WORKSTATION DESIGN AND POSTURAL STRESS

PART 1: BACKGROUND TO OCCUPATIONAL SYNDROMES

Anthony Golding
MSc Ergonomics (London), BSc Psychology (CNAA)*

SUMMARY
The growing incidence of occupational musculoskeletal disorders gives cause for concern about the effectiveness of traditional awareness programmes in preventing such problems. Overseas there has been a move towards evaluating work-related factors in an attempt to deal with complaints at their source. This paper outlines the hypothesis that postural constraint, as a result of work design, contributes towards muscular fatigue which is accompanied by an increased likelihood of developing chronic musculoskeletal disorders. Methods of studying the problem and measures used to improve the situation are discussed.

OPSOMMING
Die groeiende omvang van beroepsverwante muskuloskeletale probleme het 'n besorgdheid laat ontstaan oor die doeltreffendheid van tradisionele bewustheidsprogramme vir die voorkoming van sulke probleme. Oorsee is daar 'n beweging tot die evaluasie van werksverwante faktore om sodoende te probeer om die probleme by hul oorsprong te hanteer. Hierdie artikel beskryf die hipotese dat beperkte liggaamshoudings wat ontstaan uit werkstasie ontwerp, bydra tot spier uitputting wat weer gepaard gaan met 'n hoër waarskynlikheid van die ontwikkeling van kroniese muskuloskeletale probleme. Die metodes wat gebruik is om die probleem te studeer, asook diè wat gebruik is om die situasie te verbeter, word bespreek.

BACKGROUND

Musculoskeletal disorders at the workplace appear to be increasing[1], and to judge from the explosion of publications on the subject in the last ten years or so, the problem is beginning to be taken seriously. According to Coleman[2] the prevalence and clinical course of disorders have not been widely shown to be affected by conventional prevention efforts. Because of this, more emphasis is now being laid on the assessment of task-related factors in the workplace in the hope that this will contribute to more effective prevention.

Surprisingly little seems to be known about the ætiology of disorders. Troup[3] stated that only a small proportion of back disorders can be attributed to trauma; in the majority of problems the cause is obscure, or multifactorial[4]. The plethora of syndromes involving the neck and upper limbs appearing more recently, gives cause for concern because these do not conform to any known model. At present it is commonly believed that the pathophysiological mechanism involved in many disorders is acute/chronic muscle or connective tissue strain[5]. Alternative theories of how muscular strain leads to damage are summarised in the following section.

If the mechanism *is* muscle strain there is a good chance of success with prevention programmes (ie. programmes which prevent strain occurring, as opposed to measures to relieve symptoms). Hagberg and Wegman[6] maintain that the proportion of common disorders attributable to occupational exposure is high and that it should be possible to prevent a relatively large number of these cases. Several intervention projects have used simple models for the development of work-related disorders. These assume an interrelationship between an individual's physical characteristics and health and the physical demands of the work. These demands can either be imposed by the workstation and machine design or by the work organisation eg. the work duration and pauses, work pace, forces applied and repetitiveness of the task. Psychogenic factors also cause tension and contribute towards musculoskeletal stress.

In these models an imbalance between the factors eg. a work surface too high for the worker, may cause postural strain and result in localised pain. If this situation is not changed then there is a risk of developing a neck problem. There are obviously moderating variables and a crucial one is the amount of static muscle effort expended over prolonged periods in relation to the maximum voluntary muscle contraction the person can exert. If this effort is considerable then the risk increases.

Intervention studies have focused on improving the workstation[7], improving the work organisation[5], or by influencing both of these factors[8]. Such large-scale studies have shown promising results with quite marked reduction in the incidence of problems.

MUSCULOSKELETAL STRESS AND CONSTRAINED POSTURE

Repeated isometric contraction of muscles can lead to overuse syndromes in the upper limbs of individuals whose work is repetitive eg. typists, punch-machine operators. Sustained isometric contraction of the muscles responsible for maintaining posture in awkward or constrained positions leads to local postural fatigue. The physiological process of muscular strain is similar in both instances and begins with the static nature of the physical work being executed.

Aristotle said, "Movement is Life". This has a message for us today. There needs to be an interplay between the static and dynamic components of activity for the body to function optimally. People who exercise have got part of the message, but the problem is that this interplay must be constant throughout the day. This is the challenge to those who plan how we work and stay healthy.

* Chief Researcher, Environmental Studies Division, National Institute for Personnel Research, Johannesburg. Address: NIPR, P O Box 32410, Braamfontein 2017. Tel: (011) 648-1046.

Alternate overloading and underloading of the intervertebral discs has been identified as the principal mechanism of nutritional exchange[9]. Static positions, such as prolonged sitting, do not assist this process. Similarly with muscles. Cailliet[10] found cervical pain ascribed to soft tissues to be due to protracted isometric contraction of the paravertebral muscles. In some cases pain is generated by overuse of myofascial formations. In most cases prolonged static contraction causes a constant increase in endomuscular pressure, with constriction of the blood vessels and consequent ischaemia: in such conditions there is a reduced supply of nutrients to muscles and energy catabolic products accumulate. The pain experienced is due to oxygen deficiency, action of irritating metabolites, accumulation of lactic acid and the reduced intracellular concentration of potassium. Alternatively, Fassbender and Wegner[11] have posited that localised hypoxaemia may cause muscular degeneration through mitochondrial lesions. The resultant biochemical changes lead to mesenchymal transformation of the tissue. In sum, ischaemia and the resulting biochemical alteration of the tissue initiate an inflammatory process which over time leads to a fibrotic reaction of both the muscle and surrounding tissues. Pain is simultaneously an effect and a cause in maintaining the process since the reaction of the sympathetic nervous system to pain is decreased blood flow to muscles by way of vasoconstriction by which means static contraction of the muscles is even more liable to induce pain and inflammation.

It must also be borne in mind that while static contractions may form up to 20% of maximum voluntary contraction (MVC) and are accompanied by increased blood supply to the muscle, contractions above this level cause a decreased blood circulation and relative hypoxaemia begins to occur[12]. It is thus significant that levels of static contraction near or above 20% of MVC are easily reached during keyboard work in the muscles of the upper body and limbs, particularly when the arms are unsupported[13]. In this way non-maximal protracted isometric contractions typical of constrained postures may lead not only to pain in the short term, but eventually to disease due to alterations of the soft tissues.

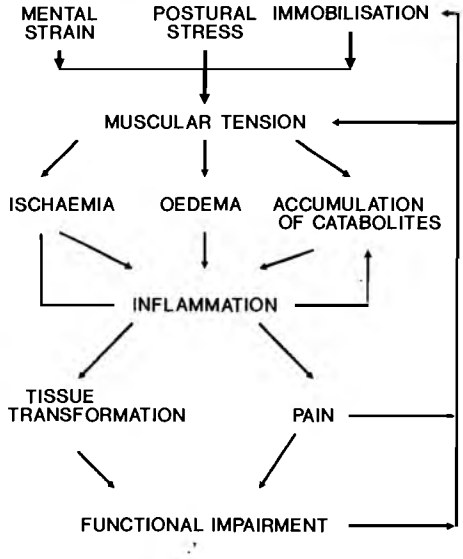

Figure 1: Role of irritative stimuli in the pathogenesis of muscular functional impairment and pain.

Rest from the fatiguing activity is one way of avoiding the process attendant with overuse. However, the limited rest which can be provided without taking sick leave is often insufficient to allow for full recovery of muscle function. Grandjean[14] states that static loads repeated daily over long periods are associated with a risk of permanent damage to muscles, joints, tendons and other tissues as well as disc troubles. The occupations most affected are those where the load is highest.

CONSTRAINED POSTURE AND WORKSTATION DESIGN

The most frequent form of static muscular work is constrained posture, mainly due to carrying the trunk, head or limbs in unnatural positions. Continuous postural stress occurs when there is a need to maintain the position of unsupported body members, to maintain the body in asymmetrical or twisted positions or where joints are used at the extreme position of their ranges.

Sedentary occupations, with their associated hazards of weakened stomach muscles and flexion of the spine, have always posed a risk to the low back. Recently, epidemiological studies have focused on the high incidence of neck and upper limb disorders among office workers. This seems to be influenced by the automation of office tasks and higher speeds made possible by computerisation. The Visual Display Terminal (VDT) is becoming the central feature of the office worker's environment. Here the entire body above the waist is typically in a constrained position, the arms with reference to the keyboard, the head with reference to the screen and source documents, the trunk in a supporting role. The speed and repetition of the keystrokes is a major constraining factor. The high speed in data-entry tasks (up to 13000 keystrokes an hour[8]) necessitates a rigid posture which results in static loading of both the back/neck muscles and upper limb muscles. Terms like "Tension Myalgia", "Repetitive Strain Injury", and "Occupational Cervicobrachial Syndrome" all refer to similar problems affecting such workers[15].

METHODS OF INVESTIGATION

One of the main aims of research in this area is to examine the epidemiology of musculoskeletal disorders and derive guidelines for preventing them. More recently methods evolved from different disciplines have been employed together to allow for cross-validation of the results of each technique.

Records may provide basic data. Work injuries must be notified by law in many countries and workers' compensation records and accident reports are often mandatory. Company medical records may exist where there are health personnel and payroll figures may provide data on labour turnover, sickness leave and absenteeism. From this information the incidence rate of disorders over a specified length of time can be calculated and comparisons made between different jobs. A problem with records is that disorders are not always recognised as being work-related and therefore many cases go unreported. Such statistics often fail to identify those jobs where there may be potential problems. Records are thus only a starting point for subsequent investigation.

Perhaps the most widely used tool comes from the behavioural sciences - the survey questionnaire. Self-rated questionnaires on physical impairments have been used[8,16] in

conjunction with medical examination and subjective comfort rating scales repeated at regular intervals have utilised body part maps to determine the location and level of discomfort[17]. A limitation of surveys is that they rely on the worker's willingness to report her health condition and that the responses will be affected due to differences in individuals' tolerance to pain. However, this can be counteracted to some extent by medical examination, including anamnesis and physical examination - inspection, range of motion, palpation, neurological and muscle power assessment etc.

In analysing jobs many people have utilised work-methods analysis or ergonomic checklists which assess the biomechanical risk factors involved in jobs such as repetitive, sustained exertions, constrained postures and high mechanical forces. The measurement of forces and muscle strength is more obscure and technically difficult - calculation of biomechanical loads and measurement of forces inferred from the level of muscle activity using Electromyography determine postural stress in precise, quantitative terms according to the model being used but do not necessarily come to the same conclusions.

Conventional ergonomics approaches evaluate workstations and posture by measuring anthropometric and workstation dimensions (reach distance, work surface height) and assessing static work, machine-induced postures, and machine-related repetitive action. The observation of work postures over time to study postural stress is either performed manually by means of coded sheets[18] or by using video film[18]. This technique has received attention recently because of the ability to use film in conjunction with computers to analyse work postures in detail[20,21].

The most difficult task is to determine whether the observed biomechanical risk factors pose demands that exceed acceptable ranges of human capacity as limited by the design of the existing workstation and machine. Fortunately the amount of information available to assist in making that judgement is increasing with the growth of the research data base.

SOLUTIONS

The efficacy of health education is often put in question because there are so many obstacles to putting it into practise. Similarly propaganda will not achieve the desired goal unless it is constantly reinforced. Informing someone about risk factors and the behaviours to avoid may make him aware that something must be done differently, but it may not give him any idea about how the job should be done. Known ways of doing things are generally "easier" because of old habits, production pressures to take short cuts, the new way may be more time-consuming ("straight-back" lifting versus stoop lifting), the risk of developing a disorder may seem remote, the workstation or job design may not permit the prescribed actions, and other work-related factors are beyond the worker's control. To be effective, training must be on-going and a major goal of company policy. Thus it is generally only large organisations which can afford the associated costs.

Workstation redesign and job redesign are the main methods which have been used in overseas intervention programmes. These aim at avoiding unnecessarily fatiguing or strenuous work postures and movements and provide the worker with the opportunity to vary his work posture. If this cannot be achieved by the normal means of job rotation or task variety, the person doing the job must be given suitably disposed breaks to reduce the build-up of fatigue. This alternative is work reorganisation, which has been tried with data-entry operators successfully[8].

CONCLUSION

The use of ergonomic intervention programmes to prevent work-related musculoskeletal disorders is a comparatively recent field of endeavour[5]. Once organisations realise the immense amount of money which is being lost because of sick leave and absenteeism due to poor work design (design of the task, the machine and the workstation) they may show an interest. The calculation based on a Norwegian figure [22] is a loss of R1000 per person per year. The costs of permanent disability run into millions.

The prevalence of occupational posturally-related disorders is becoming increasingly more evident and it appears that far too little of the problem is generally appreciated. For example, most workstations are still designed without reference to ergonomic considerations. Correspondingly there is a new urgency to pursue the development of a better understanding of posture and preventive techniques. The aetiology of such conditions is complex but through epidemiological studies it is possible to identify risk factors and jobs where there are problems. With this knowledge it should be possible to predict what is safe and acceptable with regard to this important aspect of working life.

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