Ergonomics and occupational medicine: future challenges

D. A. Stubbs
Robens Centre for Health Ergonomics, EIHMS, University of Surrey, Guildford, UK

Ergonomics has come a long way since the birth of the subject some 50 years ago. It now has an established research base and an appropriate portfolio of methodologies. A brief overview of the subject’s development will be presented, with a particular focus on the contribution of ergonomics to our understanding of work related musculoskeletal disorders. Future challenges are also considered in this area, with particular emphasis on the need for a multidisciplinary approach to many industrial problems where the ergonomist, occupational physician and other professionals are needed to tackle existing and future work problems. Additionally, the importance of participatory ergonomics is considered, with respect to understanding and advancing solutions in this area. The issues of the ageing workforce and the challenges that must be met are also outlined. This area again emphasizes the need for a multidisciplinary team approach that is proactive and designed to maximize the health and wellbeing of workers at all ages, whilst also ensuring a full and productive life.

Key words: ageing workers; ergonomics; multidisciplinary approaches; musculoskeletal disorders.

WHAT IS ERGONOMICS?

The word ‘ergonomics’ is derived from the two Greek words ergos (work) and nomos (laws) and as a science is celebrating its 50th year. It was developed into a recognized field by a group of British scientists during the Second World War. At about the same time a similar discipline evolved in North America, which came to be called ‘Human Factors’. Both names are now used on both sides of the Atlantic to mean much the same, although the implied synonymy was dealt a severe blow by the recent adoption by the USA organization of the title ‘The Human Factors and Ergonomics Society’.

Notwithstanding the debate about ‘What’s in a name?’ there is reasonable agreement concerning its definition namely:

Ergonomics is the scientific study of human work.

As a discipline it takes as its starting point the constitution of individuals (anatomical, biomechanical, physiological, psychological and social) within the work system. Thus by understanding the wide range (and their variation within populations) of these fundamental characteristics, in particular, how the individual uses them to act within their world, ergonomists seek to design work so that it will better fit the needs of the individual.

This rather novel view, that the job should be designed to ‘fit’ the person, represents a radical departure from the more traditional approach, which is still central to much work design, in which such techniques as selection, training or even coercion are used to adapt human operators to their work (i.e. fitting the man to the job, the Procrustean approach).

Ergonomics is concerned with the practical applications of the disciplines noted above. Whilst fundamental data come from the research base of the constituent disciplines, most ergonomists will have expertise in a number of core subjects resulting in the identification of several specialist areas within ergonomics, viz. environmental aspects, workspace design, human computer interaction and work organization.

Having stated that the nature of ergonomics is firmly within the applied domain and most ergonomics research is problem led, considerable debate has taken place as to whether ergonomics can or should be researched within the laboratory or whether its study requires a more naturalistic setting, i.e. people and their working environment. Both are, in my view, required. The former provides an increased knowledge base and allows the development of conceptual models, the latter provides the means of testing the extent to which the new knowledge is applicable or the models sufficiently robust.

Ergonomics research and its application can therefore be seen as an iterative process – by the application and
evaluation of new knowledge, obtained through research, to more naturalistic settings. For example, conceptual models for the pathogenesis of musculoskeletal disorders have been developed\(^1\) which hypothesize a relationship between common exposure factors and different responses. These can be used and tested in the field to evaluate and design jobs for the prevention of work related musculoskeletal disorders. This facility provides researchers with a framework for the further design and evaluation of laboratory and field studies.

In spite of the range of specialist areas, a general principle runs through the study of ergonomics problems in complex work environments. The best way to approach a satisfactory solution is to consider the whole problem in terms of a systems approach; in other words, assuming that each part of the work system may have an effect on another, i.e. that changes or problems in one area may have an influence on others.

It is convenient to consider the work system in terms of five main areas:

- **TASK**,  
- **EQUIPMENT**,  
- **ENVIRONMENT**,  
- **ORGANIZATION**,  
- **PERSONNEL**.

These all interact in the work system, hence environmental problems may make tasks more difficult (e.g. poor lighting leading to difficulty in reading scripts, leading to eye strain or uncomfortable work postures to compensate). However, well designed and adjusted equipment will not compensate for excessive task loads or poor work organization.

Importantly, an objective of the ergonomics approach is to obtain an effective match between the user and the work system and one in which there is optimization of:

- **WORKING EFFICIENCY**,  
- **HEALTH AND SAFETY**,  
- **COMFORT AND EASE OF USE**.

Figure 1 illustrates a simple model of ergonomics, the starting point being consideration of the ‘work tasks’ and how the work demands can or should be allocated between the person and machine (human vs machine tasks).\(^2\) The next consideration is ‘human characteristics’ (physical and psychological) and the extent to which the ‘human response’ will be matched or not when brought into contact with the ‘human tasks’? If the former is not optimal how can the work task be adjusted to achieve this? If the latter (i.e. mismatch) there are two primary routes for a solution. One is to change the characteristics of the users, i.e. select or train them. This is essentially fitting the user to the job. The alternative and preferred approach with respect to long-term effectiveness, is to redesign or alter in some way the work task to make the human tasks more compatible to human characteristics and needs, i.e. fitting the job to the user.

As noted previously the model described above (Figure 1) focuses on work and human tasks, and significant attention by ergonomists has been directed towards the development of research methods for task analysis.\(^3\) However, this approach needs to be seen in the context of the interactions within the work system and in such a way that the human operator is the prime component within the system. By studying the system within this framework, the person centred approach places considerable emphasis on the paramount needs of the individual and their physical and behavioural characteristics. It is only through such a consideration that it is possible to begin the process of adapting the work system to accommodate the operator. This need has led to the development of participatory ergonomics and is considered further later.

Finally, many other ergonomics models exist, all of which have been developed and have methodologies associated with them to predict or investigate each of the possible interactions, e.g. person-task; person-equipment; person-environment; person-organization; person-person; person-outside world. In this sense the systems boundaries are limitless. However, most ergonomics focuses on the human person-machine systems, socio-technical working systems and working organization. Organ, cellular and sub-cellular systems and knowledge of them is important as are communities, urban systems, industries and socioeconomic systems; ecosystems and society, and the impact that work may have on them.

To illustrate the importance of some of these systems consideration will now be given to the contribution of ergonomics to our understanding of musculoskeletal disorders (e.g. back pain, work related upper limb disorders).

**BACK PAIN: THE SIZE OF THE PROBLEM**

Over 80% of the population will suffer at some time during their life with episodes of back pain. The form this will take is variable, from transient back pain (spells
of comparatively short duration and varying severity suffered by many) through acute back pain to chronic back pain (long-term pain and disability affecting relatively few). Recovery from most attacks is spontaneous and normally within about 6 weeks of onset, and in most cases sufferers do not consult their doctors or lose time off work.

However, over the past decades there has been a dramatic increase in work loss, sickness certification, compensation and long-term disability. In the United Kingdom between 1971 and 1994 the number of working days lost because of back pain rose from 15.8 to 105.4 million thereby exceeding by far the work loss due to ischaemic heart disease (65.4 million) or bronchitis (25.7 million).5

The recent Labour Force Surveys6,7 reinforce previous concerns and underline the importance of work aspects of disorders such as back pain both in terms of causation or being made worse by work. Further evidence on the economic impact of work related ill-health and accidents is provided by Davies and Teasdale8 who estimated that some £11 billion to £16 billion are lost annually each year, this representing almost 3% of GDP (gross domestic product). This problem is not unique to the UK and data from other countries appear to be following the same trend and face the same challenges.9

Factors associated with back pain and other work related musculoskeletal disorders

In order to consider the prevention or reduction of the musculoskeletal disorders problem, it is first a prerequisite to have an understanding of the factors associated with the conditions. One approach to this is to combine epidemiology and ergonomics methods in order to identify and subsequently change factors associated with the disorder. The epidemiological evidence in support of work related, and particularly physical factors and combinations of physical factors, in the development of a number of musculoskeletal disorders is strong10,11 and this is illustrated in Table 1.

At the recent Ergonomics Society Annual Conference, a series of memorial lectures were presented in honour of Stephen Pheasant (1949–1996). They focused on the topic of musculoskeletal disorder and the contribution of ergonomics to the understanding and prevention of them.12–14

All the papers emphasized the need to reduce exposure to the physical and psychosocial work stressors and their combinations. Additionally, Burton14 noted that greater account should be taken of the psychosocial influences surrounding disability.

The important and obvious point to emphasize is that much of the above frequently comes under the direct responsibility of occupational health physicians and nurses within industry. The challenges outlined in the Stephen Pheasant memorial lectures are as much a challenge of occupational health professionals as they are to ergonomists.

| Table 1. The work relatedness of musculoskeletal disorders: physical work risk factors |
|---------------------------------|-------------------------------|----------------|----------------|----------------|
| Body part and risk factor       | Strong evidence               | Evidence of no effect |
| Neck and neck/shoulder          | Repetition                    | Force           | Posture        | Vibration      |
| Shoulder                        | Repetition                    | Force           | Posture        | Vibration      |
| Elbow                           | Repetition                    | Force           | Posture        | Combination    |
| Hand/wrist                      | Repetition                    | Force           | Posture        | Vibration      | Combination    |
| Carpal tunnel syndrome          | Repetition                    | Force           | Posture        | Combination    |
| Tendinitis                      | Repetition                    | Force           | Posture        | Combination    |
| Hand–arm vibration syndrome     |                               |                 |                |                |
| Vibration                       |                               |                 |                |                |
| Back                            | Lifting/forceful movements    |                 |                |                |
| Awkward posture                 |                               |                 |                |                |
| Heavy physical work             |                               |                 |                |                |
| Whole body vibration            |                               |                 |                |                |
| Static work posture             |                               |                 |                |                |

Strategies for prevention

It can be argued that the improvement of health and safety at work by the prevention or reduction of ergonomic mismatch would seem to be of benefit to the individual, to industry and to society. If this is the case, the question is raised as to how preventive strategies can be advanced and how work systems can be made healthier, safer and more efficient? The effectiveness of past policies is considered elsewhere.15

However, today Europe is now well into major interventions in the field of health and safety, through a series of directives16 which should have at least as great, if not greater impact on working conditions in the UK as did the Health and Safety at Work Act (1974). In particular the two European Directives which consider both manual handling operations and the use of display screen equipment have implications for work related
musculoskeletal disorders and both Directives have as their basis, an ergonomics approach to risk assessment and finding solutions. The basis of both Directives also relies heavily on the advances in research knowledge gained over the last 10–15 years, including significant ergonomics contributions.

The systems approach briefly described above is complex but does, however, enable mismatches to be identified and subsequent evaluation of any intervention may then take the form of analysis of the extent to which the mismatch has been reduced. Similarly, epidemiological needs are also evident in relation to interventions, including baseline data prior to changes. Without these and the subsequent monitoring and surveillance of the health of the workforce (and controls where possible) the effectiveness of an ergonomics intervention is difficult to judge. Similarly, the length over which a surveillance needs to be undertaken, particularly with regard to musculoskeletal health, may deter many organizations. It may therefore be useful to monitor other indices of success in addition to clinical diagnosis (e.g. prevalence of signs and symptoms, ratings and location of discomfort with respect to time, altered task behaviour to that of lower risk, reduced exposure to risk).

Such studies that have been undertaken lend support to the viability of ergonomics intervention though many have been limited in scope, duration and control.\(^{17,18}\) They do, however, provide an effective base to encourage the evaluation of interventions by scientists and practitioners.\(^ {19}\)

It has been argued on numerous occasions that the legal framework provided by many societies has limited effect on health and safety and the moral argument may carry little weight, thus increasingly the economic arguments become the agent for change. For example, in respect to work related musculoskeletal disorders the economic performance of an organization may be significantly impaired. The ergonomic, epidemiological and economic needs are evident in the evaluation of interventions and the challenge with respect to work related musculoskeletal disorders is to convince management that the approach advocated with the relevant European Directives is appropriate.\(^ {15}\)

### The ageing workforce

Whilst musculoskeletal problems clearly represent a major challenge for today and the foreseeable future, another major problem is looming that will need to be tackled in a multi-professional way including, importantly, the areas of ergonomics and occupational medicine. The issue is that of the ageing workforce and that the working population over 50 years of age will grow considerably during the next 15 years. Within Europe significant attention is now being paid to this issue and a number of clear challenges presented, including the maintenance and promotion of health in an ageing workforce and improved design and organisation of work.\(^ {20}\)

Significant progress and research has been undertaken in Finland in respect to the ageing workforce, largely because the dependency ratio (i.e. the number of people of working age in relation to the number of retired people) will reach critical levels sooner than in other European countries. Much of this research has been led by Ilmarinen\(^ {21}\) who identified four factors in modifying the 45-year-old and older population: biological ageing process, health, work, and life style; and, additionally, the interactions between these factors.

Importantly, the research investigated measures to promote and maintain work capacities and abilities of older workers. Further, the approach was multifactorial and required a multi-disciplinary approach. The model was based on three types of measures: work environment (ergonomics, hygiene, safety); organizational leadership (developmental, psychosocial and management issues) and the individual (functional capacities, exercise, lifestyle challenges and professional training).

Significant changes in what is described as ‘work ability’ have been achieved by addressing these areas in longitudinal studies. These in turn have resulted in improvements in productivity and the quality of life and well-being of those participating. It is further hypothesized that this will lead to improved retirement and a more meaningful productive ‘Third Age’.\(^ {21}\)

The main point in briefly describing Ilmarinen's work is to highlight a significant and future challenge for much of Europe in which ergonomists and occupational physicians, nurses and physiotherapists should play a major role.\(^ {20,22}\)

Finally, in a recent review Westerholm and Kilbom\(^ {23}\) presented a series of challenges for occupational health services in respect to ageing and work. In particular, they emphasized the need to individualize to achieve an optimal fit between personal characteristics and skills on the one hand, and the work tasks on the other. This, they note, poses ethical challenges to the health professionals involved. They also emphasize that this process should not lead to marginalization or rejection of people with functional deficiencies or health defects, rather that the basic orientation must always be to improve workplace conditions for all age groups.

### FUTURE CHALLENGES

It is not the intention here to outline all of the challenges ahead with respect to ergonomics and the occupational health arena, but some are well worthy of mention.

Firstly, there is a clear requirement to apply existing knowledge to satisfy the needs of the country in terms of productivity improvement and of society as a whole. This should not result in increased health and safety problems; on the contrary, health and safety should be improved by the application of ergonomics to the benefit of individuals, organizations and society. The failure to recognize the human needs in the design and development and introduction of new technology into the office environment represents a typical example. Many new technology applications, particularly in the information technology area, fail to reach their full potential because of a failure to take account of ergonomics factors.\(^ {24,25}\) A
paradigm shift on the part of engineers and designers is required to get them to consider people related issues at an early stage in the design and development process. Equally, those responsible for the introduction and implementation of such work systems need to consider user needs and utilize the users in this process, and the benefits of a participatory approach to ergonomics is now evident. Within this context, participation is taken to be ‘the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes to achieve desirable goals.\(^\text{26}\)

As with other areas of ergonomics the range of methodologies available is extensive (e.g. design decision groups, problem solving groups).

If the ergonomics profession is to have a major impact in this or other areas (e.g. tackling the musculoskeletal disorder problem or the ageing workforce issue noted earlier), and if we are to see the benefits of ergonomics spreading widely across employment and society in general (e.g. the ageing workforce), we need to recognize the potential importance of ergonomics to other professions, and to give ergonomics a way to transfer our existing knowledge and methods to others (e.g. occupational physicians, nurses, physiotherapists) who are closer to the places where changes have to be made, so that they can undertake much of the ergonomics themselves. This necessarily means a wider dissemination of the subject by means of, for example, Diploma in Occupational Medicine, Postgraduate Diploma/MSc in Health Ergonomics, Occupational Health and Safety where ergonomics is now more widely available. This progress is tangible evidence of one of the many challenges put forward by Pheasant\(^\text{28}\) in arguing the need for a multi-professional approach to many of today’s work related problems.

**CONCLUSION**

The improvement of health, safety and productivity at work by the prevention or reduction of ergonomic mismatch arising from physical and psychosocial factors would seem to be beneficial to the individual, to organizations and to society. This paper has attempted to explain the nature of the burgeoning discipline of ergonomics and its contribution to this process. The scope of ergonomics research and application have been briefly illustrated, particularly with respect to the increasing problems of work related musculoskeletal disorders and the future challenges of the ageing workforce. Ergonomics research has significantly contributed to our understanding of these issues, this being a prerequisite for the development and application of ergonomics in preventive strategies. The importance of participatory ergonomics has also been emphasized. Further, the need for a multidisciplinary team approach is advanced and for a wider dissemination of what ergonomics is and how its methodologies can be utilized within the context of occupational medicine to generate healthier, safer and more productive work systems, to the benefit of all.

**REFERENCES**

2. Buckle PW, Randle IPM. Personal communication; 1989.


