

C O N T E N T S

2	President's Message
3	Ergonomics International
10	CHISIG news
12	Branch News
15	Do It By Design
22	Low Back Pain and Sailboarding: Part 2
31	Electronic Resources
32	Conference Calender
33	Information to Contributors
33	Information to Advertisers

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President's Message

Dear ESA Members,

By the time you receive this copy of EA, the 1999 conference hosted by the WA Branch at Fremantle will be underway. During this conference will be the 1999 AGM of the ESA. This will complete the first year of the 2 year term of the current Executive. A complete report from myself, and other Executive members will be circulated prior to, and during the AGM.

During September / October 1999 we are proud to be part of Cyberg 99. Congratulations to Dr Leon Straker from Curtin University for his work in developing and hosting this important opportunity for interchange internationally between ergonomists.

This edition of EA is possibly the last contribution from the current editor, Dr Robin Burgess-Limerick. Robin has made a fantastic contribution to ESA in his voluntary capacity as editor for the last 2 years. On behalf of the Board and all the members, I would like to recognise and thank Robin for his editorial leadership with this excellent publication. I would also like to welcome Dr Shann Gibbs who has been elected by the Board to become the next editor of EA. More details shall be provided in the next edition about possible vision and restructures for this communication link with our members.

The Education Review Committee has been considering a range of options relating to certification of ergonomists, and also potential restructuring of the membership criteria for the ESA. Details shall be discussed during the forthcoming conference in Fremantle and contribution from all members is welcome.

Possibly the first time in ESA's 45 year history, we will be having an election for the next ESA President and Executive. The ESA Board decided to change the protocol in relation to the appointment of the ESA President and to invite a Branch (this year Queensland) to offer candidates. Two highly capable candidates, Jim Carmichael and Ken Horrigan, have been nominated for the position as ESA President for 2000 – 2002. This can be seen as a more democratic approach to appoint my successor and also to recognise the important contribution of Queensland within ESA. In the history of the Society, they have only ever had one President (Professor Margaret Bullock in 1998-1990).

We look forward to conducting an election at the AGM in Fremantle and announcing the Executive for the next Board.

I look forward to meeting as many members of ESA as possible in Fremantle. I also would like to thank and acknowledge the Western Australian Branch for the endless hours of preparation for this important event in our annual calendar.

Yours sincerely,

David C Caple
ESA President

Ergonomics International

STEPHEN PHEASANT PRIZE AWARDED TO LEON STRAKER

A prize awarded by the UK Ergonomics Society for the first time in 1999 in the memory of a distinguished ergonomics specialist has been won by two individual young ergonomists. The joint first-prize winners of the 1999 Stephen Pheasant Memorial Fund awards are Nancy Hume and Leon Straker. They each receive £500 to attend a scientific conference to further their professional progress.

The award is financed by a fund established in the memory of the late Professor Stephen Pheasant, who tragically died at the age of 47. He had a special interest in anatomy, anthropometry, biomechanics and musculoskeletal injuries.

David Stubbs, president of the Ergonomics Society and a trustee of the fund, said: "1999 is a special year as it marks both the 50th anniversary of the Society and is the year when Stephen Pheasant would also have been 50.

"The quality of entries was very high and we found it difficult to award only one prize. I believe that Stephen would have been delighted that two prizes have been awarded to these very worthy winners. He was renowned for his work in ergonomics and always enthusiastically supported young people working and studying in it"

Leon Straker's entry was a study on risk assessment in combination manual handling tasks. Leon was a physiotherapist when taught by Stephen Pheasant during his MSc course in ergonomics. Since then he has worked in the prevention of work related neck and upper limb and back disorders associated with office work, sitting and manual handling. He was the National Health Service's first ergonomist and is now Senior Lecturer in ergonomics at Curtin University, Australia. Leon will use the prize money to attend the International Ergonomics Association Congress meeting in San Diego, California, next year.

ANDREW MARSHALL

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IEA PRESIDENT'S REPORT TO COUNCIL

This is an abbreviated version of Ian Noy's report to the IEA council. The full text together with definitions and the strategic plan can be found on the IEA web pages. The President's report is under 'Background'.

EXPO 2000

The IEA is represented by Prof. Heiner Bubb on the Advisory Board for the World Engineers Convention at the World Exposition EXPO 2000, Hannover, Germany. We believe that IEA participation in the Advisory Board offers an exciting opportunity to promote ergonomics within the engineering community. Five Professional Congresses are being organised under the following themes: information and communication; environment, climate and health; mobility; energy; and future of work. Further information about these events can be found on www.expo2000.de.

ACTIVITIES

The various standing and technical committees of the IEA have been busy on a variety of activities, which are described in more detail in the reports of the officers and committee chairs. In this report, I highlight what I believe to be some of the current priorities.

IEA JOURNAL OF ERGONOMICS

The IEA has undertaken to publish an electronic journal. The first issue is in preparation and will be available on the IEA web site soon. This will become a widely accessible forum for exchanging scientific and technical information in the field of ergonomics.

IEA/ILO CHECKPOINTS IN AGRICULTURE

Negotiations with ILO on the publication of the Checkpoints is proceeding and we expect to have an agreement before the Council meeting. Dr. Kogi has invited potential authors to contribute to this project.

IEA 2000

Plans for the 14th IEA triennial Congress are proceeding exceedingly well, under the leadership of Hal Hendrick. This will undoubtedly be the largest Congress for many years to come since it will also be the annual meeting of the Human Factors and Ergonomics Society. Organisers anticipate 430 technical sessions and over 2500 participants.

STRATEGIC PLAN

The Strategic Plan was revised to reflect many of the ideas generated during the focus groups held during the Cape Town Council meeting. The revised Strategic Plan is available on the website. Specific elements of the strategic plan were assigned to chairs of standing committees who are to develop action plans. Some strategies are already underway and others will be initiated over the next year.

DEFINITIONS

I believe there is a need for the IEA to define the discipline of ergonomics and its branches in a way that is concise, succinct, and unambiguous. All of us are asked to explain ergonomics or human factors, its unique knowledge content, how the discipline is bound and differentiated from related disciplines.

There is widespread, though not necessarily unanimous, support for the IEA's role in addressing this need. However, we believe that there is a compelling need to promulgate an authoritative definition that can be widely referenced and that will help project a message and image that is professional and informative to the outside world.

The draft definitions of ergonomics and certain domains of specialisation are given on the web pages.

The task of the IEA Executive Committee (EC) is not to impose definitions - the task of the EC is to manage a process that engages the international community in defining the field. The EC discussion draft is intended to initiate the process - a process that must involve all federated societies.

The 1999 IEA Council will divide into focus groups to discuss these draft definitions. I anticipate the subject will generate controversy, but I believe this is healthy and that it is overdue. Discussions about the fundamental nature and scope of our discipline reinforce the foundation that will facilitate the maturation of the discipline in the new millennium. Based on Council input and subsequent deliberations we hope to present a set of definitions for approval at the San Diego Council meeting.

Jan Noy (July 1999)

OCCUPATIONAL ERGONOMICS AND SAFETY

The International Society for Occupational Ergonomics and Safety has elected new officers:

Dr. Gene (Chin) Lee:	President Elect
Dr. Ram Bishu:	Secretary
Ms. Cheryl Bennett:	Treasurer
Dr. Robert Yearout:	Newsletter Editor

For information, contact Steve Morrisey at: steve.morrisey@state.or.us or see the ISOES web site: isoes.org

CANADIAN CERTIFICATION

The Association of Canadian Ergonomists (ACE) has begun certification. It is at two levels: Candidate in Training (EIT) and Professional Ergonomist (CCPE). For information, email them at: ace-ergocanada@sympatico.ca. The ACE web site is: www.ace-ergocanada.ca.

IEA 2000

The 14th IEA Congress, 30 July to 4 August 2000, will be held in San Diego, CA, USA in conjunction with the 44th Annual Meeting of the Human Factors and Ergonomics Society. Key dates are:

5 Nov 1999

Acceptances and registration materials mailed

Dec 1999

Preliminary program published on the web site

15 Jan 2000

Camera-ready papers due

1 May 2000

Early registration deadline

30 Jul 2000

Congress begins

Represented this time will be 37 IEA federated and affiliated societies representing more than 50 countries. In combination with the HFES, we anticipate that more than 2,500 people will attend, which will make IEA 2000/HFES 2000 the largest human factors/ergonomics professional meeting ever held anywhere in the world!

Each of the 21 HFES Technical Groups will hold a meeting on either Tuesday or Wednesday of the conference; international colleagues with similar interests are invited. Following most of these meetings, there will be a social hour with refreshments.

Plan to bring your family and enjoy Disneyland, Sea World, Hollywood and the other California attractions. The Conference hotel, the Marriott, is on the beach. Mexico is just 30 minutes away. There will be an extensive technical visit program. The IEA 2000 web site is iea2000.hfes.org.

2000 ASSISTANT EDITOR PROGRAM

On behalf of the IEA 2000/HFES 2000 Congress Committee, HFES is pleased to announce a new program, "2000 Assistant Editor Program." The aim of the program is to provide writing or editing assistance to congress presenters who may need help preparing their English-language proceedings papers. We would appreciate your distributing this information to members of your > societies as soon as possible.

We invite any IEA-affiliated or federated society member to participate as an Assistant Editor. If you are fluent in English and also one or more of the following languages, your help will be invaluable for some of the hundreds of authors from the more than 40 countries that will be represented in the congress.

- Chinese
- French
- German
- Japanese

- Portuguese

- Spanish

To offer your editing services, please send a message via e-mail, mail, or fax containing your name, mailing address, phone, fax, and e-mail, along with a list of languages, to:

2000 Assistant Editor Program
Human Factors and Ergonomics Society
P.O. Box 1369
Santa Monica, CA 90406-1369 USA
Fax 310/394-2410
E-mail hfeshq@aol.com

Your information will be entered in a database, which will be provided to authors of accepted proposals. Authors will contact you if they need your help. We will also send you the list, in the event you need to refer an authors to another assistant editor.

Please send your information by October 29, 1999. You can expect to hear from authors between November 1999 and the proceedings paper due date of January 15, 2000.

Waldemar Karwowski
IEA Secretary General

INTERNATIONAL ERGONOMICS ASSOCIATION (IEA) K.U. SMITH STUDENT AWARD

The IEA K.U. Smith Student Award honors a deserving student responsible for an application of or contribution to ergonomics/human factors (E/HF). The award will be presented during the IEA 2000/HFES 2000 Congress, scheduled to convene July 30, 2000 in San Diego, CA.

The Award winner will receive of a cash amount of US \$3,000. Certificates will be awarded to the two runners-up. Any student enrolled in an accredited post-secondary institution (college, university, technical or vocational school) worldwide is eligible to apply for the award. All areas of E/HF are eligible for consideration. Examples of applicable projects include an applied E/HF project, a human performance study or analysis, a design project or product, a research project undertaken in the laboratory or field, or a theoretical/conceptual contribution to E/HF.

Students wishing to apply for the award should submit the following to the IEA Student Award Committee:

1. Five copies of the abstract for a paper which they have authored, documenting their contribution to an application of or contribution to E/HF.
2. A resume with the student's name, full address, e-mail and phone numbers, institution enrolled in, experience, list of publications, and a summary of accomplishments and/or contributions related to the field of E/HF. The resume should be limited to 4 pages in length.
3. A letter from the student's academic advisor on institutional letterhead certifying that the paper was written by the student, that the student is active in the program, and that the paper is being submitted for the IEA K.U. Smith Student Award.

The IEA Student Award Committee will select the student using a two stage procedure:

1. review of abstracts and resumes; and
2. review of full paper.

Students who will have successfully passed the first stage will be invited by the IEA Student Award Committee to submit full papers for final selection. Two selection criteria with equal emphasis will be used:

1. Quality of submission as documented in the paper; and
2. Other accomplishments in E/HF, as listed in the resume.

Deadlines for the award process are as follows:

Nov. 1, 1999

Abstracts, resumes and advisor letters must be received by the IEA Student Award Committee.

Nov. 25, 1999

Applicants eligible for submitting full papers will be notified by this date.

Dec. 20, 1999

Full papers from eligible applicants must be received by the Student Award Committee by this date.

Jan 10, 2000

Applicants informed of results of award evaluation by this date.

Jan. 15, 2000

Your full paper due to Congress (if you submitted a paper and it was accepted).

Submissions should be sent to the Chair of the Student Awards Committee:

Chair: Prof. Michael Smith
Department of Industrial Engineering
University of Wisconsin, Madison
1513 University Avenue
Madison, WI 53706
Fax: 608-262-8454
Email: mjsmith@enr.wisc.edu

CHISIG News

The year is marching on - it is nearly time for stock taking to assess the extent to which we accomplished the goals we had mapped out for ourselves for this year. The exercise is somewhat more critical for CHISIG because it was only last year in October that we decided to try reviving it, suffering from hypoxia as it did.

The idea was to inject enough life into the beast to enable us to decide whether or not to keep it going by the end of this year. Although there has been a constant buzz of activity, what will happen next year is still an open question. We have a number of very enthusiastic people all taking responsibility for some aspect of the rejuvenation, but we are also short of someone willing to take over CHISIG in 2000. Somehow, it does need someone who has the overview, who holds the reins and who coordinates activities even if every activity is working according to plan. When our grandiose strategic plan was born late last year, I did not know that I would be leaving Australia. I had planned to give CHISIG a two-year boost, at the end of which I expected it would be possible to pass on the program to a group of people in another State. By then, everything should be 'run in' and no longer need the kick start we worked on this year. Alas, that is not to be, so CHISIG is looking for a HCI enthusiast to complete the job in 2000.

So much for the darker thoughts. We should look at the brighter stuff too. I think the best decision we made at the beginning of 1999 was to employ first a professional marketing person, and then a professional writer. The marketer has been instrumental in assisting with translating our lofty ideals and wishes into measurable and achievable goals, and the fact that we have paid Margit at least something for her time has been a relief for the rest of us. We decided it is just not possible to get volunteers to do absolutely everything that has to be done nowadays; everyone is busier than we were ten years ago, and longer working hours have not made evening meetings more attractive either! The investment in marketing has been well worth our hard-earned dollars! Our program aiming to live up to our objectives of getting HCI out into the community, encouraging HCI training, building bridges between industry and academia includes:

- A national student prize worth \$2000 for the best HCI project submitted by any Australian University teaching HCI courses. There is one single-semester project the nature and conditions of which CHISIG prescribes, and Universities that would like to participate should apply at the end of 1999. Each participating University selects one entry from each course which can be either graduate or undergraduate, and a panel comprising non-participating academics, independent practitioners and the CHISIG Chair will judge the entries. The prize is partly a cash award, and also complementary attendance + presentation of the project at OZCHI, complete with accommodation paid for the winning team.
- Industry breakfasts. This year we are holding two in Melbourne but hope they will take off in other States as well. These are held at a four-star venue, costing us an arm and a leg, but keeping up the standard. A 'hot' HCI topic and speaker are the focus, but there is also ample opportunity to advertise both CHISIG and the ESA, with one experienced CHISIG person placed strategically at each table, and presentation folders containing our brochure and other bits and pieces being distributed to all participants.
- The New Look CHISIG News will be reaching our members and beyond in November. Our writer is the general editor; Helen Hasan who has carried the can for many years will thankfully remain the academic editor, and Liz Grey who built up the Newsletter with Helen Kieboom in the early days is the industry editor. The New Look News will be included in future Industry Breakfast Show Bags, and we intend to spread it much more widely than just among our members. The role of our writer is to edit articles, making it more accessible to the general public. But she will also work on disseminating as much information as possible to a wider media - she has the necessary contacts and 'know-how' to make that happen.

Branch News

- Connected with production of the CHISIG News and in order to keep our website up-to-date, we have decided to employ a 'clipping service' whereby we provide a list of keywords and the service bureau scans a large number of publications, probably weekly, for anything of HCI relevance to which we will then be able to respond directly.

Ok, so we are trying to make things happen. New challenges, and new faces; new skills, and new people's particular prejudices. We are finding it most stimulating working with other professionals in areas that we traditionally thought we could manage ourselves..... how naïve, and how arrogant we are! Still, it is never too late to learn new tricks. Let's hope CHISIG will prosper well into the 21st Century!

Gitte Lindgaard
CHISIG Chair



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VIC

BRANCH CHAIR'S REPORT:

Firstly, I would like to acknowledge and thank our Branch Committee, especially the Executive (Marg Juhasz and Liz Pratt) for their hard work, always carried out cheerfully. It was not an easy year for the Committee: several members were starting new jobs which drew on large amounts of their time and energy, and Federal issues took up Branch time. Thanks to each of you.

We set iMember benefits as a priority this year, and delivered several noteworthy services: an excellent Newsletter - thanks, Phil - now emailed to an increasing proportion of our Victorian members; a new members package (already near completion - the work of Sarah Patterson and Claire Gabriel); improved communications with rural members (evidenced by welcome attendances at meetings in Melbourne, and much helped by email); and our Branch Website www.ergonomics.com.au/vic.htm

Most of all, we had a second year of record attendances at consecutive Professional Development meetings - up to sixty. Congratulations to Steve Isam, David Trembeath and Phil Clark for arranging these gatherings, and for Claire Gabrielis hosting at our new meeting venue - the Royal Melbourne Hospital.

Meetings of members were pretty social affairs, as well: good networking, meeting mentors, fine wines and putting faces on names. Meetings attracted many new faces, too - people interested in or who use ergonomics at work. We hope they will find the ESA worth joining. We had excellent representation at meetings by associated trades and suppliers, and by other professions (OTs, physiotherapists, safety practitioners).

We welcomed back several lapsed members this year, through shared follow-up by the Committee. Victoria remains the biggest Branch (in numbers), and one of the most active. It remains my view that the strength of the Ergonomics Society lies in its Branches, which is where the ESA's focus should be directed.

The well-attended PIE en SAUCE (iPIEi = Professional Issues in Ergonomics) lunchtime meetings - a great success in 1998 - slowed this year, due to difficulties in attracting members to help share the work of selecting themes, finding presenters and promoting the meetings. Perhaps some people will come forward - we think this is an opportunity for PAB members to iput inî, and lid welcome your call. The PIE group was the focus of the Branchis consideration of the new Manual Handling Regulations.

The Publicity research program in which we sponsored the efforts of three RMIT students earlier this year revealed that lots of employers still have strange ideas about ergonomics, but that the opportunities for us to tell our story are as strong as ever. The loss of the general-entry postgraduate course in Ergonomics at La Trobe is thus much regretted, since clearly there are many potential consumers of ergonomics (and ergonomists) out there.

One sad note during 1999 was the death of our long time friends, Dr John Lane (co-founder of our Society) and Isobel (Izzy Shaw)

Our 1999 year program is not yet complete, due to compliance with a Federal requirement to reschedule Branch Annual General Meetings - in our case, shortening our year by three months. The new Committee will inherit a Branch which is solvent, organised and in good shape. I hope that the Victorian Branch emphasis continues on delivering to members whatever services which they find relevant and stimulating. Thanks to all of you.

Mark Dohrmann



QLD

At the May scientific meeting, Jim Joy, Director of the Mineral Industry Safety and Health Centre (MISHC) at Queensland University, spoke on the services provided and future objectives of the centre.

The MISHC is a joint initiative funded by the industry and the university. It provides its services on a national level. By the year 2002, the centre aims to be a provider of risk management education, information and applied research services in Australia as well as being a centre of excellence.

It aims to achieve this by defining the mining industry risk management discipline, by: providing education to undergraduate engineers; providing education and support to post graduates (including applied research projects); by formulating a database of information for industry; as well as through other methods.

The undergraduate content was stated to by quite extensive focusing on areas such as:

- Basic concepts of risk management
- Risk management process and human factors engineering
- Risk analysis and specific hazards
- Integrated risk management systems.

A number of interesting 4th year research projects are underway (Human Error re: night shift, Risk acceptability and hazard analysis of various processes). Jim promised to tell us when these projects will be presented so we can attend if we would like to (which is very exciting).

All in all Jim was very interesting and informative, and we all learnt a lot about a great resource that's being developed in our own backyard. Jim spoke very passionately about risk management. It's good to know that the OH&S/risk management message is being so well championed in mining engineering.

Kirsten Way

It is exciting news that The ARC Key Centre for Human Factors & Applied Cognitive Psychology became operational in April this year!

The Centre is in the Faculty of Social and Behavioural Sciences at the University of Queensland, but also has nodes at the Universities of New South Wales, South Australia, Macquarie, and also Swinburne University of Technology.

The objectives of the Key Centre are to raise the awareness and profile of Human Factors and cognitive psychology via four main avenues:

1. Teaching and education in the area;
2. Conducting research (there are currently approximately 20 Ph.D students with the centre);
3. Forming collaborative links with industry; and
4. Providing a contact, referral and coordination centre for human factors expertise and training across Australia.

In line with its objective to provide education, the Key Centre had its first 'Winter School' in June this year, on the topic of 'Human Factors Issues in Safety'. The three-day event was a forum for Ph.D students, and many other experts in the field, to discuss topics relating to Human Factors and Cognitive Psychology. It was great that all Qld branch ESA members were invited to attend this free professional development event.

Of interest were discussions on Risk and Compliance with Warnings (Austin Adams, U.NSW), Managing Fatigue and Duty Hours (Drew Dawson, U.SA & Anne Williamson, U.NSW), Human Factors and the Bureau of Air Safety Investigation (Allan Hobbs), and some interesting discussions on decision making (Lee Brooks, McMaster Uni, Canada; and Len Dalgleish, Lisa Del Santo, and Heidi Bushell, of UQ).

The winter school will be held annually, and is very worthwhile for the professional development of ergonomists who work in areas where the more cognitive aspects of ergonomics apply.

Lastly, it is exciting to see elements of the field of psychology come together, to focus a concentrated effort on the cognitive side of the ergonomics/human factors discipline. I look forward to a prosperous working relationship between the ESA and the Key Centre, in years to come!

Kirsten Way

ERGOWEEK IS THE PREMIER EVENT OF THE ERGONOMICS SOCIETY OF AUSTRALIA (QUEENSLAND BRANCH). AMONG THE MANY EXCITING EVENTS PLANNED ARE TWO ONE-DAY SEMINARS. SEMINAR ONE IS TARGETED TOWARDS PROFESSIONALS WORKING IN THE AREA, WHILST SEMINAR TWO IS TARGETED TOWARDS INDUSTRY.

SEMINAR 1 - PROFESSIONAL DEVELOPMENT

The Ergonomist In The Workplace

- Ethics, professional conduct & indemnity
- Skilled communication with clients: promoting behavioural change
- Current management trends
- Modern manufacturing technologies and design

Date: 4th November 1999

Time: 8:30 am - 4:30 pm

Cost: Members of ESA: \$145:00

Non-members: \$195:00 Date:

SEMINAR 2 - INDUSTRY SEMINAR

Ergonomics In The Reduction of Permanent Work-Related Impairment

- Permanent damage - the real issue
- The hidden problem of cumulative damage
- Identifying critical ergonomics issues in the workplace
- Workshop: Strategic ergonomics planning and methods

Date: 5th November 1999

Time: 8:30 am - 4:30 pm

Cost: \$195:00

Do It By Design

2 day attendance: members: \$300, and non-members: \$350

Venue: Bardon Professional Centre

Inquiries: (07) 3217 1977

Email: ergoweek99@powerup.com.au

THE AUSTRALIAN OCCUPATIONAL HEALTH AND SAFETY TRUST - GRANTS 2000

The Australian Occupational Health and Safety Trust is inviting grants for the year 2000 for projects involving the development of occupational health and safety education/training material or for personal professional education. Preference may be given to projects relating to the development of educational material due to its wider application to benefiting the health and safety of people at work in Australia.

Further information and guidelines for applications are available from this office or by contacting: The Australian Occupational Health and Safety Trust PO Box R804 Sydney, NSW 1225 Ph: (02) 9220 6374. Applications close with the Trust on 30 September, 1999.

EXCERPT FROM: DO IT BY DESIGN

An Introduction to Human Factors in Medical Devices

Dick Sawyer

Office of Health and Industry Programs

U.S. Department of Health and Human Services

Public Health Service

Food and Drug Administration

Center for Devices and Radiological Health

<http://www.fda.gov/cdrh/humfac/doit.html>

THE USER INTERFACE

This section describes and discusses problems related to human factors. Hopefully, the material will foster an appreciation of the impact of considering the user-interface during design and provide the reader with the rationale and basic principles of human factors. Brief summaries of serious incidents taken from the Food and Drug Administration's Medical Device Reporting (MDR) system illustrate the problems. The summary principles found in the "Rules of Thumb" in each subsection are by no means exhaustive, e.g., no detailed data on control dimensions and forces, body dimensions, audition, vision, or menu and screen design are included. Consult guidelines, textbooks, articles, and conference proceedings such as those listed in the References for Further Reading. Finally, design principles alone do not solve every user interface problem; the human engineering process, discussed later, is vital to such solutions.

CONTROL/DISPLAY ARRANGEMENT AND DESIGN

Many devices have large consoles with rows of mechanical controls and displays. The designer should consider the ability of users to: quickly and properly identify controls, switches, and displays; reach and accurately set controls; read displays accurately; and associate controls with their related displays. Desirable features include functional grouping of controls and displays, unambiguous labels, and easy-to-operate keys. Clear instructions and effective warnings also are important.

Examples of Errors Related to Hardware Design

The following three examples of problems were abstracted from the Medical Device Reporting (MDR) system and FDA device recalls.

- A physician treating a patient with oxygen set the flow control knob, as show in Figure 1, between 1 and 2 liters per minute, not realizing that the scale numbers represented discrete, rather than continuous, settings. There was no oxygen flow between the settings, yet the knob rotated smoothly, suggesting that intermediate settings were possible. The patient, an infant, became hypoxic before the error was discovered. One solution would have been a rotary control that snaps into a discrete setting. Some indication of flow also should have been provided.
- There have been numerous reports and recalls associated with defibrillator design. These include paddles that are hard to remove from their retaining wells and confusing arrays of poorly-labeled controls and displays that inhibit safe, efficient use.
- There have been cases in which patients were seriously injured when a nurse over infused a patient after reading the number 7 as a 1. Because the flow rate readout was recessed in the infusion pump display panel, the top of the 7 was blocked from view by the display surface, even at modest vertical viewing angles. There have been similar reports of flow rates which had been misread when viewed from the side; for example, 355 ml read as 55 ml.

These few examples illustrate the fact that seemingly small design flaws can result in serious problems. Tailoring a few general human factors guidelines, such as those below, to particular devices will decrease the risk of such problems. Following are some rules of thumb for designing the user interface.

RULES OF THUMB

- Make all facets of design as consistent with user expectations as possible. Both the user's prior experience with medical devices and well-established conventions are important considerations.
- Design workstations, controls, and displays around the basic capabilities of the user, such as strength, dexterity, memory, reach, vision, and hearing.
- Design well-organized and uncluttered control and display arrangements. Ensure that the association between controls and displays is obvious. This facilitates proper identification and reduces the user's memory load.
- Ensure that the intensity and pitch of auditory signals allow them to be heard easily by device users. Consider the effects of ambient noise.
- Ensure that the brightness of visual signals is sufficient to be perceived by users working under various conditions of ambient illumination. Also, brightness contrast and color contrast can help to optimize legibility.
- Make labels and displays so that they can be easily read from typical viewing angles and distances. Symbol size, contrast, color, and display depth are important considerations.
- Ensure that the abbreviations, symbols, text, and acronyms placed on, or displayed by, the device are also used consistently in the instructional manual. They also should correspond to standard nomenclature, if possible.
- Design control knobs and switches so that they correspond to the conventions of the user population (as determined by user studies and existing medical device standards).
- Arrange and design knobs, switches, and keys in a way that reduces the likelihood of inadvertent activation.
- Use color and shape coding, where appropriate, to facilitate the rapid identification of controls and displays. Colors and codes should not conflict with universal industry conventions.
- Space keys, switches, and control knobs sufficiently apart for easy manipulation. This will also reduce the likelihood of inadvertent activation.
- Make sure that controls provide tactile feedback.

SUMMARY

In summary, the layout and design of controls and displays greatly affect the user's ability to successfully perform functions and extract information during operation of a device, especially during critical events. The next section discusses the logic of such user-device interactions.

DEVICE LOGIC AND MICROPROCESSING

With modern automation, the logical, temporal, and informational characteristics provided via software are increasingly crucial and error-inducing. For instance, data presented imprecisely, ambiguously, or in a difficult-to-read format are likely to be misread. Examples are crowded CRT displays, cryptic abbreviations, or time lags between user input and displayed feedback. Such design may overtax the user's memory and decision-making capability.

CHARACTERIZING THE SHIFT TO SOFTWARE

With a large number of controls and displays, the user must identify and integrate spatially disparate information. Although such designs are still common, the trend is to assign more functions to software. This reduces the number of controls and displays, but it can increase the burden on the user in other ways. This is the case with many infusion pumps, as shown in

Figure 2 on the following page. Although there are few controls and displays, the large amounts of information impose heavy demands on the user's memory. Most information must be recalled in sequence, thereby precluding simultaneous viewing of related data. Users can become lost in the system if sufficient prompts and roadmaps are absent. Also, users may misinterpret displayed data and respond inappropriately if not given precise feedback and indications of functional status.

Product developers often incorporate multiple of functions into a device to provide flexibility and to serve a wider user community. However, extensive functional capability may well impose an unreasonable cognitive load on the user, unless considerable effort is devoted to the design of the user interface. The following are some problems that apply to many medical devices and can lead to errors:

- illogical or cumbersome control sequences;
- unfamiliar language, symbols, or codes;
- inconsistencies among display formats;
- conventions that contradict user expectations;
- uncertain or no feedback after input;
- functions that are hidden from the user;
- missing or ambiguous prompts, symbols, or icons;
- unsignalled resets or defaults;
- no status information;
- missing lock-outs or interlocks; and
- requirements for complex mental calculations.

EXAMPLES OF ERRORS RELATED TO SOFTWARE DESIGN

Many use errors induced by software design are incorrectly attributed to other factors, because such errors are not easily remembered or recreated for post hoc analysis or correction. Also, software-related errors can be subtle. For example, users become frustrated by cumbersome data entry steps and make errors not directly related to those steps. Ambiguous acronyms or abbreviations used in the command structure or on menus may also lead to serious errors. Below are examples gathered from incident files, recalls, and analyses:

- There have been incidents with radiation treatment devices because users failed to enter dosage levels if the device software did not prompt the user for the data. Instead, the device automatically defaulted to a given value without signaling this value.
- A cardiac output monitor alarm was disabled without the operator's knowledge when the control buttons were pushed in a specific sequence.
- There have been serious infusion pump incidents and recalls involving such deficiencies as poorly signaled operating modes, cumbersome operating steps, and the presentation of unanticipated warning data on displays normally reserved for other critical information.

Below are some general considerations that, if implemented, can prevent many software-related design errors.

RULES OF THUMB

- Do not contradict the user's expectation. Rather, exploit their prior experience with computerized equipment and consider conventions related to language and symbols.
- Be consistent and unambiguous in the use and design of headings, abbreviations, symbols, and formats.
- Always keep users informed about current device status.
- Provide immediate and clear feedback following user entries.
- Design procedures that entail easy-to-remember steps.
- Use prompts, menus, etc. to cue the user regarding important steps; do not "strand" the user.
- Give users recourse in the case of an error. Provide conspicuous mechanisms for correction and troubleshooting guides.
- Do not overload or confuse users with information that is unformatted, densely packed, or presented too briefly.
- Consider the use of accepted symbols, icons, colors, and abbreviations to convey information reliably, economically, and quickly.
- Do not over use software when a simple hardware solution is available, e.g., a stand-alone push button for a high priority, time-driven function.
- Consider using dedicated displays or display sectors for highly critical information. In such cases, do not display other data in these locations.

SUMMARY

Microprocessing offers outstanding capabilities ready data access, manipulation, computation, speedy accomplishment of functions, and information storage. Technological sophistication, however, can work to the user's disadvantage if the software design is done without a thorough understanding of the user. At a

minimum, designers are advised to utilize guidelines for human computer interface (HCI), do a thorough analysis, and conduct usability testing during software development. A thorough knowledge of the user population is necessary. Finally, software designers need to coordinate their efforts closely with hardware designers.

COMPONENT INSTALLATION

Among the most common errors reported to FDA are improper installations of device accessories. Although erroneous installation often is not obvious before an accident, design-related installation problems frequently can be detected upon examination following an accident. Proper installation is critical to safe device operation.

PROBLEMS AND EXAMPLES

Some commonly reported errors are tubing connected to the wrong port; loose connections; accidental disconnections; electrical leads inserted into an improper power source; batteries or bulbs inserted incorrectly; and valves or other hardware installed backward or upside-down. The following MDR reports are illustrative:

- A component of an oxygen machine was installed upside-down, resulting in a patient death because of impeded air flow.
- A ventilator was recalled after a low-pressure alarm had short circuited on several occasions. The failures were traced to misinstalled batteries resulting from design of the battery ports.
- Three deaths were reported due to the introduction of a feeding solution from an enteral feeding tube into an IV tubing used for medication. This happened because an adaptor intended to introduce medication from an IV tube into the enteral feeding system permitted the reverse operation.
- Several injuries and deaths occurred because users inserted a cassette from one infusion pump model into a different model for which the set was not compatible. The resultant medication volumes were incorrect, although pump operation and data display did not reflect this error.

- Numerous injuries, deaths, and “near-misses” with ventilators have occurred because of disconnections of the breathing tubes due to poor tube and connector design.

The situation is exacerbated because many manufacturers sell a wide range of accessories for a given type of device. There are a great variety of cables, leads, connectors, valves, and tubing on the market. Accessories for different models are often similar in appearance and/or difficult to install, leading to misinstallations and disconnections. Figure 3 illustrates the kinds of confusion that can lead to installation errors.

However, such accidents can often be prevented through design solutions. When conducting user studies, tests, and simulations, it is crucial that device components and accessories be regarded as part of a system, not isolated elements.

RULES OF THUMB

The following are general considerations for reducing the likelihood of confusion between similar components and accessories and making improper connections.

- Cables, tubing, connectors, leuers, and other hardware should be designed for easy installation and connection. If properly designed, incorrect installations should be impossible, extremely difficult, or so obvious that they can be easily detected and remedied.
- User instructions should be understandable, and warnings conspicuous.
- If a hazard cannot be eliminated by a design solution, color codes or other markings will help the user achieve proper connections and component or accessory installation.
- Positive locking mechanisms are desirable whenever the integrity of connections may be compromised by such factors as component durability, motion, or casual contact.
- Protected electrical contacts (e.g., the conductors are recessed) are necessary for body leads that can be inadvertently introduced into outlets, power cords, extension cords, or other common connectors. If possible, exposed contacts should be avoided.

- Components and accessories should be numbered, so that defective ones can be replaced with the proper items.
- Textual complexity in maintenance manuals should be reduced by adding graphics.

SUMMARY

There is a variety of device components and accessories. Potential hazards should be identified, and appropriate design and coding techniques should be used to prevent misinstallation.

ALARMS

Alarms and related advisories are intended to alert device users about problems with the patient and device status. This seemingly straightforward function often is complex. In some environments, alarms sounding simultaneously or intermittently on one or more devices make proper identification difficult, and staff may become distracted. Alarms may be considered a nuisance or part of the background; they also can induce stress. Ambient noise and numerous visual displays can mask the output from a particular auditory or visual display; overly loud alarms can mask other alarms. Compounding the above problems are alarm failures and false alarms due to electro-magnetic interference (EMI), static electricity, or over-sensitivity. It is critical to test alarms in the environments in which they will be activated.

PROBLEMS AND EXAMPLES

Alarm problems include the following: false alarms, delayed alarms, too sensitive or insensitive alarms, alarms drowned out by noise, ambiguous meanings, inappropriate silencing, and accidental disabling. The two incidents below resulted from relatively common problems.

- A patient receiving oxygen died when a concentrator pressure hose loosen-ed. The alarm was not loud enough to be heard over the drone of the device.
- A patient on a ventilator died following accidental detachment of the breathing tube from the humidifier. The alarm did not sound, because the pressure limit setting apparently was so low that it was essentially non-functional.

Variations of these scenarios are common. Low alarm intensity, high ambient noise, low battery conditions, inappropriate alarm settings, and other factors combine to create potentially dangerous situations.

RULES OF THUMB

- Consider the wide spectrum of operating environments when designing and testing alarms, including other equipment in simultaneous use.
- Be sure that visual and auditory alerts and critical alarms are included in the design requirements for the device.
- Carefully consider the effects of over-sensitivity, electromagnetic interference, and static electricity on alarm functioning.
- Design alarms so they meet or exceed normal hearing and visual limits of the typical user.
- Make sure that both brightness contrast and color contrast are sufficient for legibility under a variety of lighting conditions.
- Use codes, such as color, that correspond to established conventions.
- Design alarms to be distinguishable from one another and, to the extent possible, from alarms on other devices used in the same setting.
- Design alarms to activate immediately following the onset of a critical problem. It is important that alarms identify the source of the problem.
- Consider giving a priority status to critical alarms. Critical alarms should provide redundant auditory and visual signals.
- Design alarms so that when they are silenced, they remain silent temporarily. They ideally will have visual indicators to indicate status and a mechanism for querying the reason for the alarm.

OTHER IMPORTANT ISSUES

DIMENSIONS, FORCES, AND ANGLES

Workstations, seating, and consoles associated with medical devices should fit the user population. Data on body dimensions of various populations, including arm length, body height, leg length, and numerous other bodily specifications, are collected and published in a variety of documents. Such data, in conjunction with dynamic fitting trials, are important in designing equipment, so that controls are within reach and seating arrangements are comfortable. There are important implications for anesthesia workstations, prosthetics, and rehabilitative devices; these data apply to many home-use devices, such as wheelchairs, in which portability, compatibility with structures, and compactness are important. Knowledge of the clinical or home use environments is extremely important.

Important, but more elusive, are the biomechanical characteristics of tools such as hammers, dental tools, surgical instruments, control knobs, keyboards, and other devices that require substantial dexterity or strength and/or involve repetitive motions. For example, instruments such as those shown in Figure 4 can be difficult to use if they are not tested with users. Physicians and dentists often must precisely manipulate instruments in limited spaces. There may be problems associated not only with demands on dexterity and strength but those related to visibility, reach, and compatibility with other equipment.

TRANSFER OF TRAINING

Product developers often are encouraged to design products that incorporate unique, distinctive features. These can have performance and training impacts upon users in hospital units, where physicians and nurses have become accustomed to a particular device model. For example, if two models have very similar (“look-alike”) user interface configurations but require conflicting operator actions, habits established with one device can interfere with user performance on the other. This greatly increases the likelihood of errors. For example, if the ON/OFF switch positions are reversed on two very similar devices, a user transferring from one to the

other could easily revert to the switch operation habits learned with the first device. The same concern applies to a device that is retrofitted or redesigned. This discussion is not intended to discourage innovation but rather to encourage designers to carefully evaluate the impact of user interface changes on user performance.

DEVICE MAINTAINABILITY

Medical devices should be designed for simple maintenance, because poor maintenance can hinder safe, reliable operation. Maintenance personnel often encounter the following problems:

- poor component labeling, coding, or numbering;
- inadequate self-diagnostic capability;
- parts that are hard to locate visually or by touch;
- screws and other parts that are difficult to reach or manipulate;
- confusing component arrangements;
- requirements for difficult-to-find tools;
- inadequate design for easy cleaning; and
- materials that are not durable and degrade the user interface.

Possible signs of inadequate attention to human factors include improperly connected wires, stripped threads, unreliable operation, dirty displays, and sticking keys. Not only are devices that are difficult to maintain usually out of use for long periods of time, but maintenance personnel may modify the devices to compensate for deficiencies, possibly creating new problems for the user.

DEVICE PACKAGING

Packaging sometimes affects operation of a device. For example, there have been incidents resulting from packaging materials enclosed in such a way that users failed to detect and remove them. In some cases, this impaired functioning of the device. With one infusion pump, serious accidents occurred when unremoved packaging materials increased flow rates. On the other hand, packaging also can be designed to facilitate removal of devices or accessories and/or to make storage easier.

Sometimes, package design can reduce the likelihood of error. For example, catheters and compatible guide wires usually are packaged together. The same is true of needles and syringes, some infusion pumps and dedicated administration sets, and various contact lens accessories. A unique example is a customized container cover having an integral spacer that separates heart valve leaflets. Originally, cotton was used to accomplish this separation, but in a number of instances surgeons had neglected to remove the cotton spacer prior to installing the heart valve. There were several deaths due to the formation of massive clots associated with residue from the cotton. The integral spacer precludes such accidents.

SUMMARY

Implicit in the discussion of errors is the importance of implementing good design principles. Rarely do human factors principles fully cover all design situations. Good design practice entails the involvement of medical device users in studies, analyses, and tests to achieve optimal design. The next section, on human factors engineering discusses these methods.

Low Back Pain and Sailboarding: Part 2

LOW BACK PAIN AND SAILBOARDING HARNESS DESIGN:

PART 2. BIOMECHANICAL MODELLING OF LUMBAR STRESSES

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ABSTRACT

Previous research has suggested a possible association between sailboarding harness design and back pain. The main aim of this project was to determine if there was an association between harness design and back pain. The project involved two aspects, biomechanical modelling and a field survey (reported in a companion paper, Holley et al. 1999a).

The biomechanical modelling study involved the development of a model to estimate compression, shear and erector spinae force and torque at L4/L5. Six male and six female subjects participated in the study. Photographs of subjects using three different harness designs: a chest, waist and seat harness were used to calculate the forces. The results were analysed using one way analysis of variance with repeated measures and means comparison. Overall, the chest harness resulted in significantly more stress on the low back than the waist or seat harness. However there was no significant difference between the seat or waist harness.

INTRODUCTION

To determine if there is an association between low back pain and sailboarding harness design a project involving a field survey and biomechanical modelling of sailboarding was undertaken. The field study (Holley et al. 1999a) provided insight into the general wave and slalom sailboarding population in the Perth area. The results indicated that the prevalence of back pain related to sailboarding in the sample surveyed was 40%. The majority of sailboarders who associated sailboarding and back pain believed that there was a relationship between

harness design and low back pain. The most popular type of harness used by the sample was the seat harness.

While conducting the survey, a study involving biomechanical modelling was also carried out. The biomechanical model used estimated the differences in various stresses (compression, shear and erector spinae force and torque) at the lumbar spine when using three different types of harnesses. The measurement of compression forces is often the main focus of biomechanical modelling, and there is also a large body of research available to compare the results. The research into shear forces and torque is not as well documented as compression, however, Jäger and Luttmann (1992) advocate that lumbar strength is determined not only by the compressive load but also torsion, flexion, extension and shear load. The force on the erector spinae was also of interest due to the role of the back extensor muscles in stabilising and adjusting the sailboarder's body positioning to maintain balance (therefore preventing the sailboarder from falling off the board into the water!).

METHOD

DESIGN

A repeated measures design using one factor, harness type, was used. There were three levels of harness type, the chest, waist and seat harness.

SUBJECTS

A group of twelve subjects (six male, six female) participated in the biomechanical modelling study. The subjects were recruited through personal contact by the author. The subjects were aged 24 to 33 years, with a mean mass of 68 kg (range 46kg -105 kg) and mean height of 1.72m (range 1.53m-1.88m). All subjects reported they were able to water start, use a harness and ride a wave/slalom board (the same criteria used to select subjects for the field study). The rationale for the selection criteria was to ensure the sample group were expert users who would be more able to assume the optimum postures, thus resulting in a more accurate estimation of force estimates. Equal numbers of males and females were selected to eliminate possible gender bias.

MATERIALS AND EQUIPMENT

A sailboard was setup on land to simulate optimal sailing posture. Although actual sailboarding would have been preferable in some respects, due to the lack of consistency in water and wind it would not be possible to ensure a stable consistent posture. The setup consisted of a 2.85m custom slalom board, a 5m Gaastra carbon fibre slalom mast and a North boom. The mast was statically positioned at an angle comparable to a normal sailing stance by securing it to a wooden structure. The boom was secured to the wooden structure via two stabilising ropes. A vertical line and two metre steel ruler provided reference for gravity and scale.

A 35mm camera was positioned 10m from the subject, and at the height of the subjects lower back, to reduce parallax error.

PROCEDURE

Each subject's gender, mass (kg), height (m) and boom height (once adjusted the boom remained in the same position for each harness), were recorded. Subjects adjusted the boom height to their normal sailing position. Mean boom height was 1.4m, range 1.3m-1.6m). Each subject's body segment lengths were measured from landmarks, marked with orange self adhesive dots (see Figure 8) and recorded prior to photographs being taken. The landmarks were the left (L) head of the 5th metatarsal, (L) lateral malleolus of the fibula, (L) lateral epicondyle of the femur, (L) greater trochanter of the femur, lateral to L4/L5 at the midpoint of the (L) iliac crest, 2cm below the acromial arch of the scapula on the (L) humerus, (L) lateral epicondyle of the humerus and the (L) ulnar styloid. Photographs were then taken of each subject using each of the three harnesses in random order.

BIOMECHANICAL MODELLING

The angles at each segment junction (joint) were measured from the still photographs in reference to the relevant surface landmarks and a vertical plumb line in the sagittal plane. The segment junctions were the (L) metatarsal phalangeal joint, ankle joint, knee joint, hip joint, intervertebral joint of L4/L5, shoulder joint and elbow joint. Other angles measured were the angle

perpendicular to the harness line and the mast (denoted as a in the model) and the angle between the harness line and the horizontal plane (denoted as b in the model).

The distances calculated from the photographs were the perpendicular distance from L4/L5 to the line indicating the direction of the harness force (which was measured to be equidistant from the 2 harness lines) and the perpendicular distance from L4/L5 to the line indicating the direction of the foot force (measured in line with foot)(See Figure 1).

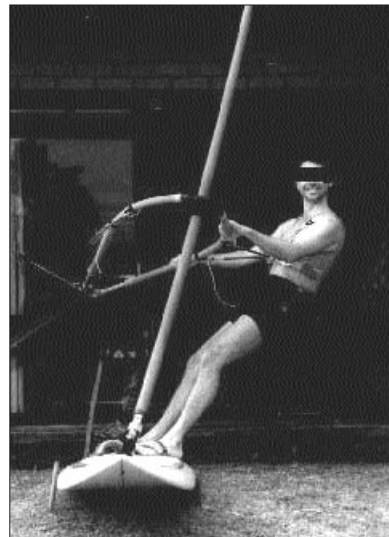


Figure 1. Laboratory setup of sailboard simulator.

The segment angles and lengths combined with estimates of segment masses in a static (2D) biomechanical model. Besides the normal assumptions required when using a static 2D model, this model also assumed that the subject's foot was in line with the mast base. The details of the model are presented in Appendix 1. The outputs of the model were estimates of compression and shear force at L4/L5, moment around L4/L5 and erector spinae force.

DATA ANALYSIS

Data was analysed using one-way Repeated Measures Analysis of Variance (RANOVA). A separate RANOVA was performed on each dependent variable; compression,

shear, erector spinae force and torque. If the RANOVA revealed that at least one of the harness types was different from the others means comparison tests were used to locate which harness(es) was different. A criterion alpha level of 0.05 was utilised in the interpretation of all results.

RESULTS

Overall, the chest harness resulted in significantly more estimated stress on the low back than the waist or seat harness. However there was no significant difference between the seat or waist harness.

COMPRESSION FORCES

The means of the estimated compression forces at L4/L5 are summarised in Figure 2. The results suggest that chest harness use resulted in the highest compression forces at L4/L5. The RANOVA indicated there was a significant difference between the harnesses ($F_{2,11} = 3.67, p = 0.0421$). Means comparisons revealed that there was a significant difference between the chest and the waist harness and there the difference between chest and seat harness approached significance. However there was no significant difference between the seat and waist (see Table 1). The chest harness was expected to result in significantly more force than the waist and seat. Although the seat harness was expected to result in significantly less force than the waist, there was no significant difference.

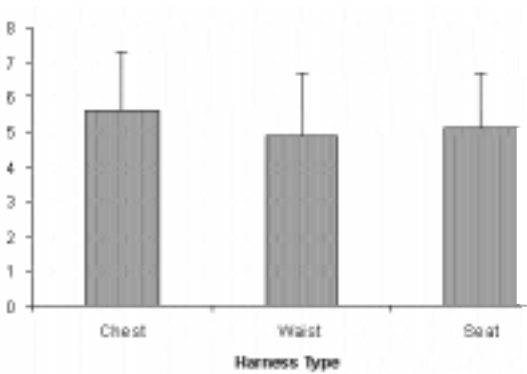


Figure 2: Mean (Standard deviation) Compression Forces at L4/L5

Table 1: Means Comparison for Compression Forces at L4/L5

Harness	df	F value	P value
Chest to Waist	1	6.777	0.0162
Chest to Seat	1	3.808	0.0638
Seat to Waist	1	0.425	0.5213

SHEAR FORCE

The means and standard deviations of the estimated shear forces at L4/L5 are summarised in Figure 3. It appears from Figure 3 that the waist harness resulted in the most shear force at L4/L5, although the seat harness score was very close.

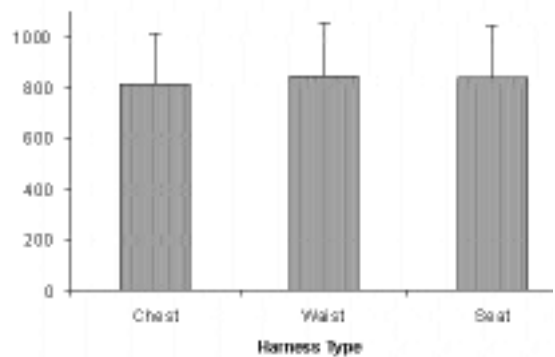


Figure 3: Mean (Standard deviation) Shear Forces at L4/L5

A RANOVA showed a significant difference in shear forces between the harnesses ($F_{(2,11)} = 4.86, p = 0.0179$). Means comparisons indicated that there was a significant difference between the chest and waist and the chest and seat (See Table 2). That the chest was significantly less than the seat was expected. However the insignificant difference between the waist and seat was in contrast to the expectation that the seat would result in significantly more shear force than the waist.

Table 2: Mean comparison for Shear Force at L4/L5

Harness	df	F value	P value
Chest to Waist	1	8.022	0.0097
Chest to Seat	1	6.468	0.0185
Seat to Waist	1	0.084	0.7752

FORCES AT ERECTOR SPINAE AND TORQUE AT L4/L5

The estimated mean forces and standard deviation at the Erector Spinae are summarised in Table 3. The means of the estimated torque for the different harnesses are summarised in Table 4. The results of the estimated torque at L4/L5 are similar to the forces at the erector spinae as the estimated force at the erector spinae is a function of the estimated torque at L4/L5. It appears that the chest harness resulted in the greatest stress on the Erector Spinae.

Table 3. Forces at Erector Spinae (kN)

Harness	Mean	Standard Deviation
Chest	5.5	1.7
Waist	4.7	1.7
Seat	4.8	1.4

Table 4. Torque at L4/L5(Nm)

Harness	Mean	Standard Deviation
Chest	323	106
Waist	283	106
Seat	288	89

There was a significant difference (RANOVA) between the estimated forces at erector spinae and torque at L4/L5 for the different harnesses ($F_{(2,11)} = 5.317$, $p = 0.013$). To determine which harness was different, means comparisons were performed and the results are summarised in Table 5. It was revealed that there was a significant difference between the chest and the waist and the chest and the seat harness. However there was not a significant difference between the seat and the waist harness.

Table 5. Means comparison for Erector Spinae Force at L4/L5

Harness	df	F value	P value
Chest to Waist	1	8.7	0.0074
Chest to Seat	1	7.18	0.0137
Seat to Waist	1	0.73	0.7890

The results indicate that overall the chest harness caused significantly more stress on the low back than the seat or waist harnesses for compression, erector spinae forces and torque. However the chest harness resulted in less shear force. There was little difference overall in the stress on the low back between the seat and the waist harness.

DISCUSSION

Two of the purposes of the study were achieved, to use biomechanical modelling to estimate the relative stresses on the lower back for each harness type and ascertain which harness resulted in the greatest stress. However the results were not completely as the authors expected. This section will firstly compare the results of the forces on the back to the literature and then consider some of the limitations of the biomechanical modelling.

COMPARISON OF RESULTS OF FORCES TO LITERATURE

COMPRESSION FORCES

The results indicated that there was no significant difference in compression force between the seat and the chest harness. The p value for the F statistic of the means comparison was 0.0638. This p value is very close to the 0.05 a level set by the researcher. The sample size of 12 may not have been big enough for the result to be significant.

Compression force is the measure of stress on the back that is most widely reported in the literature. The maximum L4/L5 compression force in this study was calculated to be 9.4kN for a 105kg subject using the waist harness. The minimum force was 2.7kN for a 46kg subject using the waist harness. The mean compressive force for all three harness designs in the current study (5.2kN) is close to the mean compressive lumbar strength of 5.0 ± 2.2 kN reported by Jäger and Luttman (1992) and exceeds the NIOSH action limit of 3.4kN.

However, as noted in the review of the literature, age is an important influencing factor on compressive lumbar strength. In the cadaver studies reported by Jäger and Luttman (1992), the mean compressive lumbar strength in the age range 20 - 40 years is 7kN. Considering the

age range of the sample of this study was 24-33 years, the results of this study are in fact below compressive lumbar strength.

Jäger and Luttmann (1992) considered gender to be the second most important factor influencing compressive lumbar strength. The mean lumbar compressive strength reported by Jäger and Luttmann (1992) for females was 5.8kN in the 20-30 age group. The mean compressive forces for females (all harness types) in the current study was 4.1kN, which is below compressive lumbar strength. For males in the study, the mean compressive forces (all harness types) was 6.3kN, which is also below the mean compressive lumbar strength of 8kN reported by Jäger and Luttmann (1992).

Chaffin and Anderson (1991) suggest that repeated, high compressive forces may lead to disc degeneration and chronic low back pain symptoms. It would appear that sailboarders are at risk regardless of the harness they use, as the values for all the harnesses are high. From the results of this study the waist harness would be the preferred option over the chest as the compression stress on the back is significantly less. However there was no significant difference between the waist and seat harness when using this model.

SHEAR FORCES

Jäger and Luttmann (1992) reported that disc displacement occurred with shear forces of as little as 0.2kN. The maximum shear force estimated in the current study was 1.3kN for a 105kg subject using the waist harness and the minimum shear force was 0.5kN for a 46kg subject using the chest harness. Therefore even the minimum amount of estimated shear force may be causing some disc displacement. The high level of shear forces may cause stress on the posterior zygapophysial joint as well as the annulus fibrosus of the disc (Chaffin and Anderson, 1991).

ERECTOR SPINAE FORCE

The force on the erector spinae was significantly higher for the chest harness than the waist and seat harness. The insignificant difference between the waist and seat could be because the harness hook for the seat and waist were worn by subjects in a similar location. The seat harness

tended to be adjusted so the bar was worn at the top of the hips and the waist harness was positioned on the top of the hips instead of around the waist. Being a laboratory setting, the problem of the waist harness moving/slipping up the body was also not encountered. Therefore the harness hook on the waist harness may have been lower in this study than in the real world situation.

The results of the current study indicate that the forces on the erector spinae are close to, or actually exceed the estimated strength capability of the muscle group of 2.2kN-5.5kN (Farfan, 1973). The low back pain associated with sailboarding reported in the literature (Ullis and Anno, 1984; Allen and Locke, 1989 and McCormick and Davis, 1988) may be in part attributable to muscle strain arising from the large forces.

TORQUE AT L4/L5

The torque at L4/L5 reflected the results of the erector spinae as they are interrelated. The results support the hypothesis that torque was significantly different for different harnesses. As for the erector spinae, the chest harness resulted in significantly greater torque at L4/L5. Torque provides a general idea of the stress on the lumbar spine in the sailboarding and will be useful when comparing to other sports or future research into harness design.

LIMITATIONS OF THE BIOMECHANICAL MODELLING STUDY

The high forces calculated in the current study, which suggest hazardous levels especially for the over 40 age group, may not be accurate. There is evidence that biomechanical modelling may overestimate forces. Reilly et al. (1993) measured harness to rig forces with a load cell and predicted harness forces using a two-dimensional model and found that the predicted forces overestimated the measured forces by 77-135N (26-49%). Chaffin and Anderson (1991) also suggest that biomechanical modelling may not accurately estimate forces, but may over or underestimate actual forces. The inaccuracy may be due to the limited complexity of the model. For example the back extensor muscles are grouped as one unit acting on the back, called the erector spinae.

The limitation in accurate estimation may be due to using a two dimensional rather than a three dimensional model. reilly et al. (1993) suggest that the two dimensional model does not take into account twisting to face the direction of motion, leaning away from the direction of motion and leaning away from the rig. the model used in the current study did, in fact, take into account leaning away from the rig. however the twisting towards the direction of motion and lateral bending away from the direction of motion (commonly used to close the gap between sail and the board, resulting in greater speed) was not taken into account. the inadequacy of a two dimensional model to capture the three dimensional nature of sailboarding was a limitation of this study .

The calculated forces in the current study are a little lower than the forces calculated by Reilly et al.(1993)(see Table 6). this difference may be due to Reilly et al (1993) setting the boom height at 1.54m which is the shoulder height for a 1.76m tall sailor. it appears from the photographs provided in their report that the boom was at head height for some of the subjects, however data on the subjects' height was not provided. a higher boom height is likely to result in higher forces as the angle of the harness line to the boom will be more vertical. in the current study, subjects utilised the 'ergonomic' features of the sailboard and were encouraged to adjust the harness and the boom height to suit themselves. Once adjusted, the boom was kept at the same height for all three harnesses, to enable a comparison between the harnesses. this was appropriate as this study used a repeated measures design so it was the difference between the three harnesses for each subject that was of interest.

Table 6: Comparison of mean harness force estimates with Reilly et al. (1993)

Harness	Results of current study	Reilly et al. calculated	Reilly et al. measured
Chest	367.1N	366.7N	289.5N
Waist	385.3N	408.1N	273.6N
Seat	394.7N	441.7N	335.0N

Both Reilly et al. (1993) and the current study found the same relative order for estimated harness forces; chest > waist > seat. However the measured harness force results by Reilly et al. (1993), of waist > chest > seat, did not follow this pattern. This indicates that either the biomechanical modelling or Reilly et al.'s (1993) measurement methods were inaccurate. The biomechanical modelling in the current study assumed that all force was transferred through the harness lines. For the measured forces in Reilly et al.'s (1993) study, it may have been possible that some force was transferred through the subject's arms. This may account for the difference in the results. The relative transfer of force through the arms and harness lines should be included in future biomechanical modelling of sailboarding. The proportion of force application between the harness lines and the arms may significantly affect the resulting stress on the back.

In Reilly et al.'s (1993) study both the *measured* and *estimated* forces indicated that the seat harness transferred the greatest amount of force. therefore when using the seat harness the arms could be transferring the least amount of force. this is supported by the spinal shrinkage measurements by Reilly et al. (1993), which showed an increase in stature with a seat harness. it is interesting to note that the *chest* was *estimated* to transfer the least amount of force, however the *waist* was *measured* to transfer the least. the spinal shrinkage measurements also indicated that the waist harness transferred the least force. The spinal shrinkage for the waist was significantly greater than for the chest or seat (Reilly et al., 1993). this unexpected result could be due to the high boom causing the waist harness to 'ride up' the body. this would reduce the amount of force the subject could transfer through the harness and therefore have to use their arms. the chest and waist are more easily anchored around the peripheral limbs.

In the current study individual differences in setting up equipment resulted in different outcomes. upon reviewing the 12 subject's individual results it was revealed that 3 actually scored the least amount of compression forces with the seat harness. in this study it was observed that the height subjects set their boom varied from chest level to eye level. further investigation

into the set up of the boom height and harness ropes is needed to provide guidelines on rig set up. it is recommended that this be done for each sailboarding task individually as the use of the harness in wave sailing is very different to it's use in longboard sailing.

IMPLICATIONS OF FIELD SURVEY AND BIOMECHANICAL MODELLING STUDY

The results from the field survey only partially support the theory proposed in the biomechanical modelling study. The chest harness was calculated to result in the most amount of stress on the back and is currently only being used by a small percentage of the sample surveyed. However the popularity of the seat harness over the chest and waist, recorded in the field survey was only partially explained by the biomechanical modelling.

The difference between estimated and calculated forces in the study by Reilly et al.(1993) may provide some insight into the disparity between the theory in the biomechanical modelling study and the current harness usage reported in the field study. Theoretically the waist harness was estimated to result in a harness force greater than the chest but less than the seat, however it was measured to result in the least harness force. As suggested earlier, it is possible that the waist harness results in the most amount of force being transferred through the arms and the least through the harness. Therefore although it may result in less stress on the back than the other harnesses it may also require greater muscular effort. Fatigue from transferring force through the arms rather than the harness is one aspect that this study did not take into account. the preference for seat harnesses revealed in the field study may be attributed to less arm muscle fatigue so the person can sail for longer periods.

Although reilly et al. (1993) compared EMG readings from Latissimus Dorsi, Rectus Abdominous and Vastus Lateralis muscles for the three different harness types, the results were incompletely reported so no conclusions can be drawn. allen and Locke (1990) studied physiological responses in different sailing conditions and Schölne and Reickert (1983) evaluated cardiovascular reactions without a harness. none of these studies compared physiological demands between

the three different types of harnesses. further research into the possible physiological differences is needed to compliment the biomechanical considerations.

The biomechanical modelling was to provide a means of understanding the reasons for harness selection revealed in the survey. The model provided evidence that sailboarders are less likely to use the chest harness as it may result in more stress on the back. The preference for the seat harness over the waist, revealed in the field study, was not explained by the model. However the model only addressed some biomechanical considerations and not the physiological demands of the different harness types.

CONCLUSIONS

The biomechanical modelling study found that the chest harness resulted in significantly more stress on the back than the waist or seat harness. However the study results were inconclusive about any difference between the waist and seat harnesses.

In the companion paper (Holley et al. 1999a) , it was reported that the seat harness was the most popular harness being used by both wave and slalom sailboarders surveyed in Perth. If it is assumed that people choose a harness because it is comfortable (ie. the least back pain), then the results from the field survey would indicate that the seat harness is preferable. Future research into harness design and back pain should consider the physiological demands as well as biomechanical demands and user preferences.

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APPENDIX 1

SAILBOARDING BIOMECHANICAL MODEL

A computer program was written in "Visual Basic" using the following formulae to calculate the force at the erector spinae, compression force, shear force and torque at L4/L5. To calculate these values the following data were required: subject segment lengths (measured directly from subjects), subject segment angles (taken from the photographs), subject segment masses (estimated from the subjects height, weight and gender using the formula in Pheasant (1986)), force acting through harness and force acting through foot to board.

Force acting through the harness was calculated by first calculating torque around the foot-ground joint generated by the body segment weights ($T_{foot} = \sum (\text{mass segment} \times \text{perpendicular distance})$ for n segments) then dividing this value by the perpendicular distance between the harness force vector and the foot-ground joint (using the static state assumption that $\sum T = 0$)

Force acting through the feet to the board were then calculated from body weight and harness force (Vertical harness force = $\sin \beta \times \text{harness force}$, Horizontal harness force = $\cos \beta \times \text{harness force}$, Vertical Force at Foot = body weight - vertical harness force, Horizontal force foot = - horizontal harness force) (See Figures 4 and 5).

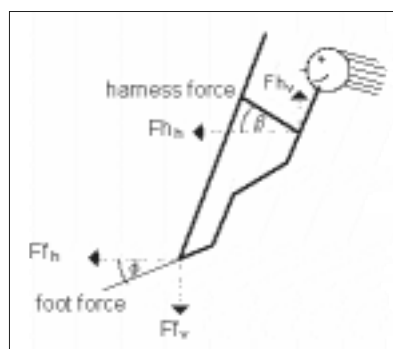


Figure 4. Diagram of harness and foot force vectors

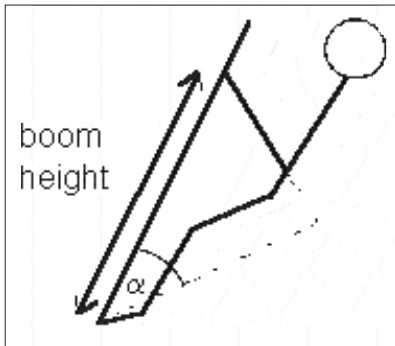


Figure 5. Diagram of angle a (fig5.tif)

$$\text{Force at foot} = \sqrt{\text{vertical foot force}^2 + \text{horizontal foot force}^2}$$

$$\theta = \arctan(\text{vertical foot force} / \text{foot force})$$

TORQUE AT L4/L5

The torque at L4/L5 was calculated by the sum of the torques of the upper and lower body, the torque of the harness force and the torque of the foot force.

$$\Sigma T = (\text{mass segments} \times \text{perpendicular distance}) + (\text{F harness} \times \text{perpendicular distance}) + (\text{F foot} \times \text{perpendicular distance})$$

- Torque =
- torque from upper body +
 - torque from harness force +
 - torque from lower body +
 - torque from foot force

FORCE IN ERECTOR SPINAE

The erector spinae force was calculated by dividing the torque of L4/L5 by the erector spinae lever arm, which was assumed to be 0.06m, as recommended by McGill and Norman (1986).

$$\text{ES force} = \text{L/S Torque} / 0.06\text{m}$$

COMPRESSION FORCE AT L4/L5

The compression force was calculated by the sum of erector spinae force, harness compression force and body weight compression force (adapted from Chaffin and Andersson, 1991). This model does not assume spinal compression alleviators such as intra abdominal pressure (McGill and Norman, 1987).

$$F_c = \text{ES Force} + \text{Harness } F_c + \text{Body weight } F_c$$

Where:

$$\text{Harness } F_c = \cos(180 - (\alpha + \beta)) \times \text{harness force}$$

$$\text{Body weight } F_c = \cos(90 - \beta) \times \text{body mass}$$

SHEAR FORCE AT L4/L5

Shear force was calculated by the sum of the harness shear force and the body weight shear force (adapted from Chaffin and Andersson, 1991).

$$F_s = \text{Harness } F_s + \text{body weight } F_s$$

Where:

$$\text{Harness } F_s = \cos(90 - (180 - (\alpha + \beta))) \times \text{harness force}$$

$$\text{Body weight } F_s = \cos \beta \times \text{body mass}$$

Electronic Resources

The Nursing Mothers' Association of Australia and the Work and Family Unit, Department of Workplace Relations and Small Business, Canberra, have released a 'Guide to Combining Breastfeeding and Work'.

http://www.dewrsb.gov.au/group_wrp/workfamily/guide1/index.htm

The guide includes information on:

- issues for breastfeeding women returning to work;
- benefits of combining breastfeeding and work;
- supporting breastfeeding women in the workplace (for example, lactation breaks and facilities);
- supportive workplace initiatives for breastfeeding women; and
- developing a breastfeeding and work information kit.

Identifying High-Risk Small Business Industries: The Basis for Preventing Occupational Injury, Illness, and Fatality (<http://www.cdc.gov/niosh/99-107.html>)

Quebec Occupational Health and Safety Research Institute (<http://www.irsst.qc.ca/indexe.htm>)

Write It Right: Recommendations For Developing User Instruction Manuals

for Medical Devices Used in Home Health Care (<http://www.fda.gov/cdrh/dsma/897.pdf>)

Alexander Technique Center Information Source: <http://www.alexandercenter.com>.

AFSCME Online Health and Safety Manual
< <http://www.afscme.org> >

OSHA Chief Chides Business Opponents of Ergonomics Charles N. Jeffress (Assistant Secretary, U.S. Department of Labor) heads OSHA's task force on ergonomics. Here is part of a speech he gave to members of the National Coalition on Ergonomics, challenging them to preach what they practice. Many NCE members do have ergo programs already. They know that ergonomics works.

The notion that we have no "sound science" linking work to MSDs or demonstrating that ergonomics programs prevent these injuries is a spurious argument. It makes good newspaper copy. But the evidence belies the charge.

Many of the corporations that you or your association represent are taking steps to prevent work-related musculoskeletal disorders. This is truly a case where actions speak louder than words. Your words bewail the lack of science. Your corporations' actions tell a different story. The actions indicate your employers believe that spending money to improve ergonomics can benefit both the workforce and the company's bottom line.

Your campaign against an OSHA standard denounces ergonomics programs as costly and of questionable value in preventing injuries. Yet many of your corporations have established programs that qualify for grandfathering under the OSHA draft proposal! There's a serious disconnect here. If ergonomics programs are a drag on productivity and a drain on profits, why are you establishing them? Because the opposite is true: good ergonomics is good economics.

Individually many of the 200 companies that publicly support the coalition's effort to discredit and delay an ergonomics standard have also established ergonomics programs. I challenge those corporations to preach what they practice. I urge you, as spokesmen and spokeswomen for these corporations to understand that people see you as saying one thing and doing another. You cry "wolf" about ergonomics, while at the same time investing in ergonomics programs to protect your employees. Have you no shame? Do you not care about the reputation for misrepresentation that you are creating for your corporations?

The reason your companies have established ergonomics programs is that they work. We know they work because employers have told us so. We have practical information

from more than 300 companies verifying that the programs they have established have prevented injuries and cut costs. So, the actual experience of business is at variance with vague claims about outlandish costs and questionable benefits.

About the Source

For the full text of the speech given to the National Coalition on Ergonomics on April 29, 1999, see <http://www.osha-slc.gov/OshDoc/Speech_data/SP19990429.html

Revised RULA for Offices <http://humanics-es.com/etc.htm>

ISB footwear conference proceedings <http://www.uni-essen.de/~qpd800/>

Statistics resources

<http://statistics.com/>
<http://www.stat.ucla.edu/>
<http://www.stat.ufl.edu/vlib/statistics.html>
<http://sportsoci.org/resource/stats/index.html>
<http://www.psychstat.smsu.edu/sbk00.htm>
<http://www.stat.ucla.edu/textbook/>
<http://davidmlane.com/hyperstat/index.html>

Conference Calender

1999

November 25 – 26 NZES Conference. Christchurch NZ
E-mail: nzesconf99@clear.net.nz

2000

March 19 - 22 Fatigue Management Alternatives to Prescriptive Hours of Service "Strategies for Programme and Promotion Evaluation", Fremantle.
Tel 618 9322 6906 Fax 618 9322 1734
Email: conwes@congresswest.com.au

April 4-6. Ergonomics Society Annual Conference, grantham. Email ergsoc@ergonomics.org.uk.

May 23-26, The International Society of Occupational Ergonomics and Safety 15th annual conference, Portland, Oregon. <http://isoes.org>.

July 23-28, Stockholm, XXVII International congress of psychology. <http://www.icp2000.se>

IEA 2000 29 July-4 August 2000 in San Diego, California, USA. Contact IEA/HFES 2000, HFES, PO Box 1369, Santa Monica, CA 90406-1369, USA; Email: HFES@compuserve.com <http://iea2000.hfes.org>

August 22nd-25th, Asia Pacific conference of computer human interaction, S.E. Asian Ergonomics Society conference, Singapore. Email myklim@ntu.edu.sg.

27 August - 1 September 26th ICOH International Conference, Singapore. Contact Secretariat ICOH2000, c/o Dept of Community, Occupational and Family medicine Faculty of Medicine MD3, Lower Kent Ridge Road, Singapore 119260.

Oct 9 - 11, 2000, **ESA 2000** Conference, Adelaide

October 25-27, 3rd International Conference of Engineering Psychology and Cognitive Ergonomics. Edinburgh. Email icep@cranfield.ac.uk; www.cranfield.ac.uk/coa/coa_conf.htm

2001

July 8-13, 2001, Zurich, Switzerland, XVIIIth Congress of the International Society of Biomechanics
www.isb2001.ethz.ch
email: isb2001@biomech.mat.ethz.ch

2002

August 3-8, 4th World Congress on Biomechanics, University of Calgary, Canada.

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The activities, achievements, experiences, views and opinions of Members are always of interest.

These can take the form of letters, notices, notes, commentaries and articles.

Graphics (photos, illustrations, drawings, computer graphics etc) are particularly welcome and should be camera ready. Photos need not be black and white and negatives are not required.

The preferred form of submission is via email, either in the body of a message, or as an attachment. Files may also be mailed on floppy, (or Zip disc if very large). Virtually any format of files can be accommodated. Otherwise contributions should be printed in a large (14 pt preferred) non-serif font (such as Helvetica) and faxed to 07 3365 6877. Printed pages of similar specification may also be sent by post. Handwritten submissions will only be accepted in exceptional circumstances.

Any enquires about contributions should be directed in the first instance to the Editor.

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