THE APPLICATION OF ERGONOMIC RESEARCH PRINCIPLES FOR WORKSTATION ENHANCEMENT OF APPAREL MACHINISTS

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ABSTRACT

The SA clothing industry shed over 67 000 jobs in the past three years (Bell, 2006).There is a possibility that more jobs may be shed in Durban (Kwa-Zulu Natal). The Alexander Report mentions that between July 2006 and May 2007 there was a drop of 5275 in employment figures (Palmi, 2007). The cut, make and trim (CMT) industries find it difficult to negotiate wage increases as production costs escalate beyond proportion. If the lay off of workers continues in the clothing industry, it would increase the unemployment rate, thus impacting on the economy. Statistics South Africa estimates that the South African population stands at approximately 47.4-million and the unemployment rate stands at 25% of the total population (www.southafrica.info).The clothing manufacturing industry is labour-intensive with repetitive and skilled manipulation of fabric. With a challenge of skills development, SA faces a dilemma in terms of its productivity status. Poorly-designed workstations contribute to cumulative trauma disorders (CTD) such as musculoskeletal disorders of the neck, shoulder and upper limb, collectively known as repetitive strain injuries (RSI). This highlights the importance of the implementation of effective ergonomic practices in the clothing industry, that would improve the competitive status of organisation and in effect the country. The importance is further enhanced by the necessity for a productive economy and thus, the necessity for a productive workforce. The methodology includes a questionnaire, discussions with the workforce and management on ergonomics issues in the workplace.

Keywords: South Africa, ergonomics, improvement, clothing industry, workplace dynamics

BACKGROUND

The manufacture of clothing, along with the closely associated activities of fibre and textile production, continues to be one of the driving forces of industrialisation throughout the developing world. At the same time, the clothing industries of many developed consumer industries are fighting to maintain their share of the total value (as opposed to volume) which is created throughout the entire chain of apparel design, manufacturing and distribution.

Technology has always been an important aspect to this competitive struggle and is still largely controlled by the "older" established industries of Japan, Europe and the USA. However, the ease and speed with which young industries have been able to absorb and master advances in machine and process technology throughout the 1980's have turned the attention of these industries to new modes of competition based on organisational know-how and systems as much as upon cost and productivity.

Information technology in all its guises lies at the heart of much of the new thinking. An explosion of capabilities in that area is now shaping patterns of development through the 1990s and into the 2000's.
The application of these new technologies is having a profound social impact, not only upon the total numbers and location of those employed in clothing manufacture, but also upon the skills, training and management needs of organisations. Almost all industrial manufacturing facilities use some type of work or labour standards to measure productivity and forecast costs. Traditionally this has been the domain of industrial engineers or work-study officers, who analyse the situation and use various methods to arrive at a standard time. Proper work standards are often a necessary part of ensuring the economic efficiency of a manufacturing company. Jobs with high-energy expenditure and whole-body fatigue are the primary cause of increased costs and loss of productivity (Kaudewitz, 1998).
More companies are feeling the inefficiencies and loss of productivity due to poor application of ergonomics. Workplaces must be designed to be human friendly as employees spend approximately one third of their lives at the workplace. A sound understanding of ergonomics and the work activity being studied is necessary (Kaudewitz, 1998).
Given the increased challenges facing organisations today, the trend is either to keep up or disappear. Statistics have shown that from the Fortune 500 companies, forty six percent have disappeared during the 1980s alone. One of the major reasons for this disappearance is the resistance to a changing world (Vermeulen, 2000).

INTRODUCTION AND OBJECTIVES

The aim of this article is to highlight ergonomic practices in the workplaces of machinists in the clothing industry and to create an understanding of how simple changes could improve the health and safety of the workforce, while also enhancing productivity in the organisation and the quality of production, thus saving jobs in SA. The following objectives will be served by the study:

- Observation of problems relating to ergonomics at workplaces in the clothing industry.
- Development of a methodology framework that would serve as a benchmark against which the current status can be evaluated.
- Making recommendations on the future use of the methodology framework in the clothing industry, based on the information generated by the evaluation of the model.

RESEARCH METHODOLOGY

The research comprised a qualitative exploratory and descriptive design. The purpose of the exploration was to report the current phenomenon of ergonomics through systematic observation done at clothing manufacturers in KwaZulu-Natal as through literature review of relevant ergonomics issues in the global and South African clothing manufacturing context. Personal interviews, questionnaires and direct observation were used to gain insight into problems caused by poor ergonomic design. The survey was conducted in two phases. The purpose of the first phase was to gain insight into ergonomic problems by way of discussions and interviews, and the second phase involved the application of a questionnaire designed to identify the problems experienced.

LITERATURE REVIEW

Global competition

Ten years ago, it was not important to be globally competitive. Now it is imperative. What has happened worldwide is that markets have opened up, environments are more actively competitive. The new economy has led to business becoming more condensed. Globalisation and international competition have become the driving forces of the revolution in the nature of the world economy and

world class trends. One of the tools that can be used to improve the situation in the South African Clothing Manufacturing industry is ergonomics (Botha, 2000).

The current state in the clothing industry is that the future is at stake due to global competition. Workplaces are based on "efficient movement of product" or best locations for machines. This is done without giving the thought to how people are supposed to fit into their workplace. Issues such as injuries, errors in production (repairs) and efficient motions are often neglected. People are expected to adapt themselves to fit into whatever arrangement has been devised, believing that it has no associated costs. Space limitations are a major contributor to poor efficiencies. Crowding of the workplace with pre-cut components of garments aggravate low efficiency. The result is the recutting of that component and contributing to the cost factor. Some tasks require operator training in contortionist sewing techniques which is done in the workplace. The human body cannot adapt to every situation. People have differences and they have limitations and this issue is not evaluated thoroughly before contracting people on the job (MacLeod, 1995).

The many meanings of ergonomics

In the South African clothing industry ergonomics can be used interchangeably with the term workplace engineering – meaning designing workplaces and tasks that are compatible with human capabilities and limitations. A formal definition of the term ergonomics, coined in the United Kingdom in 1950, is the study of human characteristics for the appropriate design of the living and work environment (Laing, 1992). Ergonomics makes use of a number of disciplines, such as mathematics, engineering, life sciences and behavioral sciences. Each of these contributes to identifying, evaluating, and solving worker-machine interactions. The objective of an ergonomics program is to design a system in which the workplace layout, work methods, machines, and equipment, and the work environment (such as noise and illumination) are compatible with the physical and behavioral limitations of the worker. The better this fit the higher the level of safety and work efficiency (Laing, 1992).

The researcher has been widely exposed to the clothing manufacturing industry and has experienced labour inefficiencies due to poorly designed workplaces. In consultation with available literature, it has become apparent that ergonomics is discussed on a broad scale covering a multitude of issues applicable to industry in general. The researcher has decided to direct his efforts towards the application of ergonomics in the South African clothing industry. This industry is in dire need of constructive effort to survive.

The government's reduction of protection policies

The new South African government is continuously reducing the protection policies that were in place before 1994. Labour productivity is always a subject that is evaluated continuously and in most instances, has a negative effect on worker-management relations. Ergonomics has numerous positive outcomes that will improve the state of the clothing manufacturing industry as indicated by the cases below.

Integrating ergonomics into a plant's culture can cut worker's compensation costs, reduce lost time, improve productivity and quality and strengthen labour-management relations. The best way to make ergonomics an integral part of the plant culture is to develop a plant-wide program. Successful ergonomics programs share features that are critical for their success. The two most important aspects in the workplace are support of top management and direct operator involvement. In addition to these two elements, successful ergonomics programs share several other features. Goal setting should specify the reasons for establishing a program and the measurements by which program success will be evaluated. A game plan is another necessary component; it lays out guidelines for how the program will function. Evaluating program results and communicating those results are also important. Finally, every employee in the plant should receive some ergonomics training (Sommerich, 1997).

In a cross-sectional survey, health complaints among 418 labourers in 15 Indian tanneries were studied. Low-back pain, asthma, dermatitis, and chronic bronchitis were the most frequently reported complaints in the 12 months prior to the survey. In general, workers reported the highest occurrence of the above illnesses, but only chronic low-back pain was significantly elevated compared with workers in the finishing departments. When using individual exposure estimates, clear associations were found between manual lifting over 20 kilograms and low-back pain, and skin exposure and dermatitis. Frequent lifting of loads was also associated with self-reported asthma. About 44% of the labourers reported at least one period of sickness absence, and 17% were involved in a serious occupational accident that required a visit to the local physician. Logistic regression analysis showed that sickness absence occurred more often in small tanneries and also was significantly associated with lower-back pain and occupational accidents (Ori, 1997).

"People centred" ergonomics

Branton in 1993 has moved away from the contemporary views of ergonomics and has concentrated his efforts on the most important variable, people. He has realised that people at work bring unique characteristics to the system, which no machine would ever, hope to match. By recognising the employees' sense of flexibility and responsibility at their work, he believes that people can make it happen. Therefore he has created a 'person centred' view that will enable action in the workplace .The researcher is in full support as without people, ergonomics will not happen, and continuous training is the key factor that South Africa lacks in the clothing manufacturing industry.

Variables that play a major role to accomplish an ergonomically viable environment

All the other literature that was examined covered the major variables applicable to ergonomics on a more general note. The variables such as posture and movement, information and operation, environmental factors and an ergonomic approach are applicable to all industries and the information will be used to direct this research specifically to the clothing manufacturing industry (Dul and Weerdmeester, 1993).

Haslegrave in 1990 indicated that ergonomics will improve the variables of safety, quality, and productivity. In the publication "Work design in practice" a number of case studies by different authors have been compiled in different industries. The variables covered ranged from ergonomic planning of industrial plants, problems addressed in the workplace and an ergonomic workplace design. The case studies outline the reality of situations in industry.

"A guide to the ergonomics of manufacturing" provides an in-depth evaluation of ergonomics and the way in which it can enhance the variables of productivity, safety and job satisfaction. The difference is the focus on job satisfaction, which is of prime importance to all human interventions. Job satisfaction is a major contributor of a motivated workforce, which in turn improves productivity. Helander in 1995 explains the many ways in which ergonomics can support and improve manufacturing engineering and systems design. It grounds these ideas in real-life case study experience. This information is applicable to a variety of manufacturing industries including its general applicability to the clothing manufacturing industry.

The "applied ergonomics handbook" by Galer (1989) has drawn a number of experts from the field of ergonomics and discussed the variables of design of displays, controls and workplaces, the layout of panels and machines and factors affecting the working environment including climate, noise, vibration, vision and lighting. The researcher is in agreement with the information, but the limitation is its application to the clothing manufacturing industry (1989).

All the literature that has been covered evaluates ergonomics and its application to industry in general. It covers a broad spectrum of variables that concentrate on a more industrialised environment.

According to Fleming in Allnoch, "improve a worker's comfort level, and you improve the company's productivity level." Ergonomics is designing things better, or integrating better work methods, work

practices, and equipment to humans. He feels that industrial engineers have spent a lot of time on materials, on the process, and on the machinery side, but they've not thought enough about the human and how the human functions. The researcher is in total agreement with this situation due to his exposure in the clothing industry (1997).

According to Alexander (1985) typical losses from the failure to apply constructive ergonomics include:

- Lower production output
- Increased lost time
- Higher medical and material costs
- Increased absenteeism
- Low-quality work
- Injuries, strains, fatigue
- Increased incidence of accidents and errors
- Increased labour turnover
- Less spare capacity to deal with emergencies
- Reduced productivity
- Reduced competitiveness

Ergonomics will make a difference if implemented constructively. It has to be a team effort by both management and operatives.

THE SOUTH AFRICAN CLOTHING INDUSTRY

Clothing manufacturing is a labour-intensive operation involving repetitive motion and skilled manipulation of fabric throughout an eight-hour day, using batch-production methods. Poorly designed workstations contribute to cumulative trauma disorders (CTDs), such as musculoskeletal disorders of the neck, shoulders and upper limbs, collectively known as repetitive strain injuries (RSIs). It was found that ergonomic interventions, including the redesign and proper adjustment of workstations, the use of ergonomically designed seating, and training in low-risk methods and postures substantially reduced health problems and accidents. Workplace innovations in equipment and job and organisational design were also explored. The positive effects of properly implemented ergonomics include a reduction in workers' compensation costs, a reduction in lost time, improved productivity and quality and a strengthening of labour/management relations. The study and application of these features could lead to a competitive advantage. The purpose of this research was to explore how the effective application of ergonomics can reduce labour costs while improving productivity (Allnoch, 1997).

The current heightened interest in ergonomics can be attributed to a number of factors. The most obvious are the rising costs associated with work-related injuries or illnesses. Safety, health and environmental (SHE) policies and procedures are being regulated in all industries around the world, and pressure from labour unions and insurers has increased employee awareness of health and safety issues in the workplace (Render & Heizer, 2001).

In the South African context very little, if anything at all, has been done to curb work-related injuries in a constructive way. According to nurses employed in the clothing fraternity in South Africa, workers who fall ill or are injured are simply treated when they visit their general practitioners. The causes of illness or injury are seldom investigated. The researcher has found that currently general practitioners are not allowed divulge information regarding their patients because of the Aids pandemic. In the United States, Japan and Germany, a number of Occupational Health and Safety fines have resulted from investigations requested by labour unions. Increasing media attention, government and insurer-sponsored education initiatives, and the growing number of fellow employees who are affected by

illnesses related to ergonomics have increased the general awareness of hazards in the workplace that could be avoided through the implementation of ergonomic principles. This increased awareness will result in further pressure to introduce appropriate ergonomic management (Kogi & Kawakami, 1997).
Workplace designs are based on the efficient movement of the product or the best locations for machines. This is often done without giving a thought to the physical comfort of the people who have to fit into these workplaces. Issues such as injuries, errors in production (repairs) and efficient motions are often neglected. People are generally expected to adapt to fit into whatever arrangement has been devised, and no consideration is given to the possible costs associated with this. Space limitations are a major contributor to poor efficiencies. Crowding of the workplace with pre-cut components of garments contributes to low efficiency. The result is the re-cutting of certain components, which increases production costs. Some tasks require that operators be trained in awkward sewing techniques, and this training is done in the workplace. The human body cannot adapt to every situation. People differ and have different limitations, and this aspect is frequently not thoroughly evaluated before people are contracted to perform specific jobs (MacLeod, 1995).
National and international literature shows that ergonomics covers a multitude of issues applicable to industry. Machinists need constructive efforts to improve their workplaces, which are currently characterised by a lack effective ergonomic practice. Simple adaptations and innovations would solve the main problems experienced by machinist in the clothing industry.

RESEARCH RESULTS FOR THREE CLOTHING MANUFACTURING PLANTS

Low productivity of seamstresses in the clothing industry is typically due to injuries, fatigue and poorly designed workplaces. The first phase of this research comprised site visits to three clothing manufacturing plants in Kwa-Zulu Natal, where the primary product lines were trousers, shirts and ladies' fashion wear. The second phase of the research involved the application of a questionnaire designed to identify in more detail the extent of ergonomics problems experienced in the work environment of the three manufacturing plants.

First phase of ergonomics intervention
Plant A employed 800 sewing operators and was considered to be an innovator in terms of new technology; Plant B employed 150 sewing operators and was prepared to accept technological advancements, provided it had been proven to be beneficial and financially viable; Plant C employed 50 sewing operators and was considered financially unable to adopt significant new technology. These plants provided a representative cross-section of company sizes and opportunities for adopting new technology including automation but it is the CMT manufacturers (approximately 300 CMT organisations) that fail to implement ergonomic practices
During a series of visits, interviews were conducted with 850 volunteer operators that were representative of the target jobs in the plants. These interviews covered:

- musculoskeletal discomfort;
- characteristics of the work environment;
- characteristics of the workstation, chair and job;
- training,
- environmental measures.

Environmental measures with regard to illumination, temperature and noise were taken at sample workstations throughout the three plants.

The results of the first phase interviews are shown in Table 1.

Table 1. Results of first phase interviews

	Total sampled	Number of complaints	Percentage of total
Upper back pain	850	680	80
Neck pain	850	646	76
Shoulder/Wrist pain	850	595	70
Working posture	850	510	60
Illumination	850	425	50
Seating	850	774	91
Repetitive manipulation	850	621	73

DISCUSSION OF RESULTS

Musculoskeletal discomfort

During the interviews, respondents reported that they experienced pain in their upper backs (80%), shoulders/wrists (70%) necks (76%) (Table1). This reported prevalence of neck, shoulder, and back discomfort was consistent with the results of the questionnaire (93%) (Table 2).

The working posture

Much of the reported discomfort in the back and neck could be attributed to the working posture of the seated operators (healthcare professional). In response to job and workstation characteristics, it was observed that operators typically adopt a hunched working posture. An analysis of the postures indicated that 60% of the machinists tilted their heads more than 20 degrees throughout the cycle (Table 1). Several workers stated that this posture was necessary to maximise production. Such postures have been cited as a factor in muscle fatigue and discomfort (Grandjean, 1982). The tendency of operators to work in this hunched position can be attributed to at least three factors, namely the visual demands of the work, the geometry of the workstation and inadequate seating.

Illumination

Most sewing operations are visually demanding, requiring the precise stitching of thread into a fabric of the same colour, so that there is little or no visual contrast. Evaluation by the internal healthcare worker revealed that 50% of the machinists had poor eyesight and required thorough evaluation by an optometrist. Machinists were advised to take the necessary action to rectify their eyesight as soon as possible, as poor eyesight could lead to accidents in the workplace. Another issue that was noticed was the colour of the lighting. On questioning line managers it was found that fluorescent tubes emitted a slightly yellowish light and as each failed tube, it was replaced by more natural light.

Workstation geometry

The hunched position in which operators tended to work also suggested a potential conflict between workstation geometry and individual operator dimensions. Analysis indicated that the machine treadle was typically located too close (mean = 15 cm) to the proximal edge of the work surface. Most commonly, operators responded by positioning the chair away from the work surface in order to allow a knee angle of 110 degrees or greater. From this position, the mean distance from the back of the chair to the point of operation (POO) was only 3 cm less than the arm length of the 50th percentile operator. To compensate for these workstation problems, operators leaned forward to maintain adequate visual and manual access to the POO.

Another factor that limited operator access to the workstation was the location of various obstructions (motors, pneumatic equipment, and machine guards) beneath the work surface. While typical

recommended lateral knee room is approximately 46 cm, the presence of these obstructions limited the available space to less than 26 cm in some cases.

Seating

The vast majority of operations were performed in a seated position. Seating encountered in the sewing environment typically consisted of straight-backed wooden or metal chairs without cushions for reducing body compression and fatigue. They also lacked adjustable backrests, and often were of improper height. Machinists (91%) (Table 1) customised their chairs by using handmade cushions on the pan and backrest in order to adjust the height and increase pliancy. Most cushion adjustments increased seat height by 3-6 cm when compressed. Although this eased the situation a little, machinists confirmed the urgent need for comfortable, adjustable chairs.

Repetitive manipulation

The primary risk factor for the development of trauma disorders is the frequency with which motions are repeated. On the basis of observation and interviews with an experienced methods engineer, the sewing jobs were classified as requiring high, medium, or low amounts of repetitive manual manipulation. While the classification was somewhat subjective, it was closely related to the frequency of changes in hand and wrist posture. High degrees of manual manipulation were associated with higher levels of physical discomfort almost throughout the day. The greatest discomfort levels were concentrated in the neck, upper and middle back, right shoulder and hands. Seventy-three percent of the high-manipulation workers reported pain in their right hands. This was the highest discomfort frequency identified in the analysis, and is consistent with the findings of Vihma *et al.* (1982), which indicated a significant relationship between hand pain and repetition rates.

The cycle time of jobs ranged from 25 to 150 centiminutes, with the majority falling within the 35 to 75 centiminutes range. An average of 29 left-hand and 25 right-hand posture changes per cycle was recorded. The most frequent hand and wrist postures included pinch (lateral and pulp), ulnar deviation, flat press, extension and flexion.

Training

In the case of Plant A, sewing operators received training in a training school. The other plants offered on-the-job training where necessary, but employment policies favoured experienced operators. Training periods varied from a few days to up to six months. None of the plants under investigation provided their supervisors or training staff with specialised instruction in effective training techniques. There was evidence that improvements in operator training were being made, especially in the case of newly appointed workers. Higher percentages of younger operators reported receiving job-methods training by way of visual aids or videotapes, as well as training on posture, lifting and safety issues. After the initial hour or so of intensive training, return visits by the trainer/supervisor were sporadic. One plant posted a daily learning curve on the novices' workstations, but even this degree of performance feedback was unusual. The next phase deals with the responses to the questionnaires that machinists were asked to complete regarding their workplace.

Phase 2: Questionnaire analysis and discussion

During these visits, questionnaires were handed to a random sample of 313 sewing operators representing all three plants. The sample was distributed as follows:

- Plant A: 200 sewing operators
- Plant B: 85 sewing operators
- Plant C: 28 sewing operators

The results of analysis of the completed questionnaires are shown in Table 2.

Table 2. Results of analysis of 313 completed questionnaires

Criteria		
Seat height	32% unacceptable	68% acceptable
Aches and pains	93% experience pains	7% no pain
Adjustable foot rest	90% not adjustable	10% adjustable
Seat adjustability	100% not adjustable	0% adjustable
Working height	27% poor	73% satisfactory
Space	69% restricted	31% satisfactory
Machine operation	33% strenuous	67% easy
Accessibility of controls	37% not accessible	63% accessible
Skill level	86% demanding skill	12% low skill
Work organisation	40% disorganised	60% organised
Posture	48% hunched position	52% natural posture
Nature of work	83% repetitive	17% non-repetitive
Illumination	48% very poor	52% acceptable
Air flow	64% poor flow	36% acceptable

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Questionnaire results for the second phase

The physical difficulty of the sewing operation (90%) correlates with the skill levels required in the performance of work (86%) and the product-orientated repetitive nature of work (83%). It can be deduced that effective work performance requires a high level of skill and that the work is physically demanding and repetitive. The easy operation of the machine (67% stated that it was easy to operate)

correlates with accessibility of all machine controls (63% stated that all controls were accessible). It can be confidently stated that the machine is easy to operate. The responses regarding airflow (64% stated that it was insufficient) correlate with those regarding air temperature (76% stated that it was uncomfortable), which further correlates with the responses regarding climatic conditions, which 61% of the respondents described as unfavourable.

FUNDAMENTAL PRINCIPLES IN THE MACHINISTS' WORK ENVIRONMENT

The following phase aims to provide a benchmark for the implementation of ergonomics research results via a framework especially for the clothing industry in SA . The details of the framework can be found in the work of Ramdass (2007).Elements of the proposed framework as pertaining to ergonomics is:

Seating requirements

- **Seat height**

The height of a seat should not exceed the popliteal height of its user (i.e. the height of the underside of the knees). For a resting chair, where the user may wish to stretch their legs, a lower seat is preferable. The popliteal height of a 5th percentile of adult women (wearing typical outdoor shoes) is 400 mm. Thus the height of a non-adjustable chair should not exceed 400 mm, or 425 mm at the most (Grandjean, 1987). An excessively low chair makes standing up and sitting down more difficult and requires greater forward leg room for the comfort of tall people.

- **Seat depth**

The depth of the seat, measured from the front edge of the backrest, should not exceed the buttock-popliteal length of a small user (5th percentile women = 435 mm).

A seat that is too deep will inevitably deprive the person using it of the full benefit of the backrest. The person will either have to lean back in a flexed position with the lumbar region essentially unsupported, or will have to sit forward and lose contact with the backrest altogether. Neither is satisfactory. A depth of approximately 380 mm is usually recommended (Osborne, 1987).

- **Seat width**

This is determined by the need to accommodate the hips and lower trunk. A width of 410 mm will fit all but the broadest person, although 50 mm should be added to this to allow for clothing and the contents of pockets. Maximum widths are likely to be constrained by space requirements at the workplace, particularly if seats are placed next to each other in a row.

- **Upholstery of the chair**

As a very rough guide, the upholstery of a chair should have a space of about 2.5 cm between body and chair structure when compressed. Upholstery materials should be porous (plastic and wooden chairs may become unpleasantly clammy in hot weather).

Workspace

Ideally industrial workstation design should satisfy the system's performance requirements, as well as the requirements of the human user. Generally, an industrial workstation is a small working area in which workers perform assigned tasks. The terms workstation, workspace and work environment are often used interchangeably and include chairs, tables, machines, tools, actual product, regular and protective clothing, lighting and climate. The physical dimensions of the workspace are very important because small changes may have a considerable impact on productivity and occupational safety and health. A well laid-out workplace, or a well-designed piece of equipment, is one in which the operator can see and quickly and easily reach all the items necessary for the effective completion of a task. This can be performed in a posture or postures in which there is no discomfort or strain.

- **Worktable requirements**

The worktable should be of the height that suits the operator, whether he/she stands or sits at the worktable. The most favourable height for handwork is 10 -15 cm below elbow level. In the clothing industry there are variations in the size of the worktable, and recommendations should be made on a specific minimum and maximum. The current dimensions are as follows:

Worktable length: 100 cm
Worktable width: 50 cm
Worktable height: 71 cm (for sitting position)

To determine proper workstation height, the following may be considered:

- Make available several workstation heights.
- Adjust the work on the workbench size (Pulat & Alexander, 1991).

The surface of the worktable should be well finished, creating a smooth surface with well-formed corners to prevent damage to fabrics, while at the same time creating a safe and comfortable surface.
The following principles should be considered when deciding on workstation dimensions:

- Consider body measurement, as well as range and strength of movements of the kinetic elements involved in a task.
- Take account of the full range of body dimensions of the working population involved in a specific task.
- Recognise differences relating to sex, ethnic group and educational or social background. Each of these may affect specific types of manipulative skills.
- Determine, by way of biomechanical analysis, the optimal position of an operator with regard to equipment controls.
- Provide maximum postural freedom in task design, especially for repetitive work situations.
- Avoid standing in full foot and torsion or sideways bending of the trunk.
- Refrain from performing a task on a strip 7.6 cm wide from the border of the bench that is closest to the operator.

Principles of motion economy

The following principles of motion economy in the workspace should be considered:

- position tools and materials to reduce searching;
- arrange materials and tools to permit the best sequence of motions;
- use gravity feed, bins and containers to deliver the materials as close to the point of use as possible;
- locate tools, materials and controls within the normal working area if possible, otherwise within the maximum working area;
- use ‘drop deliveries’ or ejectors wherever possible so that the operator does not have to use his/her hands to dispose of the finished work; and
- make the height adjustable to allow alternate standing and sitting.

Man-machine interface

The interaction between the operator and the machine occurs via control devices (knobs, levers, pedals, keyboards, etc.) and information sources or displays (dials, counters, lights, charts, etc.). The proper design of this interface has important implications for the performance of the total system and for the safety and well-being of the operator (Pulat & Alexander, 1985).

Interface layout

The most important and most frequently used hand control should ideally be located within an area that extends from approximately 25 cm to 75 cm above the seat reference point and 38 cm to each side.

When displays and controls are used in a fixed sequence, they should be laid out accordingly and grouped together for their related functions. The clearances between neighbouring controls should be sufficient to prevent accidental activation. Since no single control device can be rated as good in respect of all the operational criteria, some degree of compromise and subjective judgement is required when selecting controls. Furthermore, all clothing manufacturing equipment is imported and seems to have been built with ergonomic considerations in mind. Unfortunately this is not the case as experienced by the researcher as modifications improve operator movements and machine time (Pulat & Alexander, 1985).

The next phase of the study compares the above principles, which would be used to evaluate the current situation in the machinists' workplace.

It has been found that ergonomics is no longer just a buzzword; it is going to be around for a long time because it makes good business sense. It has become evident that companies are realising that making ergonomic changes that may prevent major work-related injuries (proactive ergonomics) is much more cost effective than introducing such changes once major work-related injuries have already occurred (reactive ergonomics). In other words, they are realising the advantages of paying for ergonomic changes up front, rather than pay later whilst running the risk of diminishing the quality of life of their workers (Ramdass, 2007).

This study made it clear that ergonomics should actually be addressed as a matter of urgency. If a company can reduce work related injuries (Phase 1), productivity would increase simply because employees are healthier with less absenteeism. It also provides an excellent opportunity to decrease waste and increase productivity. During the course of the study it was very important to determine what the ergonomic problems were. The framework (fundamental principles) that was created provides a good indication of the areas on which the work-study officer should concentrate during the intervention for constructive input with a view to improvement. In order to ensure that the benefits of success would be reaped, any implementation (training) must include a corporate cultural change focusing on education and training. Ergonomics is a constantly growing field, and as long as people are used as the primary source of labour, there would be an endless need to make them comfortable through ergonomic enhancements in the workplace.

HOW THE AIMS AND OBJECTIVES OF THE RESEARCH WERE IMPLEMENTED

The main aim of this research was to evaluate the current status of ergonomics in the machinists' environment with a view to improving on the status quo. The conclusion reached (Phase 2) was that arguments that support a good ergonomic management system cannot be ignored. The study clearly showed that in order to create a safe working environment and gain a competitive advantage, it is essential to apply ergonomic principles preferably through a framework.

It is the researcher's observation that there is a need for ongoing research and technological developments that will enhance the ergonomic viability of the sewing operation in order to achieve maximum efficiency and productivity. Further, in order for the South African clothing industry to survive global competition, ergonomically designed manufacturing systems need to be implemented.

Based on the research, a fundamental framework was designed that contains the minimum requirements for a continuous ergonomic improvement programme. The framework emphasises the fact that technological improvements in the workplace, together with commitment to education, training and financial investment, are imperative in a globally competitive market.

The study concluded that the clothing manufacturing industry in South Africa presents significant challenges for the work-study officer. A large percentage of plants are experiencing marginal

profitability and can afford no more than quick, band-aid solutions to their ergonomic problems. For these organisations, the ergonomist has much to offer in terms of recommendations for workstation geometry adjustments, improved seating and improvements in workstation lighting and noise protection. Highly motivated plant managers are able to develop inexpensive and ingenious solutions to many of the problems that are brought to their attention.

More prosperous organisations are able to experiment with introducing one or more of the elements of new technology described above. Ergonomically designed seating should be a top priority, but companies often need assistance to distinguish between well-designed chairs and those that are 'ergonomic' in name only. The research has shown that other elements of workstation and materials handling automation are becoming popular, but managers can certainly use the services of a work-study officer to help lead them past the above-mentioned pitfalls.

The study revealed that many plants still operate under an unenlightened management philosophy that rejects the application of ergonomics practices. Managers fear that the introduction of such practices will 'plant seeds of suspicion' in the minds of the workforce and will lead to increased malingering and frivolous workers' compensation claims. Machinists showed a vague recognition of their workplace problems and are aware of occupational injuries through media reports and discussions with co-workers. A few large companies have added full-time work-study officers to their management teams and a larger number of companies are using outside consultants to help organise and support plant ergonomic projects.

The researcher is of the opinion that one of the most important roles that the work-study officer can play is in the area of educating the plant management, floor supervisors and workforce. Managers must be made aware of the importance (for both humanitarian and cost reasons) of a continuous program of surveillance aimed at detecting ergonomic problems before they are translated into acute or cumulative/chronic injuries. Plant floor supervisors need to be educated to support this surveillance program by recognising symptoms of ergonomic problems, including badly adjusted workstations, inadequate seating, inadequate illumination and high-risk working postures and motions by helping to identify intervention strategies and by training workers to do the same. This research was designed to educate apparel plant floor supervisors in ways in which they can fulfil this role.

The research showed that one of the companies included in the study trained sewing operators at a training school, while the other plants offered on-the-job training where necessary. The researcher found that when appointing staff, companies always gave preference to experienced operators. Training periods varied from a few days up to six months. None of the plants provided specialised instruction in effective training techniques for their supervisors or training staff. However, the research did show that improvements are being introduced with regard to operator training, especially in the case of newly-hired workers. Higher percentages of younger operators reported receiving job-methods training by way of exposure to visual aids or video tapes, as well as training on posture, lifting and safety issues. Video tapes were used infrequently and were more commonly used to cross-train the more experienced workers. After the initial hour or so of intensive training, return visits by the trainer/supervisor were sporadic. One plant posted a daily learning curve on the novices' workstations, but even this type of performance feedback was unusual.

The research showed that the arguments that support a good ergonomic workplace management system cannot be ignored. Organisations that wish to have a competitive edge in today's marketplace, with its emphasis on quality and excellence, must embrace ergonomics management as a valuable process that has the ability to reduce costs, improve quality and performance, and enhance productivity. Although major issues were considered, this study was not intended to resolve all ergonomic issues in the workplace. However, it did show that improved ergonomics management is both a realistic goal and good for business; therefore further research should be conducted.

CONCLUSION AND RECOMMENDATION FOR AN ERGONOMIC INVESTMENT

A prerequisite for change is a sustained change in human behaviour, and this will take time. The successful implementation of ergonomic practices is wholly dependent on commitment by all the spheres of an organisation. The research indicated that a number of organisations that participated in the study are considering combating the considerable reduction in profit margins caused by increasing labour costs by moving to low-cost wage areas. This will definitely have a major impact on the South African economy. In order to remain economically viable, ergonomics should form part of all training from the very beginning, and wherever work is done, it should be done with due consideration of ergonomic issues (Stevenson, 2006).

The challenge for an apparel production manager is to minimise input costs while achieving improved productivity and remaining flexible and meeting customer demands. Labour savings and increased productivity could be achieved by reducing the ratio of number of workers to number of machines. A survey conducted by the Institute of Industrial Engineers reported that 38 percent of the respondents observed increased productivity as a result of the development of effective ergonomic principles. Systems innovations resulted in a 37 percent improvement in productivity, while the use of robotics accounted for a 29 percent improvement in productivity. Increased productivity for human activity could be achieved through multitask operations (i.e. cross-training operators) and other methods that will allow the same amount of work to be done in less time. New sewing systems (example teamwork modular manufacturing systems) should meet these requirements. In teamwork modular manufacturing, a reduction in the need for labour (i.e. number of workers) results in a corresponding rise in productivity and savings.

In the South African clothing industry, management commitment in terms of attitude, managing in a diversified workplace and the allocation of resources are essential to the process of ergonomic management. Through simple, innovative and creative thinking, the current status of the industry could be improved through the application of ergonomic principles. The researcher would like to conclude by emphasising the need to implement ergonomics in a project approach, using a systematic method of application.

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