [19]. The existence of musculoskeletal symptoms amongst individuals who stand for prolonged periods is well recognized [6, 20, 21, 22] as is the existence of these symptoms amongst individuals who sit for prolonged periods [6, 23, 24, 25].

It is a very well known fact that those who stand for a long time experience discomfort due to static effort and subsequent muscle fatigue

[21, 26, 27]. Prolonged standing has also been associated with discomfort in the lower back [26, 28].

Conversely, prolonged sitting has been associated with a high incidence of back complaints [25], increased spinal muscular activity and intradiscal pressure [24, 29] and discomfort in the lower extremities [5].

The result of the present study accepts the previously well-established fact that there is a strong impact of occupations on the muscular force in jobs which involve an excessive use of of hand, back, neck and shoulder areas.

Previous research also showed that “muscles enhance blood flow by means of the pumping that occurs when they alternately contract and relax. They can also inhibit blood flow by compressing blood vessels during prolonged, unmoving contractions” (p. 2) [12]. There are two sets of muscles in fingers: flexor muscles that close the hand and extensor muscles that open the fingers. Due to continuous grip and repetitive clicking these two muscles groups can become imbalanced. It has also been demonstrated that oxygen levels in the hand are the underlying cause of this. When a mouse is used, finger muscles are busy working, whereas the rest of the body is static or sedentary. The level of oxygen in the brain does not fall significantly when people are sitting still, even though they are working with hands. The hands have no reflex or low oxygen warning mechanism. So there is oxygen deficiency in the small muscles of the hand which leads to the production of toxins that cannot be removed due to low blood circulation in the hand during prolonged static work. These toxins, if not removed quickly, get attached to the muscle fibers, possibly irreversibly. This can cause loss of their elasticity, shape and form. This restricts blood flow even further adding to the circulation, oxygen delivery and toxin removal [30]. It was also suggested that the working environment is another cause of the reduced working capacity of muscles. Most offices are excessively air conditioned and cold muscles and tendons are at much greater risk of injuries [30]. On the other hand, word processing requires pressing or

clicking the mouse buttons 3 000, 4 000 or even 5 000 times a day [30].

The VDT operators selected in this study did their work in static sitting posture for a long time (8-hr working schedule per day), which might reduce blood flow, deplete nutrients and lead to a build-up of metabolic waste in their back. Also, repetitive movements of hand and finger muscles during computer operations cause production of toxins in the hand muscles. Hence the aforementioned factors may be responsible for the lower strength values of the VDT operators than of the industrial processing workers.

Previous literature also showed that static work induced faster muscular fatigue than dynamic work [31]. This fact also supports the current findings why VDT operators have lower back strength scores.

The industrial workers chosen in this study used their hand, fingers and back muscles during roving (processing glass fiber), which does not require static sitting or sedentary body position for a long time. Instead they had to do work in a standing (with various body postures) position so their back strength value, though lower than that of the safety personnel, was higher than the VDT operators’.

It also appears that the load on the spine increases when workers sit without back support, compared with workers standing, which is mainly due to a change in the shape of the lumbar spine [32]. During computer operations workers have to bend slightly forward (and not use back support all the time). Thus their spinal load is increased which may be another cause of their reduced back strength.

The safety inspectors in the present investigation had the highest strength values compared to the other workers. This may be due to the fact that their work did not involve excessive static load on their back or repetitive movement of their hand and finger muscles as in the other two occupations. Their work did not involve continuous sitting or continuous standing instead they had to move from place to place and observe the safety of different factories.

4. CONCLUSION

From the present study it may be postulated that VDT operators and industrial workers suffer from occupational stress which leads to a lower level of muscular fitness than that of safety inspectors. This may be due to poorly designed workstations and workstation layout, and devices (furniture, VDTs, equipment, etc.) they use every day in their professional life. These problems must be considered to avoid long-term very costly consequences.

The industrial workers in this study had greater musculoskeletal fitness than the VDT operators but still their muscle strength was not as good as that of the safety inspectors. The glass fiber processing job of the industrial workers involved continuous standing, repetitive movements of hands, etc., all of which could cause a gradual decrease in the level of musculoskeletal fitness and lead to MSDs in the future if preventive measures were not taken.

Though the problems of occupational stress (repetitive hand/finger movement, static muscular load on the back, etc.) cannot be fully eliminated, it can be minimized to a large extent with the application of some simple practical ergonomic interventions [33], which ultimately enhance workers' health conditions and productivity, make jobs easy to do and allow people to work efficiently without any hazards.

This study was a preliminary investigation on very few individuals from a sample group suggesting that in future studies occupation must be taken into account as a vital factor when assessing the level of musculoskeletal fitness.

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