"ERGONOMICS AUSTRALIA"

The Official Journal of the Human Factors and Ergonomics Society of Australia

In future "EAJ" will be an online document rather than hard copy journal

This edition: Volume 24 Number 1 March 2010, ISSN 1033 – 875

ERGONOMICS AUSTRALIA — MARCH 2010

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EDITORIAL

Greetings to everyone, for joy and success in 2010. This is the first of a different EA journal that will no longer have its design, printing and postage handled in Melbourne by Acute Concepts and Impact Printing. The Board advised that funds were needed for other projects last year and eliminating the professional journal costs would make significant savings. A considerable debt of gratitude is owed to these Melbourne firms for their unfailing support and cooperation with the present editor since 2000 and also with previous editors, Robin Burgess-Limerick and Ross Armstrong. The times are changing and the Internet will be the new medium ... at least one benefit will be to see illustrations in colour at no extra cost! Readers will need to adjust to the visual and ergonomics demands of screen-based journal reading or printing their own copy.

This, my last contribution as editor, will be prepared as usual as a Word manuscript and then converted to a PDF file for uploading to the HFESA Website. In future, Rebecca Mitchell will coordinate an online version of the journal. The IEA Council has discussed the difficulty that affiliated societies are having in producing scientific journals and acknowledges that academics generally prefer to be published in internationally recognised locations. The Council apparently suggested that probably only two journals, *Applied Ergonomics,* and *Ergonomics*, have significant standing across the scientific community to ensure the necessary research funding credits. That limits the opportunities for beginning authors / students / practitioners and a low-key Internet journal may be the best alternative.

The long silence since the last EAJ in 2008 has had several causes. The dearth of local content has been a major concern. During much of that period, considerable time has been spent in reviewing, editing and corresponding with overseas authors. The new HFESA Website has been under construction and the journal portal was not available. It has now been reinstated. My husband suffered a major stroke in July 2008 while we were on holiday in New Zealand. He spent five weeks in Wellington Hospital and a similar time in Hornsby Hospital once we were allowed to fly home. It has been a slow recovery time and he has had numerous unexpected medical dramas throughout 2009 that have focused my time and priorities for work commitments and volunteering responsibilities.

I have greatly appreciated the willing support of senior colleagues who have found the time to review papers. I continue to receive papers from overseas authors and there are likely to be more as the major journals have long lists and probably less detailed editorial / referee interaction. It is certainly desirable that we support our colleagues in other countries — this has been a factor in the Board's budget considerations about hard copy editions. However, HFESA members must be willing to contribute if there is to be an online Australian journal. *Ergonomics Australia* is in transition and its future depends on continuing contributions.

For the present, we need to be positive in our outlook, keep faith with the overseas authors who are contributing to EAJ, and proceed on the assumption that *Ergonomics Australia* is a valuable professional tool for our society and the promotion of ergonomics in general — particularly in the developing countries south of the equator. I have greatly valued and enjoyed my time as editor and the interaction with a host of interesting authors, HFESA members and people from many different fields and locations. I wish Rebecca similar joyful experiences, every success and continuing membership support.

Shirleyann Gibbs PhD
Retiring Editor: *Ergonomics Australia*

ARTICLES

(1) Ergonomics risk factors in some craft sectors of Jaipur

Prabir Mukhopadhyay and Saurabh Srivastava

Abstract

This paper investigates three craft sectors in the Jaipur city of Rajasthan, India, namely stone painting, bangle manufacturing and clay sculpture. Postural analysis techniques REBA, RULA, and OWAS) indicated that the workers were subjected to vulnerable postures that exposed them to injury and work related musculoskeletal disorders. Repetitive activities were very high, with inadequate rest breaks, as indicated by elevated OCRA scores of 3 and above. This was further substantiated by high Strain Index scores of 9 and 6.8 in stone painting and clay sculpture sectors, indicating the need for immediate ergonomics intervention.

Key words: posture, musculoskeletal disorders, strain index, khyphosis.

1. INTRODUCTION

Human beings have evolved over millions of years leading to the bipedal creature that are seen today with a highly developed brain (Kumar 2001). The genesis of ergonomics is probably as old as civilization, as people learned to develop their own tools for hunting and gathering food. Subsequently people also learned to produce different types of artefacts by hand, which fall under the domain of the craft sector today. It was the cultural or artistic capabilities that were expressed in this work. Technology developments gradually commercialized craft and in turn created time pressures that placed a priority on productivity levels rather than creativity. This lead to long working hours in constrained postures and repetitive activities without adequate rest which ultimately were manifested in Work Related Musculoskeletal Disorders (WMSDs). It should also be acknowledged that craft workers in these situations are unlikely to have provision for formal workstations.

WMSDs are a group of disorders affecting the bones, muscles, ligaments and tendons of the human body. There are certain risk factors like awkward posture, force, repetitive activities and inadequate rest (Mukhopadhyay et al, 2007a, b). Presence of all these factors sets the stage for WMSDs. This eventually leads to a decline in the productivity and quality of the work. In the first stage of any design intervention, the identification of risk factors is very important. This is where ergonomics can play a very big role. A close look at the craft cluster addressed in this paper indicates that the majority of the risk factors for the genesis of WMSDs are present: namely awkward postures, repetitive activities and forceful exertions. Unfortunately when it comes to investigation of ergonomics risk factors in craft clusters like stone painting, clay sculpture and bangle manufacturing, almost nothing is reported in the literature. The scenario is the same for the global as well as the Indian context.

Related work in similar unorganized sectors like agriculture, fishery, hand loom or manual brick manufacturing form the only source of information for researchers willing to investigate these areas (Mukhopadhyay, 2006). For example, Mukhopadhyay (2007, 2008) identified ergonomics risk factors among manual brick manufacturers in western India using REBA and RULA, but there was no mention of clusters like stone painting, bangle manufacturing or clay sculpture. In a study on weavers, butchers and tailors in eastern India (Gangopadhyay et al, 2003) researchers identified repetitive movements of upper limbs to be the main contributory factors in the genesis of cumulative trauma disorders. However, there was no investigation of postural risk factors. Other researchers (Sen and Chakraborty, 1984, Sen and Kar, 1984) investigated the agricultural sector, but their focus was on developing different types of personal protective devices against different environmental hazards. There was no probe into postural and other risk factors. In a study on handloom workers in eastern India (Vargens et al, 1994) the occupational workload in terms of energy expenditure of the workers on different sections of a loom was assessed and found to be higher than the prescribed limit. Here again there was no probe into other risk factors such as posture or repetition. In a similar study, Tiwari et al (1998) estimated the occupational workload of fisherwomen, but there was little investigation in terms of posture and other risk factors.

Thus from the literature review it transpires that there is still a dearth of data about the craft sectors in India. This sector generates employment for the local youth. However, currently there are no statistical data on injury rates, diseases or disorders prevalent in this sector. The high level of drudgery involved in these tasks led the authors to investigate the risk factors associated with craft activities.

2. METHOD

2.1 Direct observation and activity analysis

A modified form of Drury's (1990) direct observation and activity analysis was applied. This was necessary as the activities in this sector were varied — unlike any organized sector such as manufacturing or banking — for which the original method had been devised. Subjects were observed in actual working conditions. The posture assumed the path of travel of the hand and the number of repetitive activities was observed. Data from this was used for postural analysis for assessing risk factors for WMSDs on the lines of the work done by other researchers in the unorganized sectors like manual brick manufacturing (Mukhopadhyay, 2008).

2.2 Questionnaire and interview technique

Questionnaires were developed based on the method of Sinclair (1975). Four versions of the questionnaires were made, validated and then a final questionnaire was agreed. For validation purposes, the questionnaires were tested on the subjects in actual working conditions. The time taken to complete the questionnaires, the quantum of information being collected and the sequence of questions were carefully analysed. Based on these analyses further modifications to the questionnaire design were made to enable the researchers to extract the required information in the shortest possible time. The questionnaire comprised questions pertaining to different problems related to a particular craft such as: normal daily activity; discomfort in the different body parts; working hours; resting periods; and total working duration. (see Appendix)

2.3 Photography of different workstations

Photography (still and video) of different workstations was undertaken, with a specific focus on postural issues. The photographs were later analysed in the laboratory. The still photographs were used to identify the different categories of working postures vulnerable to injury, such as bending, twisting and tilting the head forward. Video photography was used to analyse the number of repetitive movements, especially movements of the limbs, forward body movement and twisting. The video photography also helped in cross checking the detailed time and motion study performed for postural analysis in the field.

2.4 Measurement of psychophysical parameters

A modified form of a body part discomfort map (Corlett and Bishop, 1976) was applied to identify discomfort in the different body parts. Subjects were asked to rate the zone of maximum discomfort.

2.5 Postural analysis

Different techniques were applied for postural analysis of work related musculoskeletal risk factors. These methods were OWAS working posture (Karhu et al, 1977), Rapid Entire Body Assessment (REBA) method (Hignet and McAtamney, 2000) and Rapid Upper Limb Assessment Method (RULA) method (McAtamney and Corlett, 1993). Apart from this Occupational Repetitive Action Index (OCRA) for repetitive activity (Occhipinti, 1998) and Strain Index devised by Moore and Garg (1995) was applied. To get an insight into the workload on hand musculature Threshold Limit Value (TLV) for hand activity (devised by Lalko and Armstrong, 1997) was applied as well.

3. RESULTS

3.1. Direct observation and activity analysis of 21 persons in each group

Activities in all the three sectors, namely bangle manufacturing, stone painting and clay modelling, were predominantly carried out in a seated or standing position for long periods extending from 30 minutes to 2 hours at a stretch. Overall working hours extended from 8 to 12 hours depending upon the number of orders received and time dead lines. The work was predominantly light with high static muscular loads on the upper arm and forearm. Since the tasks were precise, the grip had to be a "pinch" type, which further increased the static load on the muscles of the shoulder, arm and hand systems.

In the bangle manufacturing section the bangles were made out of a lump of lacquer. First the lump of lacquer (Figure1) was heated on wooden charcoal fire with the help of a wooden rod. The rod was gently rotated to gradually soften the lump of lacquer. When the lacquer was soft enough it was rolled by hand into the form of a thin cylinder. To give the cylinder a defined colour, a block of a particular colour was heated and coated over the lacquer cylinder (Figure 2).

Figure 1. Heating & rolling lacquer lump in bangle manufacturing

Figure 2. Colour of lacquer lump (All photos provided by the authors)

The thin cylinders were then joined by hand to form a ring like structure (Figure 3). This ring was then heated and passed over a wooden cylinder of a specific diameter selected to suit individual sizes of human hands and wrists. The semi-solid lacquer cylinder then took the shape of the wooden cylinder (Figure 4) and the ring was finally pressed against a reference bangle of the same size. After this, if additional ornamentation was required, the lacquer bangle was gently heated and semi-precious jewels were fitted by using a pair of tongs to press them into the still soft bangle surface (Figure 5). The bangle was then left to cool. The entire process took place with the worker seated on the floor in different positions such as squatting or sitting cross-legged. In the entire process the back or the vertebral column was unsupported and assumed a lumbar khyphosis. The upper arm was in abduction and at times in forward flexion as well (Figure 6). The entire forearm was unsupported and involved circular motion from the wrist.

Figure 3. Joining cylinders from lacquer lump

Figure 4. Sizing tender bangle against a reference wooden cylinder

Figure 5. Fitting semi-precious jewels on tender bangle surface

Figure 6. Upper arm abduction & forward flexion

In the stone painting unit, articles (mainly showpieces) made out of stone, for example wall hangings, pen-stands, tumblers, photo-frames and flower vases were painted. There was again no fixed workstation as such. If the article was too big then a small table was used (Figure 7) and all work was done on the floor with frequent postural changes. Smaller articles were taken in the non-dominant hand (Figure 8) and then painted. For painting purposes a paintbrush and oil based colour was used. As expected, the act involved static loading in the forearm, coupled with deviated postures of the wrist and forearm, and fingers holding the brush in a pinch grip. (Figure 9) The duration of work normally varied from 8 to 10 hours and was dependent on orders received. All workers worked in awkward and constrained postures with the cervical vertebrae in forward flexion (Figure 10, 11) and the vertebral column in lumbar khyphosis.

Figure 7. Pinch grip (R hand) and wrist deviation (L hand

Figure 8. Static load on forearm muscle in prolonged holding of vase

Figure 9. Awkward postures in stone painting

Figure 10. Forward flexion of neck and and abduction of upper arm

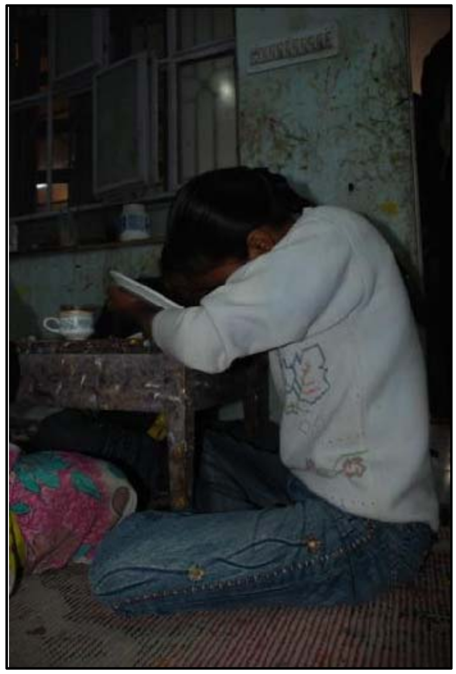

Figure 11. Abduction and forward flexion of upper arm at a typical stone painting table

In the clay sculpture section the work was varied (Figure 12) and was dependent on the size of the statue. Work was done at awkward postures (Figure 13).

Figure 12. Forward bending in clay sculpture

Figure 13. Abduction of upper arm in clay sculpture

The upper arm was in abduction and forward flexion with frequent pronation and supination of the forearm (Figure14). The grip varied from pinch to power depending upon the stage of sculpture, and it further added to the static loading of the shoulder and arm system. The artist had to bend forward at times for a long duration. (Figure 15)

Figure 14. Abduction & pronation of upper arm in clay sculpture

Figure 15. Forward flexion of upper arm with pinch grip and deviated wrist in clay sculpture

3.2. Postural analysis

Rapid Entire Body Assessment (REBA) (Hignet and McAtamney, 2000) and Rapid Upper Limb Assessment (RULA) (McAtamney and Corlett, 1993) working posture analysis were used to analyse the postures and the associated risks. REBA scores (Table 1) were very high (12/12) in bangle manufacturing sectors and also high (11/11) in clay sculpture sections. RULA scores were (Table 1) consistently high in all the sectors. In stone painting and clay sculpture the RULA score was 7/7. It was 6/6 in the bangle-manufacturing units. Very high scores indicate a need for early ergonomics intervention. The OVAKO working posture analysing score (OWAS) method of Karhu et al (1977) was applied. In the clay sculpture sectors legs (score 5) and arms (score 3) were very high and vulnerable to injury. OWAS scores for other sectors — head, back, arms and legs — were within the normal range of 1 or 2 (Table 2). The Occupational Repetitive Action Index (OCRA) (Occhipinti, 1998) and Strain Index (Moore and Garg, 1995) were applied to get an insight into repetitiveness of the job and the resulting strain on the limbs. The OCRA scores (Table 1) were in the borderline area in all sectors, with the highest value in the bangle-manufacturing sector, at 3.9/3.9. The Strain Index value was very high in the stone painting (9); high in clay sculpture 6.8); and within normal limits (4.5) in the bangle-manufacturing sector.

Table 1. Results of postural analysis and repetitiveness scores in different sectors

Sector	REBA	RULA	OCRA	Strain Index
Bangle	12/12	6/6	3.9/3.9	4.5
Stone painting	9/9	7/7	3.3/3.3	9
Clay sculpture	11/11	7/7	2.4/3.9	6.8

Table 2. OWAS working posture analysis in different craft sectors

Sector	Head	Back	Arms	Legs	Force/Weight
Bangle	2	2	2	1	1
Stone painting	2	2	1	1	1
Clay sculpture	2	2	3	5	1

The Threshold Limit Value (TLV) for hand activity (Lalko and Armstrong, 1997) was within normal limits (0.3) for both right and left hand in the bangle-manufacturing unit. (Table 3) It was just at the borderline (0.5) for right and left hand in the stone painting and clay sculpture units.

Table 3. Threshold Limit Value (TLV) for hand activity in different sectors

Sector	Left	Right
Bangle	0.3	0.3
Stone painting	0.5	0.5
Sculpture	0.5	0.5

3.3 Body part discomfort score

The bangle-manufacturing sector indicated that 40% of workers experienced maximum discomfort in the lower lumbar region while 4% noted that their minimum discomfort was in the forearm. The stone painting sector reported that 32% had maximum discomfort in the neck (cervical) area and 8% had minimum discomfort in the lower lumber region. In the clay-modelling sector 24% reported maximum discomfort in the shoulder area, 16% noted minimum discomfort in the forearm. There were no parts of the body that had no discomfort at all — all parts were affected.

4. DISCUSSION

In all sectors the posture was one of the potential risk factors in the genesis of Work Related Musculoskeletal Disorders (WMSDs). There were certain postures, like abduction and forward flexion of the upper arm, which lead to stress on the gleno-humeral capsule of the shoulder (Mukhopadhyay et al, 2007a). This could ultimately lead to permanent damage of the shoulder and arm system. Along with this, pronation and supination of the forearm (especially the former) have been found to contribute to WMSDs like epicondylitis (O'Sullivan and Gallwey, 2005). A precision type of finger pinch grip was seen to be used in all sectors, and was considered to be unavoidable. A pinch grip coupled with a deviated posture of the wrist and forearm poses a high risk factor in the genesis of WMSDs. Awkward postures like forward bending and twisting of the trunk, lead to an enormous amount of stress on the lumbosacral segment of the vertebral column and were observed in all sectors. All three sectors involved precise work and hence the static muscular load on the upper arm especially (shoulder-arm system) was involved. This loading was manifested by high REBA and RULA scores in all sectors — especially bangle-manufacturing and clay-sculpture — the clay sculptor had to stand for long durations without any forearm support. This led to a static load on the muscles of the lower limb, which in itself is a strain on the softer tissues. A high OWAS score — particularly for the clay-sculpture unit — reflected this outcome, specifically in the legs but also in the arms. The body part discomfort score further substantiates the findings above, in terms of a mismatch between the task and a human operator. (Mukhopadhyay et al, 2007a, b)

A high OCRA score in all the sectors strongly indicates that although the workload was relatively low, the repetitive movements of the limbs were high and there were inadequate rest breaks. It has been reported (Daams, 1993, Mukhopadhyay et al, 2007a, b) that repetitive movements involve micro wear and tear in the soft tissues of the limbs. This minor damage in the tissues is repaired if adequate rest is given, but that was absent in these work sectors. The duration of work was long, extending between 8 and 10 hours and sometimes even longer, leaving no time for the worn-out tissues to regenerate. A high Strain Index in stone- painting and clay-sculpture indicated strain in the distal upper extremities. The distal end of the upper extremities was maximally involved in these two sectors in terms of repetitive activities and static load leading to soft tissue injury as mentioned before. The value of TLV in all the sectors was within normal limits, which was the result of barely any force being involved in these activities. As there was less muscular activity of the upper limb, the TLV value was low.

5. CONCLUSION

The different sectors studied do not involve the application of a large amount of force, but do involve repetitive activities in vulnerable postures without adequate rest breaks. All these set the stage for the genesis of eventual work related musculoskeletal disorders. The risk factors noted above, as well as the design of hand tools, workstations, work processes and adequate work-rest cycles must be addressed. Only then will high-level risk factors and worker injuries be reduced. This in turn will lead to improvements in worker productivity. A change in attitude to risk management could make craft a future lucrative career among rural youth in India.

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ACKNOWLEDGEMENTS

A Ford Foundation — National Institute of Design, Gandhinagar India Research Grant, funded this project. Acknowledgement is owed to all the subjects who volunteered for the research. Very special thanks are extended to Professor Yunus Khimani of the Indian Institute of Craft and Design, Jaipur, India, for all his support during the field study at Jaipur.

Appendix: Questionnaire
Sample questionnaire used in the craft sectors

The purpose of this survey is to gain an insight into the different problem areas in the craft sector from a design ergonomics perspective. All data collected would be kept confidential and would be destroyed after analysis.

Please answer the following questions:

Name: Age (years): Height (cm): Weight (kg):

Unit: Mention the nature of work you do:

1. How long have you been in this profession (years):
2. On an average how long do you work daily (tick):
   a. 7 hours
   b. 8 hours
   c. more (specify)
3. Select you normal working hours:
   a. 9am – 6pm
   b. 8am- 5pm
   c. 10 am-7pm
   d. others (specify)
4. What is the duration of rest/break in between working hours:
   a. 1 hour
   b. 30 minutes
   c. others (specify)
5. Do you take mandatory break at specific intervals while working?
   a. Yes b. No
6. If yes is the break of a fixed duration?
   a. Yes b. No
7. Mention the body part that gives you maximum pain/discomfort at the end of a days work. You may select multiple sites.
   a. neck; shoulder; upper arm; forearm; waist/lower back;
   b. upper back; upper leg; lower leg; other (specify)
8. Did you ever remain out of work due to severe pain in your body parts?
   a. Yes b. No
9. If yes please specify the body parts affected:
10. How long were you out of a job? (specify):
11. Please elaborate:

12. Any other problems faced in this profession:

Thank you for your kind cooperation!

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DESIGN, DEVELOPMENT AND ERGONOMICS EVALUATION OF A HAND OPERATED SPADE (PHAWRA)

Mahendra Singh Khidiya and Awadhesh Bhardwaj

Abstract

A human workforce contributes substantially to crop production in Indian agriculture. Approximately 220 million workers provide about eight per cent of all related agricultural activities. Although farm mechanization is increasing rapidly, it is the men whose tasks are predominantly affected. Whereas only hand tools were used in ancient times, there has been a gradual improvement in their design, efficient handling, weight, and cost and worker acceptance in recent times. People today realize that there are still many possibilities to modify these tools for better work efficiency. This paper addresses ergonomics factors that can increase the utility of a hand-operated spade or hoe (phawra). The design modifications were prepared using software CATIA (version V5R12) and were analyzed using software ANSYS (version 11.0). Evaluation studies have been conducted with Subjective experiences of the subjects (to measure comfort or discomfort Corlett and Bishop technique is adopted) subjective measurements are preferred when evaluating hand tools on comfort and discomfort, as comfort and discomfort are subjective feelings. To achieve goal, a designed hand tool evaluation study was conducted and Comfort Questionnaire for hand tools (CQH) is used and evaluated the modified trowel.

Keywords: spade, ergonomics, agriculture, hand tool, productivity CATIA, ANSYS

Introduction

Ergonomics should be seen as an opportunity to improve productivity and quality while increasing employee safety and morale. Benefits of ergonomics are higher productivity, higher quality, reduced operator injury, increased morale, greater job satisfaction, lower medical & insurance costs, reduced lost time, and lower absenteeism, less employee turnover.

The main economic characteristic of agriculture in developing countries is the low level of manual productivity. While the benefits of technology have been shown in many and varied circumstances, even rational and intelligent farmers may resist their implementation, so that any tool improvements involve a slow rather than instantaneous acceptance. This is a factor, which may affect efficiency in any labour operation. Small farmers and labourers use a number of tools each day which, given improved design, could lead to higher productivity. This research Paper relates to one such tool ─ a spade or hoe (phawra) ─ used almost universally for farming and other labouring work where there may be scope for improvement in conventional spade design. Using design software like ANSYS and CATIA can assist design and structural analysis, but ergonomics must be considered for better productivity.

Ergonomics has many aspects, one of which is anthropometry, which addresses posture analysis to reduce worker stress, fatigue and injuries. At the same time, attention to details such as these has the potential to increase worker performance and productivity. Those factors underpin the current analysis of the hand-operated spade. Spade is a manually operated common hand tool used for digging and in nursery bed preparation. It is known by different names in different parts of the country. It consists of a thin flat blade set transversely on a handle. The digging head has an "eye" or socket for the insertion of the handle. The socket is either separately welded to the digging blade or is an integral part of the blade, which is usually made of medium carbon steel. Its shape is developed by a forging operation. The cutting edge is hardened to 350-450 HB. These tools are available in different shapes and sizes. For operation, the handle of the spade is held in the hand, head raised and struck into the soil for digging. For grounding operation the tool head is pulled towards the operator who is obliged to adopt a bent forward posture.

Method

i. Testing the existing Spade in the field & evaluation of comfort questionnaire
ii. Modelling in CATIA of existing hand trowel
iii. Analysis of existing hand trowel in ANSYS
iv. Modifying the existing tool ergonomically according ANSYS and anthropometric data.
v. Testing again in the field with modified trowel

Tool Specifications

Spades are specified by their types and weight:

- Weight (kg) : 1.1
- Blade thickness (mm) : 2.5, forged and sharpened at the cutting edge
- Blade width (mm) : 220
- Uses : including digging, loosening of earth, making of trenches, weeding and nursery bed preparation.

Fig. 1 Existing Spade tool
Courtesy: CTAE workshop Udaipur, India

In mechanics, the principle that no work is done unless a force moves its point of application is used. The human operator is certainly capable of work, either by isometric (static) muscle action or by isotonic action, in which there is limb movement. Isometric activity probably is superior in reaction sensitivity as it generates kinesthetic feedback. In kinesthetic feedback, the operator receives more informative feedback from the feel of what he is doing than from observing the results of the activity. Isotonic action occurs when muscle fibres are moving in relation to each other. Thus, for maximum precision, isometric action is often used, but for maximum power output and for postponing fatigue, isotonic action is superior.

Role of anthropometry

Anthropometry enables a working environment to be designed for its users, rather than requiring them to adapt to a given setting, its use is likely to result in increased acceptability, improved ease and efficiency of use and therefore greater operational safety and cost effectiveness.

Postural analysis

Postural analysis can be a powerful technique for assessing work activities. The risk of musculoskeletal injury associated with the recorded posture(s), in the context of a full ergonomics workplace assessment, can be a major factor for implementing change, so the availability of task-sensitive field techniques is of great assistance for the ergonomics practitioner. Most postural analysis techniques have two, often conflicting, qualities of generality and sensitivity. High generality in a postural analysis method may be compensated by low sensitivity. For example: the Ovako Working posture Analysis System has a wide range of use but the results can be low in detail. In contrast NIOSH requires detailed information about specific parameters of the posture, to give high sensitivity with respect to the defined indices, but has a limited application in health care in particular with respect to animate load handling. A need was perceived within the spectrum of postural analysis tools, specifically with sensitivity to the type of unpredictable working postures found in health care this lead to increase the use of the postural analysis tool, Rapid Entire Body Assessment (REBA) & Rapid Upper Limb Assessment (RULA).

Some basic human body postures

Full span of the human body: Figure 2. Demonstrates the full span of the human body or what alternatively could be said to describe a person's workspace volume. This is an important aspect for any designer and ergonomist in assessing the parameters to accommodate for a specific user.

Fig. 2: Human body span
Courtesy Khidiya & Bhardwaj, Udaipur, using Catia software

Position at the time of working with spade*:* The illustration in Fig 2.3 below shows the usual position of a person when working with a spade. Generally this is said to require a torso angle of between 20^o-25^o flexion for comfort and efficient working. Working with a spade is repetitive work, so the back angle is an important factor for consideration.

Fig. 3: working with spade position
Courtesy Khidiya & Bhardwaj, Udaipur, using Catia software

Movement of human arm and elbow: A person's hands are used for almost 90% of daily routine work. Hands, wrists and shoulder movements are involved in working with a spade. Therefore these body parts need to be considered for optimum movement angles for repetitive spadework. As shown in figure 3, the elbow movement should be between 0^o to 100^o in XY plane for safety and better output. Similarly movement of the arm at the shoulder should be restricted to a maximum 90^o for repetitive work.

Fig. 4: Arm and Elbow movement
Courtesy Khidiya & Bhardwaj, Udaipur, using Catia software

Finger Movements: Finger movements for normal activities should be restricted to 15^o above and below the horizontal line of those fingers. However, while using a spade, the fingers will be bent at an angle of 120^o for proper gripping.

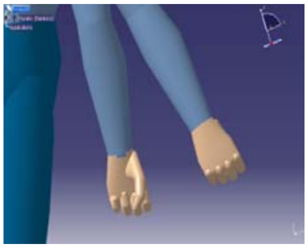


Fig. 5: Finger movement
Courtesy: Khidiya & Bhardwaj, Udaipur, using Catia software

Effect of stress on human performance

Stress causes a direct impact on human performance. The person's effectiveness is low at high stress and as a result there is high probability of human error, the graph indicates that at no stress, the work is probably dull and unchallenging. Maximum effectiveness observed when a person is working with moderate stress.

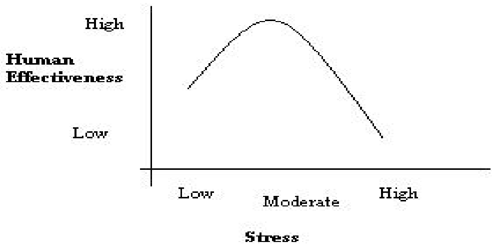


Fig: 6 Human stress v/s Human performances Curve
Courtesy: www.ieee.com

If the stress is very high because of worry, fear, poor security or any other psychological stress, then the human effectiveness or performance will decline. The reasons for stress may be work overload, lack of any intellectual input, an occupational change, occupational frustration or environmental factors.

Considerations in the design of hand tools

Poorly designed hand tools may be too heavy, poorly balanced, have a grip that is too large, the wrong shape, or slippery. Any of these factors can lead to injuries of the hand, wrist, forearm, shoulder, and/or neck. Spades with bent handles keep the wrist and forearm straight to reduce injury and increase power. They also require less finger and hand effort. Spades with foam or rubberized grips help to reduce the transfer of vibration to the hands and arms.

The Stresses and Forces

In Figure 7 the various forces acting on the worker while working with the tool are illustrated using the following identification code:

F = Force applied by the worker
L = Distance between the line of force and the centre of gravity of the worker
Θ = Angle of inclination of the worker with the vertical plane

Fig. 7: Force analysis on human body
Courtesy www.ieee.com

Grip

A well-balanced tool with a properly designed grip or handle instantly feels comfortable in the hand. If a spade is poorly designed or is not right for the job, it may have to be held more firmly and at an awkward angle. A properly designed grip helps to reduce fatigue and pain. Consider whether the job requires an in-line grip. When significant power or torque need to be delivered, select tools that allow for a power grip; the hand makes a fist with four fingers on one side and the thumb on the other, similar to holding a spade that can be used in either hand to allow workers to alternate hands and the tool then can be used properly by the 10 percent of workers who are left handed.

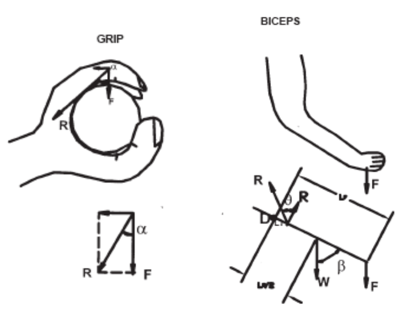


Fig. 8: Reaction forces on hand and arm
Courtesy www.ieee.com

Fig. 9: Grip of an existing spade
Courtesy: CTAE farm India

Handle size

The right-sized handle is one that allows the hand to go more than halfway around the handle without the thumb and fingers meeting. The recommended grip diameter in most cases falls between 30 and 40 mm. To provide good control of the spade and prevent pain and pressure hot spots in the palm of the hand, handles should be 60 to 90 cm long. A precision grip (when the tool is pinched between the tips of the thumb and fingers) is primarily used for work that requires control rather than a lot of force.

Fig. 10: Length of the handle
Courtesy: CTAE farm India

Grip Surfaces

The grip surfaces of a spade handle should be smooth, non-conductive, and slightly compressible to dampen vibration and better distribute hand pressure. Tools that have grooves for fingers should be avoided since the grooves may well be either too big or inappropriately spaced for most people. The resulting pressure ridges across the hand can damage nerves or create hot spots of pain. Grooves along the length of the handle are intended to prevent slipping but can also cut into the hand and create pressure ridges, particularly if the tool is in continuous use. If a grooved handle is the only choice available, the user should ensure that the grooves are many, narrow and shallow.

Weight

Weight is often a problem with hand tools such as spades, axes, hammers, and saws. To reduce hand, arm, and shoulder fatigue, the hand tool should not weigh more than 2.3 kg. If the centre of gravity of a heavy tool is far from the wrist, this maximum weight should be reduced. Studies have shown that tools weighing 0.9 to 1.75 kg feel just right for most workers. For precision work, where the small muscles of the hand support the tool, it should weigh far less. Lighter is better. In some circumstances, heavy tools can be made easier to use by suspending or counterweighing them, although such alternatives are unlikely to be applicable to spades and their use.

Scope for ergonomically designed improvements to a spade

After reviewing the various features of a hand tool, such as a spade, it can be seen that there are numerous factors to be changed in order to have a better tool. When ergonomics factors are considered in the design, the user is able to work better, with comparatively less effort. Some of these factors are discussed below:

Biceps movement

In relation to force and the upper arm joint, (refer to Figure 8.2 above) (there are 2 degrees of freedom consisting of two reaction force's direction having angle θ between them,) β is the angle between the line of gravity and the forearm, so as β decreases, the amount of tractive force will be needed for digging diminishes; this factor is one of the determinants for a handle design.

Grip

As the angle α decreases, the value of $R \cos\alpha = F$ increases, which provides a greater reactive grip resulting from the repetitive impact when operating the tool.

Waist

As male worker leans forward, the centre of gravity shifts in the opposite direction from its original position at the navel area, hence the angle θ must be as small as possible to maintain body equilibrium.

Neck

As a person looks downward, the centre of gravity shifts towards the forehead, which results in a greater amount of reactive moment at the universal joint support between the spinal vertebrae and the skull because of the increased length of the lever.

Role of computers in the design process

The design of spade related tasks, which may be performed by modern CAD system, could be grouped into three functional areas:

1. geometric modelling;
2. engineering analysis; and
3. design review.

Geometric modelling

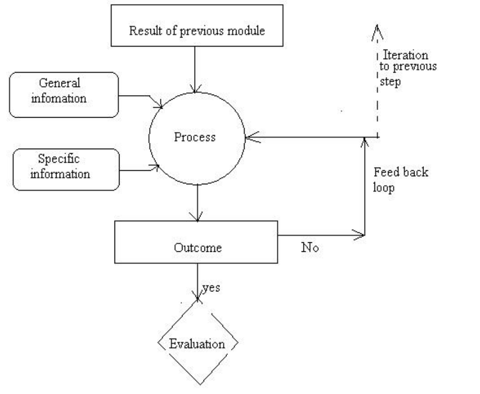
Computer aided design (CAD) tools are available to provide computer generated modelling to illustrate the geometry of an object. The mathematics involved allows the image of the object to be displayed and manipulated on a graphics terminal using signals that come from the central processing unit of the CAD system. In geometric modelling, the designer constructs the image of the object on the CRT screen of the interactive computer graphics system, by inputting three types of command to the computer.

Engineering Analysis

In the design formulation part of this project, some analysis is required. The analysis may involve stress-strain calculations that may use a computer program to assist this work. The most powerful analysis feature of a CAD system is the Finite Element Method (FEM) as used for this type of analysis.

Design Review

Checking the accuracy of a design can be accomplished conveniently on a graphics terminal. Semiautomatic dimensioning and tolerance routines, which assign size specifications to surfaces indicated by the user, can help to reduce the possibility of dimensioning errors. Computer animation may help in checking the kinematics performance of the design without resorting to a pin board experiment.



Process for design

Fig. 11: Process for design
Courtesy Khidiya & Bhardwaj, Udaipur

Modelling and Analysis of a Spade

Modelling and analysis of a spade can be divided into two parts. Tool Modelling in CATIA and Analysis of spade with ANSYS.

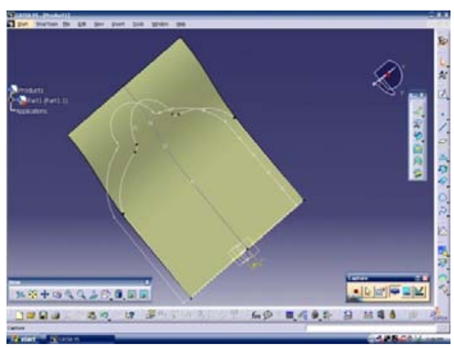


Fig 12
Modelling a tool by generative shape
Courtesy Khidiya & Bhardwaj, Udaipur

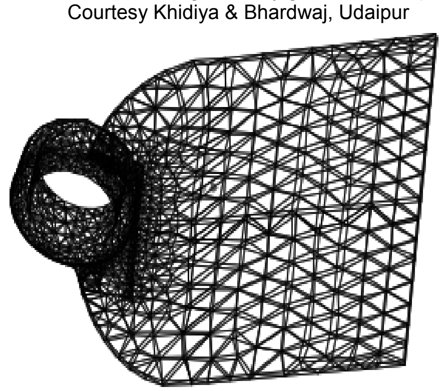


Fig13
Isometric view of meshed spade
Courtesy Khidiya & Bhardwaj, Udaipur

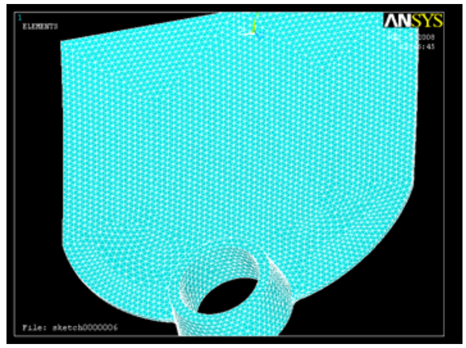


Fig. 14: Meshing of the part
Courtesy Khidiya & Bhardwaj, Udaipur

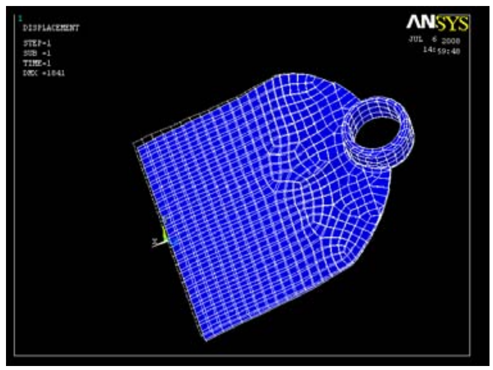


Fig 15: Deformed Shape
Courtesy Khidiya & Bhardwaj, Udaipur

Plot the Von Mises equivalent stress (Von Mises theory of failure)

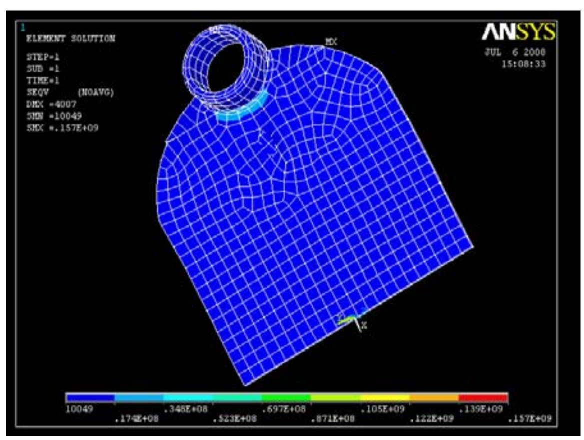


Fig 16: Deformed Shape with result
Courtesy Khidiya & Bhardwaj, Udaipur

Experimental Designs

The subjects were asked to dig a hole of 1 feet depth and area of 1 square feet with conventional spade. The soil was made moist by sprinkling water about 3 or 4 hours before the start of experiment. The subjects were asked to dig holes in the soil as quickly as possible without any rest breaks. After the subjects finished digging holes, the descriptors of the

Comfort Questionnaire for Hand tools (CQH) were rated and—if necessary—the meaning of the descriptors was explained. At last, the subjects rated overall comfort. After a rest break of at least 5 min, the next digging-task started. This procedure was repeated for both spades existing and developed one.

Overall discomfort rating in Table 1 gives the capacity of the worker or subject to work and it is defined on a scale with a sliding pointer with graduations marked. The rate is important because with its help a workers body's overall capacity can be known during working and proper intervals during working can be given for rest.

Comfort descriptors						
Hand tool	Unsatisfied		Satisfied somewhat		Fully satisfied	
Fits the hand	1	2	3	4	5	6
Is efficient	1	2	3	4	5	6
Is simple in use	1	2	3	4	5	6
Transmits applied force admirably	1	2	3	4	5	6
Has a pleasant feeling handle	1	2	3	4	5	6
Offers a high task concert	1	2	3	4	5	6
Needs low hand grip force supply	1	2	3	4	5	6
Needs good function between hand and handle	1	2	3	4	5	6
Causes in inflamed skin of hand	1	2	3	4	5	6
Causes peak pressure on the hand	1	2	3	4	5	6
Feels sweaty	1	2	3	4	5	6
Causes lack of sensation in hand	1	2	3	4	5	6
Causes muscles cramping	1	2	3	4	5	6
Looks professional	1	2	3	4	5	6
Overall comfort						
This hand tool is	uncomfortable		Average		comfortable	
	1	2	3	4	5	6

Table 1: The Comfort Questionnaire for Hand Tools

To grade posture, the body parts focused on is back, neck, shoulder, elbow, hand/fingers, hip joint, knee and ankle. While force evaluation, the users have a table for assistance where measurements in kilos and Newton are represented. The following aspects are assessed:

- weight, lifted in standing or sitting position;
- assembly force, exerted by fingers or hand; and
- grip opportunities and other heavy load handling.

The underlying factors of the hand tools are identified using principal components analysis (PCA). The relationships between comfort descriptors (i.e. statements in end-users' own words that are related to comfort) and comfort factors (i.e. groups of comfort descriptors) with comfort experience are calculated. It is concluded that the same factors (functionality, physical interaction adverse effects on skin and in soft tissues) underlie comfort in different kinds of hand tools, however their relative importance differed. Functionality and physical interaction are the most important factors of comfort in using hand trowel.

Testing & Evaluation

Fifty male agricultural subjects were randomly selected from different villages and it was assured that they had sound physical and mental health. For Testing of Existing spade, the spade was issued to the subjects and they had to work 35 minutes work followed by rest of 10 minutes and during rest they were asked to fill the CQH.

For measuring ODR (Overall discomfort rating) they were asked to indicate a number on CQH. Determining Comfort Postural discomfort is the discomfort experienced by the subject because of muscular discomfort to maintain the body posture during the work. Discomfort is the body pain arising as a result of the working posture and/or the excessive stress on muscles due to the effort involved in the activity. In many situations, though the work may be well within the physiological limits, the body discomfort may restrict the duration of work depending upon the static load component involved in it and this is the case for most of the agricultural activities. For evaluating Comfort, CQH was used. In this technique the body was divided into 27 regions. The subject was asked to indicate the number on CQH for his work experience with the modified tool and noted.

Overall discomfort rating was taken on a ten point psychophysical scale (0=totally disagree with given CQH statement, 6= totally agree with given CQH statement) that is an adoption of the Corlett and Bishop (1976) technique. A chart namely CQH was prepared including comfort descriptors. At the end of a 35 minutes period the subject was asked to indicate the overall discomfort rating on this chart. The overall discomfort ratings given by each subject were added and scaled from one to six

Subject no.	CQH of existing tool	CQH of modified tool	Subject no	CQH of existing tool	CQH of modified tool	Subject no	CQH of existing tool	CQH of modified tool
1	4	6	18	3	4	35	3	5
2	4	6	19	5	5	36	2	4
3	2	3	20	4	6	37	3	4
4	2	5	21	3	5	38	2	4
5	4	5	22	4	6	39	3	4
6	5	6	23	3	4	40	3	5
7	3	4	24	4	5	41	3	5
8	5	6	25	3	5	42	4	5
9	3	4	26	4	5	43	2	4
10	4	5	27	4	5	44	3	5
11	4	5	28	3	4	45	4	5
12	4	5	29	3	5	46	3	5
13	3	5	30	3	5	47	2	4
14	3	4	31	3	4	48	3	5
15	4	5	32	4	5	49	3	5
16	2	3	33	3	4	50	2	5
17	4	5	34	4	5			

Table 2: CQH for old and new handle

	existing tool	modified tool	Percentage improvement
Sum	165	238	44.2%
Average	3.3	4.76	44.2%

Table 3: Analysis of existing and modified tool

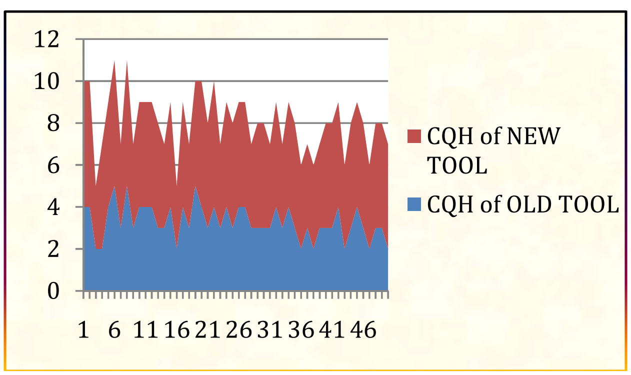


Figure 17: coparision of CQH of an old and new tool
Courtesy Khidiya & Bhardwaj, Udaipur

Result of the analysis

The spade being discussed in this paper offers an optimal design when it was analyzed with the help of ANSYS; it was revealed that there are still some factors to be considered in order to develop a tool that is also ergonomically suitable for an operator. As shown in Figure 16 the spade has its weakest point around its eye as well as having maximum stresses in this part. By using this analysis one can easily find the various parameters to be considered. According to the analysis carried out on the spade, a manufacturer could also vary the material used for a spade in order to make it strong enough to withstand the various loads and stresses involved in a particular activity. As shown in fig. 17 (a) and (b) the material may be added to the weakest part of the tool.

Fig. 17 (a) Fig. 17 (b)
Courtesy Khidiya & Bhardwaj, Udaipur

Modifications and Comparisons

The newly developed tool in this paper is different from the tool that presently is being used by the agricultural workers. The existing blade is almost flat; this paper resulted in a slight curvature to make it easy for the worker to lift the material and also to shift a greater quantity of soil. With the help of CHQ it is evidence is provided.

Fig. 25: Developed Curved edge
Courtesy Khidiya & Bhardwaj, Udaipur

The blade developed from this research has a sharp ground contact edge. This provides the better digging action by cutting the soil in an easier way. By CHQ it is proved.

Fig. 26: modified cutting edge
Courtesy Khidiya & Bhardwaj, Udaipur

Some extra toughening of the joint of eye joint material has been added around the eye of the spade to make it stronger, since ANSYS detected that to be the weakest area and maximum stress bearing part portion of the tool.

Fig. 27: Material added
Courtesy Khidiya & Bhardwaj, Udaipur

Fig. 28 (a) **Fig. 28(b)**
Eye hole for handle difference between existing and developed
Courtesy Khidiya & Bhardwaj, Udaipur

Modifications in the Handle of the Spade

The handle of the existing spade is shorter in length, being about 60 cm so it is cumbersome for the workers and requires a greater bending of their back. It will lead to earlier back fatigue. The current research team has provided a sufficient handle length of about 75 cm for an average worker.

Fig. 29 (a)

Fig. 29 (b)

Handle of spade, existing and developed
Courtesy Khidiya & Bhardwaj, Udaipur

A curvature in the handle has been provided to ensure less movement of the wrist in comparison to that required when using a conventional spade. Another change has been to make the tool's grip tighter.

Often the handle of the spade can be seen to slip from a worker's hand and this could lead to an accident. A better handle grip has been provided in order to prevent undesired outcomes when the tool is in use. In addition, based on anthropometrical data, the diameter of the handle has been increased in order to provide a better gripping facility. As the circumference of a palm is generally 3.8 cm, a handle diameter of 3.5 cm has been provided at the top and is gradually increased to 4.7 cm at the bottom. The rubber grip further prevents the handle from slipping in the worker's hands.

Fig. 30 (a)

Fig. 30(b)

Grip of spade existing and developed
Courtesy Khidiya & Bhardwaj, Udaipur

CONCLUSION

The main objective of this project has been to find a theoretically better way of working with less fatigue and better strength when using a spade. This has been carried out by an analysis, which determined that the posture of the head during the operation of the existing tool caused an excessive reaction force on the neck. This was shown to be mainly influenced by the handle length. The mass of the tool should be at a minimum to have the least reaction force on hand. In agricultural work a farmer's spade is used for removing the weed and digging small perforations into the waterways. This is monotonous work; so a lighter tool is much better from an ergonomics point of view. It can be seen that farm accidents and MSD are also reduced with a lighter tool. The reaction force on the upper arm from gripping the tool is greatly influenced by the tool force and orientation of the hand as well as the anthropometric dimensions. Reaction forces on the back muscles near the lumbosacral joint have been identified as lower, when using a long handled spade and thus ensuring less body fatigue in the worker.

For the better and easier utilization of human power there is a need to develop a better working environment. In the process of making a better tool, this research team first determined an outline of a hypothetical tool and defined some dimensions in consideration of desirable ergonomics aspects. The study identified some areas in need of change. An alternative was then investigated using CATIA design software. The next challenge was to analyse the new tool both technically and ergonomically using the analysis software ANSYS. The newly developed spade has been shown to be better than the existing one but there are still some areas that require further work. The primary areas of concern relate to various component weights including the wood selection (in order to reduce the weight of the handle) and the spade material (blade weight).

This paper indicates a way forward to improve spade design and construction. Finally, it should be acknowledged that ergonomics does not offer an instantaneous process; rather it is a gradual process that must consider many factors. The present design as developed and explained in this paper may not be the ultimate solution, but may be a step closer to a more satisfactory design. In the process of making a better tool, the new spade has been shown to be better than the existing one. The comfort level has been improved 44.2% and could offer an improved working environment and a reduction in workplace injuries.

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REPORT

TECHNOLOGY CHALLENGES FOR PRIVATE PRACTICE CLINICIANS: HUMAN FACTORS TO THE RESCUE

Jennifer Long

This paper is based on an invited presentation given by Jennifer Long at the Informa "Human Factors in Healthcare Symposium" held in Darling Harbour, Sydney, in March 2009

Abstract

There has been considerable research into human factors issues in large healthcare settings such as hospitals. However, a large proportion of healthcare in Australia is delivered through smaller healthcare settings such as private practice. This paper explores some of the human factors issues confronting clinicians in private practice, particularly issues resulting from the introduction and use of technology. Since the requirements of clinicians can vary between practices, a consultative approach is recommended for individual practice settings. Nevertheless, there are commonalities within private practice settings, which need to be explored. This is likely to be a new frontier for healthcare ergonomics.

Introduction

Clinicians, both medical and paramedical, are at the coalface of medical care. There is an unwritten expectation that they will always make the correct decision and recommend appropriate treatment, all while keeping to an appointment schedule. However, the conditions under which clinicians are required to make these decisions are not always optimal.

Much has been written about human factors issues within healthcare, particular in hospital-based settings. Runciman et al[1] give a good, current overview of this topic with specific case examples. The human factors issues associated with healthcare delivery are important in larger facilities, such as hospitals and aged care facilities, as these sectors account for 42% of health expenditure in Australia (36% hospitals, 7% high level residential aged care services[2]). Incidents and errors in these healthcare settings are also more likely to capture media attention through the political ramifications of such errors.

These statistics do not capture the entire picture of healthcare in Australia. A large proportion of doctors working in Australia are self-employed[3] in either general or specialist practice ─ as are the majority of allied health professionals such as optometrists, physiotherapists, chiropractors and dentists. There are also programs in Australia to minimise the time patients stay in hospital and to support their healthcare needs in the community, for example, for the elderly[4]. While errors and incidents in smaller healthcare settings may not make the newspaper headlines in the same way as incidents within hospital settings, private practice clinicians are still faced with human factors issues, albeit on a smaller scale. There has been comparatively little discussion in the scientific literature about human factors issues in these healthcare settings.

One of the most significant trends within healthcare over the past two decades has been the introduction of technology. This is a double-edged sword: on one hand it has changed the way in which clinicians diagnose and treat patients; on the other hand, it has increased our expectations about the level of care. For example:

- Many diagnostic tools that were once the province of university clinics and teaching hospitals are now de-rigueur in everyday practice and may even attract their own Medicare item number.

- Instead of attending an annual conference or visiting a university library to keep up to date with medical advances, clinicians can now gain this knowledge quickly and easily through Internet searches and online forums.

This paper presents two case examples from the ophthalmic industry illustrating these trends. The purpose of this paper is not so much to provide a definitive solution, rather to discuss some of the human factors issues associated with these trends. It is only by identifying these issues that we can hope to manage them and make steps to improve clinical care.

Introducing new technology into clinical practice: the visual field examination

Visual field examinations are conducted to measure peripheral vision, for example, in eye diseases such as glaucoma. A quarter of a century ago, a method commonly in use was the Bjerrum Screen (see Figure 1). This is a manual procedure in which the patient faces a black screen and fixates on a target. A second target on a wand is held by the clinician and is moved into various positions on the screen. The objective is for the patient to say when they see the target. A skilled clinician can precisely map the extent of a patient's peripheral vision and the location of scotoma (or blind spots).

In the mid-1980s computerised visual field examinations were developed (also known as computerised perimetry). This is an automated technique in which the patient places their chin on a chinrest with their eyes facing an illuminated bowl (see Figure 2). The patient is instructed to fixate on a target and to press a button when they notice a second target appear in their peripheral vision. Computerised perimetry has revolutionised clinical practice, as it is no longer imperative that the primary clinician administer the test. Instead, the patient can be positioned and monitored by a trained assistant, allowing the clinician to consult other patients while the test is being conducted.

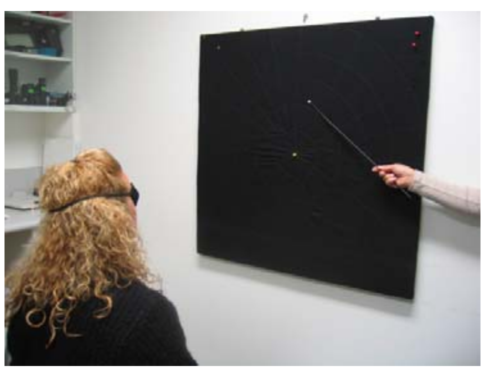

Figure 1: the Bjerrum Screen

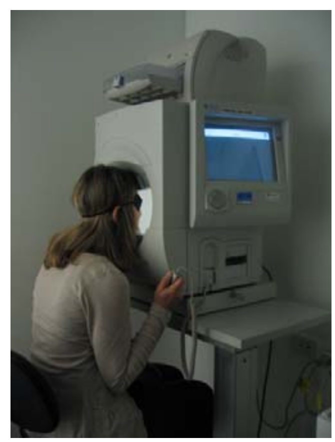

Figure 2: A computerised perimeter

Using a trained assistant for automated procedures is a trend occurring in many aspects of healthcare. It is often based on the assumption that a clinician who monitors an automated procedure is doing nothing and that this is a waste of their valuable time.

On one level, the decision to use a trained assistant is a financial one: a trained assistant will allow the clinician to perform other consultations requiring their specific skills, but will there be sufficient use of the equipment to justify employing an assistant?

However, it also introduces logistical issues such as:

- How will the clinician's appointments be managed?
- When the test is completed, will the clinician examine the results and explain the findings in between seeing other patients (i.e. will they be seeing more patients in

the same period of time)? Or will there be a specific time allocated in the appointment schedule for this purpose?

There are also quality and safety issues. For example:

- Will clinical decision-making be compromised if there is inadequate time for the clinician to interpret the findings?
- Who trains the assistant and ensures that they are competent?
- Will the assistant notice subtle but crucial information that may affect the clinical decision? How is this communicated to the clinician before clinical decisions are made? Is there a formal handover procedure?

Non-clinicians, such as a practice manager, could predict these issues during the process of deciding whether a practice requires a trained assistant. However, there are also broader ergonomics issues, which may only become apparent through a consultative approach with the clinicians themselves. For example:

- Is the clinician really doing "nothing" while administering the test? Or does this "down-time" allow them to catch up on other administrative tasks such as writing referrals and reports to other clinicians, reducing the need to work after hours to complete this work? This may have implications for the communication of results to other clinicians, especially for patients with complex medical conditions such as diabetes who may be under the care of multiple practitioners.
- Does administering an automated procedure provide variety for the clinician throughout the working day? Does this bring a physical benefit (reduce overuse injuries?) and a cognitive benefit (reduce boredom)?
- Will a trained assistant employed solely for the purpose of administering an automated procedure be at greater risk of developing overuse injuries or becoming bored with their job because of its lack of variety?

Keeping up to date with medical information

John works in a busy suburban optometry practice. A series of patients presenting with unusual and complicated issues means that he is now running behind schedule. His next patient, a savvy, middle-aged gentleman opens the consultation by asking "I saw this new surgical procedure on television last week. They say if you have it done you don't need to wear glasses any more, even for people my age. So I took a look on the Internet and printed this out. What do you think?"

Healthcare is constantly changing — new treatments and drugs are regularly introduced to the market. There is an unwritten expectation, on the part of clinicians and patients alike, that appropriate care and treatment will be provided — after all, patients see a clinician because they think that they will be able to help them.

There is also a trend for patients to seek medical information themselves through resources such as the Internet[5]. A New Zealand investigation published in 2002 revealed that 10% of patients bring information from the Internet to consultations[6]. More recently, an informal report published in Australia indicated that more than 60% of patients consult the Internet before visiting their doctor[7]. While some practitioners may consider it their role to interpret medical information for their patients, the difficulty often lies with the clinician being able to assess the quality and accuracy of information presented by the patient … and lack of time during consultations to assimilate the information and address patient questions[5, 8].

How can clinicians cope with the meteoric rise in available knowledge and give appropriate advice on a diverse range of topics? There are numerous technological options for keeping abreast of medical knowledge. These include:

- systematic reviews of the scientific literature, such as the Cochrane database;
- media alerts such as Australian Doctor, “Six Minutes Newsletter”;
- online references such as Mims online; and
- database systems such as pick lists of drugs with common side-effects.

While providing clinicians with a computer and Internet access might seem an easy solution, it does introduce other physical, cognitive and organisational issues. For example:

- Is the clinician computer literate? Has that person had time to learn the relevant computer skills?
- Does the clinician know how to access and use the online resource?
- Is the interface user-friendly? For example, is it easy to switch from a practice management interface to a web-based interface? Are the two compatible?
- Are there adequate resources to implement the technology? For example, does this mean that the computer system needs to be upgraded?
- Does the clinician have time to access and read the information?
- Where will the computer be located? Will it fit on an existing workstation? Can it be accessed easily during a consultation?

Human factors to the rescue

One of the basic tenets of ergonomics and human factors is a consultative approach: if you want to understand the issues affecting productivity, efficiency and safety, then ask the person who is actually doing the job. It is also a well-accepted strategy to monitor any issues which may arise as a result of implementing change to a system. These processes form the basis for a risk management approach[9] and are incorporated into Australian occupational health and safety legislation. They are applicable for organisations of all sizes.

Decision makers and policy makers should be cautious about making generic recommendations on issues such as the use of trained assistants for automated procedures. There are a wide variety of practice styles, modes of practice and individual preferences, even within professions. Interventions are more likely to be accepted and successful when individual practices undergo a consultative process with all members of their practice, from the receptionist who manages appointments through to the clinicians themselves.

Similarly, providing a computer for every clinician so that they can keep up to date with medical advances is not the panacea it first appears. Such interventions are in need of a risk management approach to ensure that new problems do not arise from the introduction of such technology. The introduction of technology may even be contraindicated in some practices as it does not provide a net benefit; there may be other more appropriate ways of managing information acquisition.

Conclusion

Healthcare faces many challenges, many of which may be resolved by a human factors approach. There is considerable body of research in this area, from technology through to teamwork. Integration of this knowledge across a range of disciplines is paramount for addressing the challenges.

Much of the current published research relates to large healthcare facilities such as hospitals. This is important as incidents and errors can have dire consequences and they often achieve a high profile in the media. However, a large proportion of healthcare in Australia is provided in small healthcare settings such as private practice, where incident and error can also have tragic outcomes. The human factors issues associated with this type of work are relatively unexplored.

Advances in technology are having a major impact on the way clinicians perform their work. The next step for healthcare ergonomics (or human factors in healthcare) is to address the issues that confront smaller practices.

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BOOK REVIEW

SAVE YOUR HANDS!

Complete Guide to Injury Prevention and Ergonomics for Manual Therapists

Lauriann Greene and Richard W. Goggins
With contributions by Janet M. Peterson
Reviewed by Shirleyann Gibbs

The first edition of this book was published in 1995 and the revised and extended second edition in 2008. Lauriann Greene, a manual therapist, wrote the first book in response to her own experience of occupational injury ― which forced her to find alternative uses for her academic training and acquired practice skills. By publishing papers and conducting workshops across North America she has since combined with Richard Goggins to generate the present edition which is intended to aid the reduction of occupational injury for manual therapists. While the first edition became a standard practical guide for this sector, it became obvious that the information had a much broader application for all health professionals … and anyone else whose work involved physical activity. Richard Goggins, a certified professional ergonomist and manual therapist, has worked with both employers and employees, in a wide variety of industries, on ways to prevent work related injuries. He has added some of his findings and case stories to the original work.

The advice offered in this book makes easy reading and is readily accessible for specific interrogation. It has plenty of examples to explain particular concerns and is well illustrated with photographs, drawings and simple diagrams. One of its strengths is that it offers value for the experienced OHS practitioner as well as an inexperienced member of the wider community. Ergonomists will appreciate the fact that it presents a holistic view of a person, task and environment … something that is not always appreciated by either busy medical practitioners or business management.

Janet Peterson is a member of the National Board of Directors, American Physical Therapy Association (APTA) and has been particularly concerned about her members' vulnerability in relation to work-based injuries. It is the reason she became involved with the concerns of these two authors and agreed to take a critical overview of the work in progress for the second edition and subsequently write a supportive Foreword to the book. It is a cogent textbook for the health professional and an easy read for anyone interested in understanding the problem. The Table of Contents and Index provide speedy access to specific information or 'random dipping' across some 300 pages.

The book is divided into three parts with the following chapter titles:

- Part 1: Why Manual Therapists Get Injured
  - Raising Your Awareness of Injury Risk
  - Weak Links in the Body
  - Risk Factors for Musculoskeletal Disorders
- Part 2: Preventing Injury
  - Using Ergonomics in Your Work
  - Developing Good Body Mechanics
  - Modifying Your Techniques
  - Looking at Your Emotions and Your Work
  - Special Considerations and Tips
  - Injury Prevention Outside of Work
  - Your General Health
  - Physical Conditioning
  - Planning for Career Longevity

- Part 3: Injury, Treatment and Recovery
    - Understanding and Responding to Symptoms
    - Injuries Common to Manual Therapists
    - Diagnosis and Treatment of Injuries
    - When Injuries Become Chronic
    - Conclusion: You Are Not Alone

There are four Appendices, a Glossary, Bibliography, Index and information about Training and Consulting Services conducted by the authors.

Its final chapter, *You are not alone* — is a most important factor when overcoming potentially chronic difficulties. In the preceding chapters there is a wealth of practical advice … much of it inducing instant recognition for an experienced practitioner, but being none the less valuable as a reminder of details that may be overlooked or ignored in a busy schedule. This reviewer is well aware of the shortcuts taken … and sense of invulnerability demonstrated … by many highly intelligent and experienced professionals who should know better!

Perhaps the most significant aspect of this work is the authors' concern to influence the training of young therapists in awareness of hazards and how to prevent future unwanted outcomes as well as being activists for current practitioners. They note that these matters did not raise noticeable concerns until the last decades of the twentieth century but that considerable community awareness has been evolving in recent years. Their book is well written and edited and is a desirable addition on the bookshelf of any health related professional. It is co-authored and published by Lauriann Greene at:

Body of Work Books
4799 Coconut Creek Parkway # 125, Florida 33063, USA
Website: www.SaveYourHands.com
Available on order from there and in Australia and New Zealand from:
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PO Box 56
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Telephone: +64 4 296-742
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TALKING POINT

Delegates' Report on Developments at Standards Australia

Shirleyann and Grahame Gibbs

Performance goals replace prescriptive detail when using updated ANZ Standards in the design, installation and use of biological safety cabinets.

Updated ANZ Standards for Biological Safety Cabinets

All designers (including architects, ergonomists, HVAC and electrical engineers) as well as users, project and facility mangers responsible for the selection, positioning, testing and maintenance of critical controlled environments need to be aware of major changes to national standards for biological safety cabinets. The details represent an international response to experience gained in relation to product and staff safety in hospitals and related health industries. The documents include a new Australian standard for the design of a class II biological safety cabinet (AS 2252.2) and a proposed new standard (AS 2252.4) for installation and use of biological safety cabinets as a revision of AS/NZS 2647:2000 that will be withdrawn on publication of the new standard. AS 2252.4 has been published as a draft standard for public comment between 28 January and 11 March 2010. Once agreed (noting any additional responses) at the committee meeting proposed for 18/03/10 it will be published as the new standard. It must be appreciated that AS 2252.4 is part of a series of related standards that need to be addressed as well as necessary compliance with relevant local building codes, legislation, regulations and nominated technical specifications such as:

- AS 2243.3 Safety in laboratories;
- Guidelines for physical containment facilities levels 2, 3 & 4 as issued by the Office of Gene Technology, Canberra; and
- Code of Good Manufacturing Practice (GMP) as issued by The Therapeutic Goods Administration, Canberra.

Hospital biological safety cabinets are used for many applications such as testing for swine flu, handling and dispensing hazardous or sterile medicinal products, or conducting forensic investigations and various research activities.

These ANZ changes are the result of work carried out by members of SA Committee ME–060 Controlled Environments. Key elements are contained in a new standard: AS 2252.2–2009 — Design of class II biological safety cabinets. This standard supersedes AS 2252.4–2004 and incorporates several significant changes so it should be read in its entirety. In particular the following changes were made (see Preface AS2252.2—2009):

> *"(a) EN 12469 or NSF/ANSI 49 or equivalent Standards are acceptable alternatives to AS 2252.2 for the manufacture and certification of negative pressure plenum cabinets. When these cabinets are selected, certification for on-site commissioning and periodic test requirements are to be performed to comply with the requirements of the relevant Standard of manufacture or AS2252.2.*
>
> *(b) Factory test requirements have been introduced in addition to the existing test requirements.*
>
> *"(c) Field test requirements have been amended.*
>
> *"(d) Previous prescriptive requirements have been amended in favour of performance-based requirements.*
> *"This Standard is Part 2 of a series on biological safety cabinets."*

When complete, the series will comprise the following:

Australian Standard:

2252.1	*Controlled environments—Part 1: Biological safety cabinets Class 1 — Design*
2252.2	*Controlled environments—Part 2: Biological safety cabinets Class 11— Design*
2252.3	*Controlled environments—Part 3: Biological safety cabinets Class 111— Design*
2252.4	*Controlled environments—Part 4: Biological safety cabinets Class 1, 11 & Cytotoxic — Installation and use*
2252.5	*Controlled environments—Part 5: Cytotoxic cabinets —Design,*
2252.6	*Controlled environments—Part 6: Clean workstations—Design, installation and use*
2252.7	*Controlled environments—Part 7: Pharmaceutical isolators — Design, installation and use*

"The separate parts of this series specify cabinets that provide protection from hazardous biological materials. These materials may need to be handled in contained spaces for the safety of the operator (classes 1, 11and 111) or if product protection only is required this can be handled in laminar flow clean space. (*In this Standard, the term 'laminar flow' has the same meaning as the term 'unidirectional flow'.)"*

The ME–060 Committee has reviewed various available options for a new AS 2252.4 *Controlled environments—Part 4: Biological safety cabinets Class 1, 11 & Cytotoxic — Installation and use,* and has decided to adopt the British Standard: BS 5267:2005 as an AS Standard 2252.4 with an ANZ Appendix. The draft of this proposed document is now available for public comment. The British Standard, BS 5267:2005 — Microbiological safety cabinets — provides additional recommendations and guidance in relation to information that should be a negotiated agreement among all involved persons (buyer, seller, designer, contractor, installer, tester, user) regarding optimal siting and use of a particular cabinet. These items are illustrated in the standard as:

Figure 1 — Recommendations for minimum distances for avoiding disturbance to the safety cabinet and its operator
Figure 2 — Recommendations for minimum distances for avoiding disturbance to other personnel
Figure 3 — Air make-up and room ventilation systems

The ANZ Appendix

The draft ANZ Appendix compiled by a working group of SA Committee ME–060 has a suggested title of *Guidelines for the installation and use of biological safety cabinets in Australia and New Zealand.* This has been prepared by Standards Australia for public comment and its anticipated adoption following a review of public comment and decision at the next committee meeting scheduled for 18 March 2010. This proposed draft covers:

- types/classes of biological safety cabinets;
- reliable building engineering services (particularly continuous electrical supply to critical equipment in the event of mains power failure);
- secondary barriers;
- room integrity;
- access to a controlled environment;

- anterooms;
- air conditioning plant;
- air conditioning, exhaust and air supply;
- air pressure control;
- lighting control;
- air filtration;
- calculation of outdoor airflow rates; and
- decontamination of cabinets.

A note about changes to Standards Australia operation

Since the recent Productivity Commission of Inquiry into Standards Australia and NATA, there has been considerable change within the organization. Standards Australia (SA) has advised that the GFC has caused a reduction in SA investment income and thus its ability to service committees as previously. It has therefore advised members that a new format must be implemented to enable the survival of SA as a sustainable entity. Many submissions to the recent Productivity Commission of Inquiry indicated a strong reaction by voluntary committee members to the realization that their free gift of intellectual property to SA, now generated financial gain for a public company, SAI Global, with exclusive SA publishing rights — as confirmed in an online news release by SAI Global on 23 June 2009:

> *"Reference is made to the Company's announcement to ASX on 22 July 2008 concerning arbitration proceedings between SAI and Standards Australia Limited. These proceedings concerned the commercial-in-confidence Publishing Licence Agreement between the parties, dated November 2003 ("the PLA") as it applies to "Australian Standards" developed by bodies that have been accredited by Standards Australia, known as accredited Standards Development Organizations ("SDOs").*
>
> *The issue for the Arbitrator's determination was whether SAI's "exclusive" rights to publish "Australian Standards" under the PLA extend to standards called "Australian Standards" that are developed by SDOs, as contended by SAI.*
>
> *The arbitration, confidential to the parties, was heard by The Honorable Michael McHugh, QC on Wednesday 6 May 2009. Today Mr McHugh handed down his Award and Reasons, which upheld SAI's claim."*

Since its formation in 1971, ME–060 has been responsible for over 60 standards. Under the traditional SA committee structure voluntary committee members relied on a dedicated project manager from the SA Secretariat to coordinate their work and prepare standards for publication. Current funding shortfalls have greatly reduced the number of SA paid staff, so committees will need to provide those services from an alternative source. In future, it seems priority for SA secretariat involvement will be given to commercially viable rather than technical standards. It is clear that options for ME-060 and many other committees will be limited.

Standards Australia subsequently arranged for a facilitator to be present at a meeting of each of its committees to outline details of the changes and explain its proposed five options for future development of standards based on its new business model.

1) Committee Driven Solution

Highly autonomous committees draft Standards to the requirements of ABSDO with defined technical and secretarial support and access to technical advice and editorial support from Standards Australia.

This first alternative is similar to the traditional process that SA committees have followed. However, SA has advised that this pathway is unlikely to be supported for ME–060 in future because of the relatively large number of standards it has produced and requiring ongoing support for periodic review. Shortage of SA funding reportedly has halved the number of paid staff and therefore voluntary committee members will need to take up the slack. In addition, SA will give priority to commercially viable standards for SA secretariat involvement. It was clear that options for ME–060 and many other technical committees (with significant value but less consumer revenue generation) would be limited.

2) Bureau

An advanced version of the Committee Driven pathway where most of the responsibilities are held by one proposing organisation.

This is one possible alternative pathway that could be developed by establishing an association or society with a number of goals, one of which would be the development of standards for submission to SA in a publishable format.

3) Collaborative Solution

Specialist support products and services are provided under a collaborative agreement to meet market needs and solutions in agreed terms and time frames.

This alternative pathway is also said to be unlikely to have SA support, as it will require significant ongoing SA resources to maintain the development and maintenance of those standards.

4) Standards Australia Driven Solutions

High level technical and support services are offered for projects of high net benefit and priority. This pathway offers greater contribution from Standards Australia.

This alternative pathway will require significant ongoing SA resources to maintain the development and maintenance of standards and SA has indicated that technical committees are unlikely to qualify for this option.

5) ABSDO

Accreditation as an Australian Standards developer via the Accreditation Board for Standards Development Organisations (ABSDO)

This pathway is only suitable for large organisations such as government organisations or independent authorities that maintain significant infrastructure and are able to handle all aspects of the standards publication process (such as the CSIRO).

Likely Future Direction for ME–060 Standards Development

Given the above options, the Controlled Environments Committee ME–060 is in the process of exploring the Bureau Model. This could involve setting up a society or association primarily for the development of Standards for Controlled Environments. The association would be based on the existing ME–060 committee, which would be expanded to include a wider representation of interested parties, since there has been a significant decrease in the range of organisations represented on the committee in recent years. Government and industry support has been reduced by the associated costs of supporting staff committee attendance in recent years. A small working group is investigating possible options for, and objectives of, an airborne contamination control society under the auspices of a related organization. In discussions so far, initial concerns are to:

- consider means for future controlled environment standards development given available SA options;

- generate a means of conducting educational and training courses, seminars and lectures that would engage associated academics, professionals, suppliers, testers and users of cleanroom facilities across a broad spectrum of industrial applications; and
- generate funds for establishing the necessary secretariat support for these activities.

Meanwhile current draft standards, which can be completed and issued by July 2010 SA deadline for the present support mechanisms, are in hand. Management of critical items for future development, such as review and adoption of future ISO Standards; development of necessary local standards — such as for cleanroom garments, isolators and nanotechnology — will be subject to further discussion in light of SA operational changes and the possible establishment of a new working group (as noted above) to generate secretariat funding. Similar investigations regarding future options for existing Standards Australia committees are reportedly being undertaken by many other professional organizations that are concerned by post–July 2010 implications.

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Note from Grahame Gibbs:

Readers may be interested to know that Shann was recently invited to publish a book by LAP Academic Press, Germany: "Staff safety in complex industry systems" and it is now available from bookstores in USA, UK & Europe and online from "Books on Demand" and "Amazon". This involved a very fast learning curve as a PDF file containing the entire manuscript and cover had to be uploaded to the LAP website; while online it was necessary to select a front cover illustration from thousands of images (!) and then upload a photo and 'blurb", from whence it was checked, printed and published to a database. Copies are made available on a 'just-in-time' process in response to demand … saves booksellers' expenses having to carry large stocks and organise sales and returns of remainders. The firm guarantees to publish within three days of an order from anywhere in the world.

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Articles in this edition of *Ergonomics Australia* have been peer reviewed.