



C O N T E N T S

2	Editorial
3	Letters
5	President's Message
8	Board News
9	Branch News
11	Thesis Abstract
11	Lifting Technique
15	Neck Electromyography
22	Electronic Resources
22	Conference Calender
23	Instructions for Contributors

The Official Journal of the
Ergonomics Society of Australia Inc.

Volume 13, Number 1 edition, ISSN 1033-1875

Editor: Robin Burgess-Limerick

Design and Layout: Perception Communications tel: 03 9593 9993

Printer: The Jamison Printer tel: 06 253 1222

The Ergonomics Society of Australia Inc.

Canberra Business Centre

Bradfield Street, Downer ACT 2602

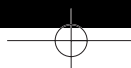
ESA URL <http://www.curtin.edu.au/society/esa/home.htm>

tel: 02 6242 1951 fax: 02 6241 2554

email: esa@ozemail.com.au

ESA MISSION STATEMENT

Promoting systems, spaces and designs for People



Editorial

"For centuries lumbago has been regarded as a rheumatic manifestation. ... It is evident that abnormalities have been sought in the lumbar muscles without critical enquiry into whether or not lumbago is primarily a muscular lesion. In my view it is not; it is the result of an attack of internal derangement of a low lumbar joint. ...

Prophylaxis.- Patients liable to lumbago must avoid heavy work involving trunk-flexion. They must learn to kneel and squat instead of bending forwards. ... it is full flexion that encourages the onset of lumbago. ... Should a patient liable to lumbago feel discomfort in (their) back lasting more than an hour, (they) should go and lie down at once... Recurrence of attacks at short intervals ... points to the danger of the development of sciatica from disc protrusion. Hence, patients in this state should adopt lighter work, and wear a belt stiff and tight enough to limit movement at the lower lumbar spine.

If the views set out in this paper gain acceptance, it will become reasonable for medical officers attached to factories to warn employers of the danger of allowing anyone with a defective low lumbar intervertebral disk to do heavy work...

So wrote James Cyriax, (then Assistant Medical Officer, Physiotherapy Department, St. Thomas's Hospital) in a letter published in *The Lancet*, October 6, 1945 (Volume 2, pp 427-429). The passage quoted is the earliest occurrence I have been able to locate of recommendations regarding altering lifting technique to avoid back injury. There are a number of interesting observations to make about the article. One is that Cyriax believed "lumbago" was caused by "a momentary posterior displacement of a movable piece of intra-articular fibrocartilage", and that the "defect" was genetic, rather than a consequence of loading. He wrote:

"Posterior defect of the annulus fibrosis may be regarded as a failure in embryonic fusion... I regard the accident mentioned by some patients not as fracturing the cartilage but as making manifest a defect already in existence. A history of lumbago or sciatica in parents and siblings is often met with..."

Interestingly, Cyriax's comments regarding the benefits of avoiding heavy work involving trunk-flexion were restricted to such genetically predisposed persons.

Anyway, the history lesson is a consequence of some reading I did late last year while I was writing an article on lifting technique, which is reproduced in this issue of the journal. Comments or feedback on the article are very welcome, please indicate if I may include them in the next issue. And if you know of any earlier reference to avoiding trunk flexion while lifting, I'd be very happy to be out-researched. Just don't tell me that it has been around since the building of the pyramids (according to the Larson cartoon!).

Other items in this first issue of 1999 include a technical note on the Elimination of electrocardiograph noise in neck muscle electromyography (thanks Leon) and an abstract of Shirleyann Gibbs recently completed PhD thesis (congratulations Shann).

Lastly, keep those contributions coming!

Best wishes,

Robin Burgess-Limerick

Letters

DR. JOHN LANE

As this issue was about to go to the typesetter the very sad news came from Michael Regan of the death of Dr. John Lane a Fellow and past President of the Society.

Dave Caple writes:

I was deeply saddened to read Mike Reagan and Tom Trigg's news that John Lane has died. Having John as the Ron Cumming memorial lecturer at ESA 98 was an opportunity to hear of the extensive history of ergonomics in Australia and John's dedicated contribution as a foundation member of our Society. I remember John attending Vic. Branch meetings over the last 20 years as one of the wise counsellors. He was always encouraging to the new members and a humble contributor of his extensive knowledge.

As a Fellow and past President of ESA, John has made a significant contribution to the history of ergonomics in Australia. He will be sadly missed by all.

As the current President of ESA I would like to recognize John's contribution at this time. Your suggestions how this may be most appropriately done would be appreciated. I have spoken to his wife who spoke fondly of John's work with the Ergonomics Society and his many friends from this area. The lung disease which quickly debilitated John was not related to their recent car accident that prevented his attendance at ESA 98. Mrs. Lane is still recovering from that accident.

I will be attending John's funeral today (Mon. 25th. Jan.) at 2pm., at the Deepdene Uniting Church.

David C Caple

PO Box 2135
East Ivanhoe
Victoria 3079
Australia
Telephone: 03 9499 9011
Fax: 03 9499 9022
Email: dcaple@mira.net

FAREWELL IAN MITCHELL

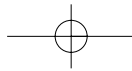
It is with some regret and a lot of sadness that the Society is saying farewell to Ian who has been our Executive Director since June 1994. He is retiring in February, 1999. He was appointed after much soul-searching and planning by the Executive and Council and after a long period of 'head hunting' by the Executive at the time. Ian appealed to us because he appeared to have the personal and professional qualities we desperately needed in the Society. He also came highly recommended by several people whose opinions we valued.

In June 1994 he accepted our offer to work with us one day per week and he hit the ground running by organising and conducting a strategic planning meeting for the Council in mid June in Sydney. This was a most enjoyable and productive two days and I believe that the Council and the Society turned a corner at that time. He subsequently ran other workshops for the Council and for the general membership, all of which were invaluable for the development of the ESA as a whole.

Despite many hurdles and some rough patches Ian has stuck with us and guided us firmly through the minefield of legal and organisational issues 'not-for-profit' societies such as ours must manage. His job has been a thankless one at times as the usual problems (and sometimes a few we were not expecting) threatened to derail the process of professionalising the Society.

I know I can speak for all the Federal Councils (Boards) since 1994, and especially the Presidents, when I say how grateful we are to Ian for helping us to make the ESA a stronger, more professional and a better organised Society. Although we shall not be losing contact with him entirely (the Society has asked if it can call on him in the future for advice and guidance on specific projects) we hope that he enjoys his retirement - at last - so well deserved and so long in the coming!

Barbara McPhee
18 January 1999



ESA LOSES LYNCH PIN


Has it been 7 years since Margot Lynch hitched her star to the ESA bandwagon? I can hardly credit it. I was part of a small interview panel charged by the Society to find an Administrative Secretary. We had no idea at the time that Margot would become such an important part in ESA's organisational machine.

Margot had a number of things to recommend her; she had worked for a national organisation, was computer literate and lived locally. In other words a perfect recruit, experienced, capable and bound to turn up to work on time. Margot of course had also won over the interview panel with her pleasant personality and confidence in her abilities. She has been many things to many people. For the general public, the face or more correctly, the voice of the Society answering queries about the ESA from a disparate group including politicians, lawyers, business people, union reps, teachers and students. I know because Margot would often put them on to me! To Society members she was the one that could be contacted when they needed to check on why their name wasn't included in the ESA Directory or to say their cheque was in the mail. Mind you there were a lot of pleasant interactions too.

Amongst a host of other things she, was instrumental in setting up and updating membership data bases, providing Society members with information and copies of conference proceedings. She provided committee members with papers for meeting arranged phone conferences and could be relied upon to provide timely reminders to members when their subs were overdue. Margot had to use all her tact when informing one of the Society's Treasurers that he would be unable to vote if he was unfinancial at the time of the AGM. Mind you that was a comparatively easy job compared to the poor unfortunate individual who had to tell Paul Keating, the then Treasurer of the Federal Government, that he had not put in his tax return for a few years. The Professional Affairs Board become more professional by engaging Margot to provide a range of secretarial support functions which took up an increasing amount of her time.

Just when the work load looked to be more than a permanent part timer could reasonably cope with the Lone Ranger appeared in the guise of Ian Mitchell, the Society's Executive officer. Together they set about introducing and streamlining the administrative systems that makes the ESA today the envy of other small to medium sized professional associations. So after 7 years of holding our collective hands Margot has itchy feet and wants to travel. She is well placed to do so, she has a son who works with QANTAS. If he can't fix things nobody can! On behalf of the Society it was my pleasant duty to host a farewell lunch for Margot and Ian attended by a number of ACT Branch personalities and Christine Stone, the Society's new Administrative Secretary. All that remains is to wish Margot bon voyage and a happy and fulfilling retirement.

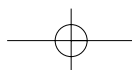
Jeffrey Frith



**Perception
Communications**

Marketing
Communications
Research
Publications
Graphic Design
Printing
Internet

31 Blanche Street
St Kilda 3182
Tel: 03 9593 9993
Fax: 03 9593 9669
Mob: 0412 604 414
Email: goro@percept.com.au



President's Message

With the growth in the membership of the Society there are proportionally fewer members who remember life before Ian Mitchell. I write as one who was originally from the ranks of Tuscany* – I really thought the idea of an executive officer was a bit of a waste of money for a small organisation like ours. And I did not have much to do with him in the early years AM (Anno Mitchellium) although news of his reign filtered west, distorted by static during its long journey across the Nullarbor. When I got to know Ian better I was somewhat in awe of his administrative and academic stature, but I soon came to realise the extent to which the Society had grown in maturity and professionalism during his time, if not exactly at the helm then close to the helmsperson's elbow. With the other member's of the executive I came to appreciate the qualities of integrity and forthrightness, together with his wide knowledge and experience, which he brought to his work. I actually came to look forward to our Executive meetings in Perth! And even when we decided not to accept his advice he would take it pretty well and not spit the dummy or throw his toys out of the pram.

Speaking personally I am glad that his health is much improved in recent months – I am not sure which was more stressful at times – ESA or his goats, but it is good that he has stayed with the Society for so long. One of my favourite books is an 1856 textbook of physiology (a major resource for my lectures, of course) and part of the author's dedication to his former teacher reads: "That you may long be spared to be the ornament of your University, and the honour of your City, is the earnest wish of, Dear Sir, Your obliged Pupil," Even though the language is old-fashioned I would like to echo these sentiments.

(From Macaulay's poem about Horatius gallantly, and successfully, defending the bridge into Rome against the Etruscan army – "And even the ranks of Tuscany/ Could scarce forbear to cheer.")

Ian Gibson

Welcome back to work for 1999 to all our ESA members. I have enjoyed a break at our family house on Phillip Island with poor skill acquisition programs of fishing and surfing.

A big welcome to our new Administrative Officer, Christine Stone who completed her induction with Margot Lynch prior to Margot's retirement in December. Christine will be at our Canberra offices each morning so please make contact and help her skill acquisition program.

Margot was treated to a lunch by the ESA with Ian Mitchell and members of the ACT Branch to acknowledge her 7.5 years service. I have received a lovely note of thanks and best wishes from Margot to all ESA members.

Our Executive Officer, Ian Mitchell will be retiring from his ESA duties at the end of February 1999. Ian has been a major influence over the affairs of ESA and his contribution has stabilised our federal affairs to ensure compliance with the many reporting and procedural requirements. I have enjoyed my brief period with Ian's guidance and wish him well with tending

his flock. The past president who also have worked with Ian will separately acknowledge his contribution in this edition of EA.

A brief report on our 1999-2001 strategy plan.

1. Membership

It is pleasing to see our financial membership list increasing. As of 10th November 1998 we had:-

- Fellows	10
- CPE	38
- Members	412
- Affiliates	69
- Corporate Affiliates	5

534

Also we have had 21 new members and 11 new Affiliates since July. I encourage all to extend an invitation to qualified ergonomists to join ESA to maintain opportunities for professional development.

A working party consisting of:-

- Ruth Stuckey
- Owen Evans
- Phil Clark
- Wendy MacDonald
- David Caple

has met to review the certification standards adopted by IEA and other bodies in Europe, USA and Canada. With guidance from our IEA delegate, Prof. Margaret Bullock, and contributions from participants from the ESA 98' workshop, a discussion paper is being prepared for comment. This should appear in the next edition of EA.

The 1999 edition of the Membership Handbook is currently being collated. This is provided free to all members as part of our membership fee.

2. Professional Development

I congratulate the Branch committees for the range of interesting topics being scheduled for ESA members during 1999. During visits to Branches in ACT, NSW and S.Aust it is evident that joint programs with relevant external bodies will provide technical basis for various programs this year. These include:-

- other professional societies
- government regulators and inspectors
- researchers and graduates
- employer associations and unions

We will be writing to a number of these peak bodies on behalf of ESA to seek their interest in joint professional development opportunities.

3. Promotion

The program opportunities at the Branches will certainly assist in our promotional program for 1999. The promotion of ergonomics through CybErg 99' (convened by Leon Straker); our ESA 99' Conference in Fremantle (convened by WA Branch) as well as special Australian edition of the Journal of Industrial Ergonomics will assist in general promotion.

Our new ESA home page on the Internet (www.ergonomics.com.au/fed.htm) has received many international enquiries. An informal network of Australian ergonomists "Ergonoz" has become a wonderful interchange of opinions and exchange of

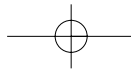
information. I encourage all members with email access to join this. See December 98' edition of EA for instructions or contact Owen Evans (o.evans@latrobe.edu.au) for help if not successful.

4. Finance

The major review of finances by the previous Board resulted in a program for Branches to consolidate funds into a single Federal account. Each Branch will prepare a budget for 1999/2000 to meet their needs. This will replace the previous system where each Branch received a fixed percentage of membership fees, called "capitation", regardless of their financial needs. This program of consolidation of funds is now being implemented.

1999 looks like being a tremendous year for the ESA, and I look forward to the ongoing support and participation from members.

David C Caple
 President
 PO Box 2135
 East Ivanhoe
 Victoria 3079
 Australia
 Telephone: 03 9499 9011
 Fax: 03 9499 9022
 Email: dcaple@mira.net



Board News

Christine Stone writes:

I am 47 years old, Married to a Member of the Australian Defence Force with one daughter who is 21 years old. I have worked in various areas of business including hospitality, Legal, Not for Profit Membership Organisations and the Leisure and Amusement industry.

I am at present working towards a Bachelor of Commerce through Deakin University, Warrnambool - off campus mode.

Now that I have a part time position I will be either finishing this earlier than was planned or will be doing some other activity with my spare time. A luxury I haven't had for a few years!

I am looking forward to working for the Ergonomic Society and its members.

NEW COMPUTER PROGRAMS

As many of you if not all will be aware the secretariat has a new computer at its disposal. We have up graded to Windows 98 and are in the process of transferring our database over from Rapidfile to Microsoft Access. We are also about to upgrade to version 7 of Quicken, our accounting package. These moves should ensure that we are now Y2K compliant at the very least.

With these changes we will also be able to provide better service to our members and various committees.

Christine Stone



Eighteen years of ESA presidents (1982-2000) at the ESA Annual Conference, Melbourne, October, 1998.

Left to right

Back row: Roger hall (1982-84), Ian Gibson (1996-98), Alan Howie (1986-88), Verna Blewett (1994-96), Micahel Patkin (1984-86), Margaret Bullock (1988-90), Jeff Frith (1990-92)

Front row: David Caple (1998-2000), Barbara McPhee (1992-94)

Margaret Bullock has been appointed Emeritus Professor following her retirement from the The University of Queensland. The Board of ESA congratulate her on this distinguished appointment. Margaret will continue as the ESA delegate to the IEA.

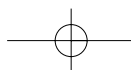
New Members

NSW

Mr Robert Johnson
PO Box 48
KEIRAVILLE NSW 2500
Upgraded to Certified Professional Ergonomist

QLD

Mr Derek Smith
Capricornia College
Central Queensland University
ROCKHAMPTON QLD 4702
Affiliate
Tutor Central Queensland University



Branch News



WESTERN AUSTRALIA ANNUAL GENERAL MEETING

The WA Branch AGM was held on 29th September at the Esplanade Hotel, Fremantle, venue for the

1999 ESA Conference. The dinner was followed by an entertaining talk by professional speaker, Peter Sumner who shared his experiences of OSH / ergonomics from the point of view of the visually impaired person. The 1998/1999 committee is as follows:

Chairperson	Lynne Rogers
Secretary	Melanie Baker
Treasurer	Judith Lauri

Programme Co-ordinators

Marie Tully
Carol Cain

Boardmember - Federal

Ian Gibson

Membership

Alister Broughton

Normal Board Member (Conference Rep)

Kerry Jones

Newsletter Liaison Wendy Elford

EDUCATION PROGRAMME 1998

Technical Meetings were well attended this year, a sign that the topics covered were interesting and relevant to the practice of WA ergonomists. Members also appreciated the opportunity to network and catch up on the latest resources. Topics included:

Taking the sweat out of heat stress measurements.

(Dr Ian Gibson; 28th January). Reviewed equipment for measuring WBGT to estimate heat stress and considered the more practical aspects of using WBGT as a measure of heat strain which may be a 'trap for the unwary'.

How to write better scientific reports in ergonomics

(Anne Austin) 24th February Described the principles of an effective writing style as applied to scientific reports.

Blue Sky mining: Highlights and lowlights of work in a remote mining community. (Sharon-Lee Dyer; 24th March). Gave an insight into working in a remote area and described the work alert programme introduced at Hamersley Iron, WA.

Beyond one size fits all hours of service regulations: The development of a comprehensive system for managing fatigue. (Associate Professor Laurence Hartley; 29th April). Focused on fatigue in the transport industry and introduced the draft code of practice for WA entitled "Fatigue management for commercial vehicle drivers".

The legal profession's requirements of an Ergonomist. (Phillipa Nash; 3rd June). Looked at the requirements of an ergonomist's report from a legal perspective and gave pointers on how to be a good witness.

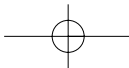
Beyond size and weight, what more do we need to know? (Dr Ian Gibson; 19th August). Considered the tools, techniques and methods available to ergonomists for workplace evaluations.

Postgraduate students research presentations.

(Stephanie Ovens, Suzanne Bannerman and Andrea Roelofs; 4th November).

The physical implications of laptop computer use by school children. (Courtenay Harris; 2nd December). Revisited a poster presentation given at the PREMUS – ISEOH '98 conference in Helsinki

Overview of ergonomics related research at Hangzhou University, China (Associate Professor Zhang Zhijun) 2nd December.



NSW NEWS

WorkCover NSW is currently undgoing a re-structure and the grapvine reflects the

general mood of staff uncertainty that accompanies this process which has rippled through both public and private sector organizations as a seemingly constant form of late twentieth century corporate titanic game. Helen L'orange did not seek re-appointment as CEO of Worksafe and has been replaced by Alan Rowe from the Federal Office of the Employment Advocate (no-one I've spoken to has ever heard of that particular branch of the bureaucracy). Ruth Campbell who was the Worksafe Director of the National Forum and Information Branch has resigned and returned to the private sector. Helen Orr is now acting in Ruth's former position at Worksafe. At its December meeting, the NSW Branch Committee decided to hold a one-day workshop on 30th January to review its local structures, branch operations and future directions. It will employ the guidance services of an experienced facilitator. The venue is yet to be announced but members requested an interesting location and good food within driving distance of Sydney to avoid overnight expenses but to have that get-away-from-the-office sensation! An update will be given next edition!!

Shann Gibbs NSW Correspondent

CYBERG 1999

Dear Colleagues,

Travel to your next international ergonomics conference free!

CybErg 1999, the second international cyberspace conference on ergonomics, follows the highly successful CybErg 1996. Over 1,000 ergonomists from 34 countries participated in CybErg 1996. CybErg 1999 promises to be even bigger and better.

For further details visit the website:
<http://www.curtin.edu.au/conference/cyberg/>

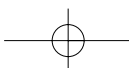
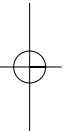
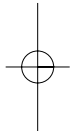
Please pass on these details to other colleagues who may be interested.

Looking forward to your participation in CybErg 1999.

Dr Leon Straker
General Chair, CybErg Conference.

Conference Secretariat:
Congress West Pty Ltd
PO Box 1248
West Perth WA 6872
Australia

Ph: + 61 8 9322 6906
Fax: + 61 8 9322 1734
Email: conwes@congresswest.com.au



Thesis Abstract

Safety: a complex, interactive and adaptive systems model depicted by health industry workers handling cytotoxic drugs.

Shirleyann Gibbs
shannng@gibbsplus.com.au

Supervisors: Dr Neil Adams, Prof. Jean Cross
Department of Safety Science Faculty, UNSW

Data published over several decades in a variety of scientific journals have mooted the risks to staff handling cytotoxic drugs and their waste products. A staff exposure index for handling this material is not available; nor is there an accepted method for obtaining the relevant information. Some professional groups have attempted to establish safety guidelines for their own personnel handling of these products. National and international standards for cleanrooms, safety cabinets and personal protective garments address an engineered solution to some cytotoxic drug dispensing problems. Transport issues associated with these drugs and the disposal of their related waste products generate largely unresolved environmental concerns in the late nineties.

This thesis discusses bivalent and multivalent safety audits in complex, interactive and adaptive systems such as the health industry. Interviews, fieldwork visits and a review of the literature identify a diverse global pattern of staff safety performance in the handling of cytotoxic drugs. The study includes both ethical and legal implications for current behaviours, management theories and financial priorities.

Results from this investigation show that attitudes at any level of an organisation can affect safety. A safety systems model requires global management rather than discipline specific protocols. It involves a different way of thinking about safety, accident prevention and post trauma recovery. A bivalent or reductionist form of risk analysis can be an inappropriate tool for determining the safety implications of subsystem variables. Scientists need multivalent or fuzzy logic to evaluate system safety. In real terms, a state of apparent equilibrium may be only transient between current and future information and technology. New processes and the adaptive interactions of animate systems continuously modify behaviour. The study of safety belongs to the science of complexity since researchers can apply no absolutes to human factors in organic systems.

Lifting Technique

Robin Burgess-Limerick PhD
Department of Human Movement Studies
The University of Queensland, 4072
AUSTRALIA
email: robin@hms.uq.edu.au

1. INTRODUCTION

Compensation claims for occupational injuries attributed to lifting have typically represented a significant proportion of claims (of the order of 20%), and the majority of these (typically about 70%) are for injuries to the back. This article discusses the postures and patterns of movement used to lift low lying objects, and the implications of these postures and movements for back injuries in particular.

Current knowledge regarding the mechanisms of back injuries and the biomechanical consequences of different lifting techniques are described; and attention is directed toward the postures and patterns of movement normally employed to lift low lying objects. The article concludes by presenting recommendations for preventing back injuries caused by lifting.

Starting from upright standing, lifting a low lying object placed in front of the person involves a cycle of movement beginning with flexion of the knees, hips, and lumbar vertebral spine (and dorsi flexion of the ankles). The load is then grasped, and raised against gravity by extension of the knee, hips, and lumbar vertebral spine (and plantar flexion of the ankles).

Lifting technique has typically been defined in terms of the posture adopted just before the load is lifted (at the start of the extension phase). It has commonly been proposed that the postures adopted to lift loads from a low level may be characterised in terms of two extremes. One extreme, described as a stooped posture, is one in which the knee joints are almost fully extended and the hip joints and vertebral column are flexed to reach the load. The second extreme, described as a full squat, is one in which the knee joints are fully flexed and the trunk is held as vertical as possible. It has become a matter of dogma that the latter posture is the "correct" manner of lifting. However, on the basis of current knowledge of injury mechanisms and lifting biomechanics, it is clear that lifting from a full squat

posture is not an appropriate recommendation. It is also evident that self-selected lifting technique typically involves adopting a posture at the start of the extension phase which is intermediate between full squat and stooped postures, and that the pattern of movement normally employed reduces muscular effort.

2. MECHANISMS OF INJURY DURING LIFTING

During lifting, large extensor moments about the joints of the lumbar vertebral column are produced by the paravertebral musculature to overcome the flexor moment caused by the weight of the upper body and load. Injury to musculo-ligamentous structures commonly occurs as a direct consequence of the high forces involved.

These high forces also result in large compressive and shear forces acting between each pair of vertebra. Unless the lumbar spine is in a posture of extreme flexion, the mechanism of failure in compression is failure of the endplates of the vertebral bodies and the underlying trabeculae as the nucleus pulposus bulges upward and downward (Adams and Dolan, 1995). The magnitude of compressive forces experienced during a single lift is unlikely to cause endplate failure, and injury of this type caused by lifting is more likely to be cumulative.

Cumulative damage to the vertebral endplates may occur in a number of ways. Microdamage to vertebral endplates is likely during heavy lifting, and injury may arise if the microdamage accumulates more rapidly than can be repaired. Repeated compressive loading will also reduce the failure tolerance of the tissues, resulting in injury if repeated loading continues (McGill, 1997). Damage may also be additive in that prolonged exposure to other sources of loading, and especially whole body vibration, may render the vertebral bodies vulnerable to injury during lifting.

Lifting from postures involving extreme lumbar vertebral flexion has the potential to contribute to injury. Extreme lumbar vertebral flexion is characterised by absence of electromyographical activity in erector spinae (e.g., McGill and Kippers, 1994). In this situation the anterior moment caused by the weight of the upper body and load is balanced by an extensor moment created by tension in the paravertebral ligaments, interspinous ligaments,

posterior fibres of annulus fibrosus, and passive elements of the musculotendinous tissues. The first tissues to be injured in this situation are the interspinous ligaments (Adams and Dolan, 1995). Disruption of the posterior fibres of annulus may follow if extreme lumbar flexion is combined with compression and lateral bending or torsion.

If damage to the posterior annulus progresses, seepage of the nucleus pulposus through the annulus may result (an intervertebral disc prolapse). While intervertebral disc prolapse only accounts for small proportion of claims for back injuries (5-10%), the injury frequently results in chronic back pain and accounts for a considerably larger proportion of claims costs.

Compressive load alone will not cause intervertebral disc prolapse, and damage to the intervertebral disc is unlikely to occur as a consequence of one-time loading (although this is possible if high compressive load is placed on the spine while hyperflexed and laterally bent) (Adams and Dolan, 1995). Injury to the intervertebral disc is more likely to be the consequence of an accumulation of microdamage due to repeated compressive and torsional loading applied while the lumbar spine is extremely flexed.

Anterior shear forces are also very high when loads are lifted from a posture of extreme lumbar flexion and this represents a risk of injury. However, the orientation of the fibres of the erector spinae muscles (in particular, the pars lumborum fibres of longissimus thoracis and iliocostalis lumborum) is such that when tension develops in these muscles a posterior shear force is created on the superior vertebrae which counteracts the anterior shear created by the weight of the upper body and load (McGill, 1997). The erector spinae are active unless lumbar flexion is extreme, and consequently the anterior shear forces are reduced in postures which do not involve extreme lumbar flexion.

Prolonged exposure to static postures involving extreme lumbar vertebral flexion will also cause the tissues to creep (the ligaments do not return to their resting length immediately upon unloading). The consequence may be a temporary loss of stability after the period of sustained extreme lumbar flexion which may lead to a higher

likelihood of injury in subsequent loading in any posture (McGill, 1997). The abdominal muscles normally contribute to stability of the spine, and failure to contract these muscles appropriately may also increase the risk of injury.

3. THE "FULL SQUAT" RECOMMENDATION

According to Brown (1973), the recommendation that lifting should be carried out from a full squat posture has been promulgated since the 1930's. Many researchers have subsequently noted that this recommendation is unjustified (e.g., Whitney, 1958, Brown, 1973, NIOSH, 1981). The authors of the otherwise influential 1981 NIOSH "Work Practices Guide for Manual Lifting" observed that the full squat posture reduced stability (the heels are inevitably lifted from the ground and the knees are in an unstable "loose packed" posture when maximally flexed) leading to the possibility of injury due to unexpected perturbations; and that the technique increased the distance of wide loads from the spine (increasing the load moment and consequently the resulting extensor moment and compressive forces). It was concluded that the squat lift recommendation was based on simplistic mechanical logic which failed to take dynamic loading on the back and the knees into account.

The proponents of the full squat technique suggested that the stresses on the vertebrae are better distributed with the lumbar spine in a lordotic posture. In fact, lordosis poses several disadvantages relative to postures of partial flexion (Adams & Dolan, 1995), including increased loading of apophyseal joints and increased compression of the posterior annulus. Lordosis has been advocated to reduce hydrostatic pressure in the nucleus, but this only indicates that the load has been shifted to the annulus and apophyseal joints.

An additional pragmatic problem with the "full squat" recommendation is that it cannot be utilised in many situations. Maximal knee flexion has the consequence of lengthening the quadriceps beyond their optimal length leading to decreased knee extensor strength. The result is that lifting capacity is reduced: sub-maximal loads require greater muscular effort leading to more rapid onset of muscular fatigue; maximal loads cannot be lifted at all.

From the discussion of injury mechanisms it is evident that the only appropriate recommendation regarding posture of the lumbar spine is to avoid extreme lumbar vertebral flexion, and trunk rotation and lateral flexion. There is no basis for avoiding postures involving moderate lumbar vertebral flexion.

4. SELF-SELECTED LIFTING TECHNIQUE

The traditionally recommended full squat posture is seldom, if ever, spontaneously adopted in the absence of specific instruction. Investigations of self-selected lifting technique have revealed that the postures typically adopted to lift low lying loads are intermediate between full squat and stoop extremes, and might be termed semi-squat (e.g., Burgess-Limerick et al., 1995; Burgess-Limerick & Abernethy, 1997). Lifting a low lying load from a semi-squat posture typically involves about 45° of lumbar vertebral flexion, that is, about 75% of the normal range of movement. In conjunction with the absence of an electromyographical silent period in erector spinae, this suggests that the passive structures of the back are not substantially stretched during lifting from this posture. Stooped postures involving greater lumbar flexion are adopted by some people in some circumstances, although typically this occurs when the load is relatively light.

An adequate description of lifting technique requires consideration of the pattern of interjoint coordination as well as the posture adopted at the start of the lift. The posture adopted at the start of extension influences the pattern of subsequent interjoint coordination by determining the range of movement available at each joint. The semi-squat posture most commonly adopted at the start of extension allows a pattern of interjoint coordination which appears to be functional.

The coordination of self-selected lifting involves contemporaneous movement of the lower limb and trunk joints, that is, the joints flex and extend at the same time rather than sequentially (as is sometimes modelled). However, the joints are not perfectly synchronised: a consistent pattern of deviation from synchronous coordination is commonly observed. Knee extension typically occurs more rapidly earlier in the lifting movement relative to extension of the hip, and

the onset of rapid lumbar vertebral extension is delayed substantially after the start of the lift. The moderate lumbar flexion observed lengthens the erector spinae relative to its length in normal standing, and the delay before rapid lumbar vertebral extension delays rapid shortening of the erector spinae. Estimation of the length changes of the biarticular hamstring muscles has revealed that these muscles are also relatively lengthened at the start of the extension phase, and that the pattern of coordination between knee and hip joints also has the consequence of delaying rapid shortening of the hamstrings.

Muscles are stronger when lengthened, and when not shortening rapidly, and thus this pattern of coordination increases the strength of the hamstrings and erector spinae early in the extension phase when the acceleration of the load is greatest by both lengthening the muscles, and delaying their rapid shortening.

Delaying shortening of the hamstrings has the additional functional consequence of allowing the monoarticular knee extensors to, paradoxically, contribute to hip extension through a tendinous action of the hamstrings. The pattern of coordination observed thus reduces the muscular effort required to perform the task, and the pattern of interjoint coordination is exaggerated with increased load mass.

A different pattern of coordination between hip and knee occurs when a stooped posture is adopted at the start of extension. The large range of hip flexion and small range of knee flexion involved results in the hamstrings being lengthened further than if a semi-squat posture were adopted. A stooped posture has the advantage of lowering the centre of gravity of the upper body less than a semi-squat posture and thus less work is done in lifting the upper body during each lift. However, during lifting from a stooped posture the hamstrings must immediately shorten rapidly because the knee is unable to extend rapidly. This counteracts to some extent any strength advantage which might accrue as a consequence of the increased hamstring length and prevents the monoarticular quadriceps from contributing to hip extension.

5. RECOMMENDATIONS FOR PREVENTING BACK INJURIES DUE TO LIFTING

Training people to perform lifting in safer ways has been consistently proposed as a means of reducing the risk of injury, however research evaluating the effectiveness of lifting training programs involving uninjured workers has generally failed to find any evidence of persistent modification in lifting technique (Pheasant, 1986). If it can be assumed that muscular fatigue contributes to injuries suffered as a consequence of lifting, then a technique which reduces muscular effort may be preferred. Rather than prescribing a single "best" technique which is not likely to be appropriate in all situations, it may be preferable to provide education in general lifting guidelines and use exploratory learning techniques (Newell, 1991) to assist lifters to discover individually appropriate postures and patterns of movement.

General lifting guidelines which can be justified on the basis of current knowledge include:

- Wherever possible, remove exposure to manual lifting by providing mechanical aids.

If manual lifting must be undertaken:

- Reduce the load mass
- Raise the initial height of the load
- Keep the load close
- Adopt a posture at the start of the lift which involves a moderate range of motion at the knee, hip and vertebral column
- Avoid lifting from a posture of extreme lumbar vertebral flexion
- Avoid trunk rotation while lifting
- Avoid lateral trunk flexion while lifting
- Avoid lifting after prolonged periods of extreme lumbar vertebral flexion.
- Avoid high acceleration of the load (lift smoothly)

The risk of injury to the back caused by lifting can also be reduced by:

- Reducing exposure to whole body vibration.
- Strengthening the bones, ligaments, and muscles by appropriate exercise.

Neck Electromyography

REFERENCES

Adams, M.A., and Dolan, P., 1995, Recent advances in lumbar spinal mechanics and their clinical significance. *Clinical Biomechanics*, **10**, 3-19.

Brown, J.R., 1973, Lifting as an industrial hazard. *American Industrial Hygiene Association Journal*, **34**, 292-297.

Burgess-Limerick, R., Abernethy, B., Neal, R.J., and Kippers, V., 1995, Self-selected manual lifting technique: Functional consequences of the interjoint coordination. *Human Factors*, **37**, 395-411.

Burgess-Limerick, R. & Abernethy, B., 1997, Toward a quantitative definition of manual lifting postures. *Human Factors*, **39**, 141-148.

McGill, S.M., 1997, The biomechanics of low back injury: Implications on current practice in industry and the clinic. *Journal of Biomechanics*, **30**, 465-475.

McGill, S.M. & Kippers, V., 1994, Transfer of loads between lumbar tissues during the flexion-relaxation phenomenon. *Spine*, **19**, 2190-2196.

National Institute for Occupational Safety and Health, 1981, *Work practices guide for manual lifting* (Cincinnati, OH: US Public Health Service), No. 81-122.

Newell, K. M., 1991, Motor skill acquisition. *Annual Reviews of Psychology*, **42**, 213-237.

Pheasant, S. T., 1986, *Bodyspace: Anthropometry, ergonomics and design* (London: Taylor & Francis).

Whitney, R.J., 1958, The strength of the lifting action in man. *Ergonomics*, **1**, 101-128.

ACKNOWLEDGEMENT

Vaughan Kippers provided several helpful comments during the preparation of this article.

ELIMINATION OF ELECTROCARDIOGRAPH NOISE IN NECK MUSCLE ELECTROMYOGRAPHY.

Mekhora, K†‡ and Straker, L‡

†School of Physiotherapy, Mahidol University, Bangkok, Thailand

‡School of Physiotherapy, Curtin University of Technology, Perth, Australia

ABSTRACT

Noise contamination is a common problem in the use of electromyography (EMG), with the electrocardiograph (ECG) signal a common noise source. In the evaluation of muscle work load among office workers, the activity of shoulder, neck and thoracic muscles are usually compared and ECG contamination of EMG is a potential problem. This paper reviews techniques to eliminate ECG contamination and introduces a simple gating technique. EMG were collected from trapezius and cervical and thoracic erector spinae muscles during performance of a computing task by 20 subjects. ECG was collected at the same time. The R wave peaks and QRS intervals of ECG data and a delayed onset of ECG contamination in EMG data were used as an alignment for removal of a section of EMG data. EMG data were processed and comparisons made between the data before and after ECG elimination. The results indicated the EMG root mean square (RMS) of both sides of thoracic erector spinae and left trapezius before and after ECG elimination were significantly different. In conclusion, ECG contamination may influence the EMG data when investigating low level static EMG activity of muscles located near the heart and this needs to be eliminated before analysis. The simple gating technique described can successfully eliminate the ECG contamination, when certain assumptions are met.

KEYWORDS

Occupational electromyography, electrocardiography, noise

INTRODUCTION

Electromyography recording of muscle is commonly used to detect muscle activity. The source of the EMG signal is the difference in electrical potential when the

muscle is activated. In ergonomics, EMG is used as one objective criteria to understand the match of human and machine. EMG can be analysed in terms of amplitude, frequency and power. However, problems frequently arise with noise (unwanted signal) influencing the EMG. Marras (1987) suggested that successful use of EMG depends on an understanding of the nature of the signal collected and being able to separate useful information from noise and signal artifacts.

EMG noise comes from the EMG recording systems, the environment and the subjects. The effects of noise on the EMG data can alter the amplitude and the frequency of collected EMG data. However, these effects can be minimised and/or prevented during the process of EMG collection and analysis. Noise transmitted through the system or through the air can be minimised by using a high quality preamplifier with a short lead distance to the electrodes (Westgaard, 1988). The noise from the subjects can be divided into motion, cross talk and ECG signal. Motion noise can occur with any movement of electrodes and leads. Schweitzer *et al* (1979) reported that high-pass filtering at 20 Hz can delete all motion artifacts and maintain an isoelectric baseline. Hagemann *et al* (1985) developed special electrodes which together with the preamplifier and power supply units can minimise the effect of motion noise. Cross talk noise is unwanted EMG from nearby muscles and is sometimes difficult to eliminate. Changing electrode sites and observing EMG activity while activating the muscles of interest may be useful. Cross talk may also be minimised by using needle electromyography, but this technique is more invasive.

The ECG signal is also a possible EMG contaminating noise. Like skeletal muscle, cardiac muscle is activated by an electrical potential. Therefore, the EMG signal can sometimes be contaminated with ECG signal, particularly when any muscle of interest is located nearby the heart. Several methods to deal with this ECG contamination have been reported; clipping, filtering, subtracting, and gating techniques. Each technique has advantages and disadvantages.

The clipping technique was an early technique involving truncation of the ECG peak (see *Figure 1b*). The amplitude of the EMG where the ECG is presented,

is cut at a certain fixed range. Consequently, some parts of ECG remains, which may effect the data reliability (Pang *et al*, 1995), and the amplitude and the frequency in the truncated part is altered which can be recognised by a square wave form (Schweitzer *et al*, 1979). With electronic and digital advances this technique is usually redundant.

The filtering technique can be accomplished by high pass filtering the raw EMG signal (Redfern, 1987). This technique is based on the knowledge that the dominant frequency power of ECG is at 20 Hz and of EMG is at 25-250 Hz (Schweitzer *et al*, 1979). However, it has been argued that some potentially important EMG information is lost, since the power frequency of ECG is in the frequency range of EMG (Redfern, 1987; Schweitzer *et al*, 1979). Whilst high pass filtering can remove much of the T wave, the QRS complex may be more difficult to remove as more EMG is also removed (Schweitzer *et al*, 1979).

The subtraction technique is said to be able to reliably eliminate the ECG signal (Pang *et al*, 1995), without losing any EMG signal (Bartolo *et al*, 1994). This technique involves either the use of cross correlation (Bartolo *et al*, 1994; Levine *et al*, 1986) or midpoint of R wave (Bloch, 1983) to detect the ECG contamination and use an ECG template from the same data during silence of EMG to subtract the ECG contamination (Bartolo *et al*, 1994; Levine *et al* 1986). The EMG signal after ECG elimination is clear without any loss of data (see *Figure 1c*). Compared with gating technique, it was found to be not significantly different (Levine *et al*, 1986) without the loss of data caused by gating. However it may not work if the QRS is fluctuating (Fox *et al*, 1988) and requires an ECG template for each muscle as the different vectors will change ECG shape at different muscle sites.

The gating or masking technique (Pang *et al*, 1995), is most frequently used in dealing with ECG contamination (Levine *et al* 1986). This method can be accomplished by deleting some part of EMG data where the ECG contamination is present. The gating technique is normally used in combination with the filtering technique in order to eliminate the whole complex of QRS and T waves (Schweitzer *et al*, 1979; Sharp *et al*, 1993).

However, loss of EMG data in the section removed may be a problem (see *Figure 1d*). Moreover, in the case of high heart beat, after gating there may be little uncontaminated EMG left for analysis (Bartolo *et al*, 1994; Levine *et al*, 1986). There has also been difficulty in detecting where the ECG contamination is in some EMG and dealing with multiple muscles.

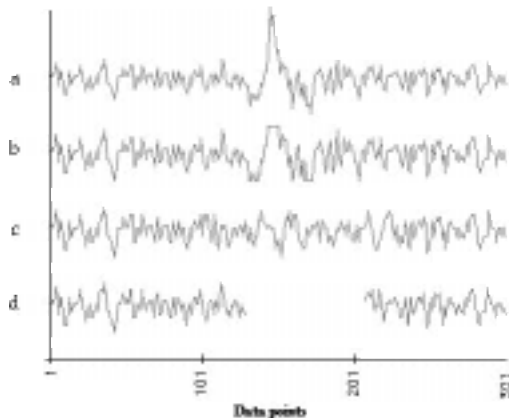


Figure 1. Demonstration of EMG data;
 a. with ECG contamination,
 b. use clipping technique
 c. use subtraction technique (simulated wave)
 d. use gating technique

In ergonomics research muscle activity, particularly of trapezius, has been commonly investigated in association with musculoskeletal disorders (Aaras, 1994). This muscle is close to the heart so the EMG recorded may be easily contaminated by the ECG signals. Subtraction is difficult since it is difficult to get a clear ECG signal at the trapezius EMG site. If ECG from a different site were used, its profile would not be correct. Filtering sufficient to remove ECG alters the EMG so much that frequency analysis may be invalidated. This study therefore aimed to investigate and develop a gating technique to eliminate ECG contamination from the EMG of several muscles relating to head and neck posture.

METHODS

The EMG data used in this study was part of the data in a study on the effects of high and low visual display unit placement by electromyography, posture, discomfort and preference (Mekhora and Straker, in press). The full study was conducted with 10 male and 10 female volunteer subjects performing a computing task. The data was collected from both sides of trapezius and cervical and thoracic erector spinae muscles for 5 seconds at 1, 10 and 20 minutes during work at the 2 different monitor height placements. The EMG data from all muscles of all subjects at the first minute in the high monitor placement condition was used in this study.

The process of ECG elimination involved several steps of data processing (see Figure 2). The first step was at data collection. The second step was to identify and characterise subject specific ECG and EMG aspects (the lowest peak of R wave, QRS interval and the time offset for the ECG signal to appear in the EMG of each muscle). The last step involved the computing process using individual ECG characteristics and time offsets to eliminate the contaminated EMG.

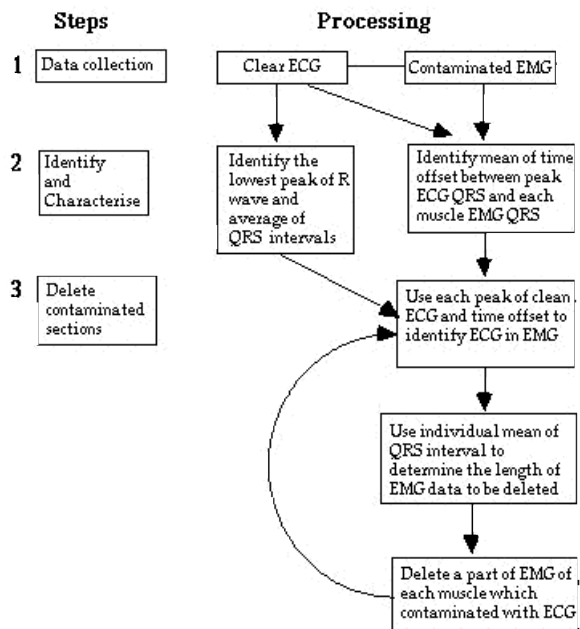


Figure 2. Step of ECG elimination process

DATA COLLECTION

The skin was prepared by rubbing with fine emery paper and alcohol. Bipolar Ag-AgCl surface electrodes (3M) were attached in the orientation of the appropriate muscle fibres. One electrode pair for each of the six muscles being investigated plus a ground electrode were placed in accordance with Schweitzer *et al*, (1979). An additional electrode pair was used for detecting ECG. The sites of electrode placement were as follows.

1. For upper trapezius, along the anterolateral aspect of the descending portion of the trapezius muscle at the midpoint between the occiput and the acromion process, with the inter-electrode distance being 30 mm.
2. For cervical erector spinae, the first electrode at the C2 level and the second 30 mm caudally to the first. Both electrodes were 15 -20 mm lateral to the midline of the spine (Lannersten and Harms-Ringdahl, 1990).
3. For thoracic erector spinae, the first electrode at C7-T1 and the second 30 mm caudally to the first. Both electrodes were 15 -20 mm lateral to the midline of the spine (Lannersten and Harms-Ringdahl, 1990).
4. For the heart (clear ECG signal), both electrodes were placed on the sternum above the xiphoid process, with the inter-electrode distance being 30 mm.
5. For the ground electrode, on the prominent bony area of the left acromion process. This electrode was connected to the amplifier via the same channel as for the left trapezius muscle.

Impedance of the skin between the pairs of electrodes was not greater than 10 K Ω . Each electrode was connected to a Bortec amplifier (Bortec Electronics Inc., Calgary, Alberta, Canada.) via an individual 100 gain preamplifier (distance from electrodes to preamplifier was 200 mm) and connecting cord. At the amplifier, the signal was further amplified by a factor of 200. The signal from the amplifier was digitised by a Mac II computer running SuperScope II software (SuperScope, GW Instruments Inc., Somerville, USA.). The data was not filtered and was sampled at 800 Hz. The data was also not demeaned but it was checked for DC offset visually. The resultant signal was stored on disk as binary data.

ECG periods, interval and offset characteristics

The ECG signal was detected as a noise in the EMG signal of some muscles. The most noticeable presence was the QRS component of ECG which seemed to effect the low magnitude of EMG data collected. The T wave did not appear to be of sufficient magnitude to interfere with the EMG signal. To eliminate ECG contamination, the clear ECG data of individual subjects was visually identified and characterised using the Mac II running SuperScope.

The lowest peak points of the R wave from the ECG were sought to be used to help the computer to detect the position of QRS complexes in each ECG signal. The length of the QRS complex for each subject was detected to be used to determine the length of the section in the EMG data to be removed. The average QRS interval identified in this study was 0.104 seconds, which is consistent with previously reported QRS intervals of 0.1 seconds (Hampton, 1986).

The onset of ECG contamination in EMG data was slightly after the ECG collected from the sternum. This delay varied for each muscle and each subject due to different transmission times through the subject's tissues. The delay offset for each muscle was determined by identifying a consistent peak in the EMG data soon after the peak of the ECG wave (see example in *Figure 3*). In some muscles of some subjects the EMG signal appeared without any clearly visible contamination from ECG signal. In these cases, the averages for ECG offset were used. The average time offsets for each muscle for all subjects are shown in *Table 1*.

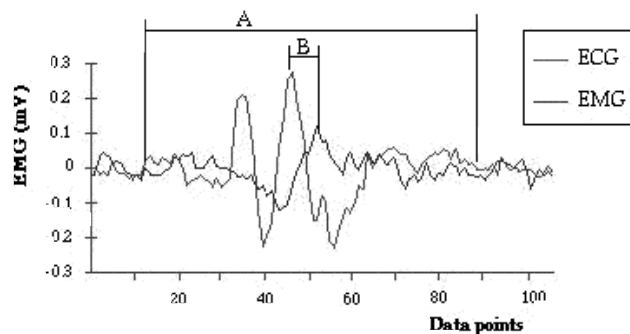


Figure 3. ECG wave interval and delay onset of left trapezius muscle for one subject; A=ECG wave interval, B=ECG delay onset in EMG, 1 point = 1.25ms.

Table 1. The mean QRS interval, peak of R wave and delayed offset of ECG signals of each muscle for 20 subjects.

QRS Interval (ms)	Peak of R wave (mVolts)	Ltrap (ms)	Rtrap (ms)	LCES (ms)	Rces (ms)	LTES (ms)	RTES (ms)
104.2	0.051	7.368	8.067	8.714	9.727	9.467	10

Note: Ltrap = Left trapezius, Rtrap = Right trapezius LCES = Left cervical erector spinae, RCES = Right cervical erector spinae, LTES = Left thoracic erector spinae, RTES = Right thoracic erector spinae

DELETING CONTAMINATED EMG

The raw ECG data and EMG data for all muscles were transferred to a spreadsheet for deletion of contaminated EMG. The spreadsheet was arranged with the first column containing the ECG data and subsequent columns containing the EMG for left and right trapezius, CES and TES. Each subject's lowest R peak, QRS interval and offset delay for each muscle were used to locate and remove contaminated sections of EMG. This process was completed by running a macro program on Microsoft Excel software. The program was run as follows:

1. Start search of ECG data in the first row of the first column to find a peak of R wave in ECG data by using the lowest peak of R wave visually identified.
2. Mark a peak of R wave in that ECG signal, then move to the cell in the same row and the adjacent column (for the contaminated EMG), move down within column to the appropriate cell by using the delay offset for that subject/muscle and then delete the number of data points given by the subject's average QRS interval. This was repeated for another 5 columns to delete another 5 periods of contaminated EMG data using each delay offset for each muscle for each subject.
3. Repeat steps 1 and 2 to locate the second, third and fourth ECG QRS wave and so on to cut the other QRS complexes from the EMG data for that subject. Repeat for each subject.

RESULT

The EMG data after ECG elimination appeared not to be influenced by the ECG signal. This was visually compared with the data before elimination. See an example for one muscle in a certain period of collecting time, before elimination in Figure 4a and after elimination in Figure 4b.

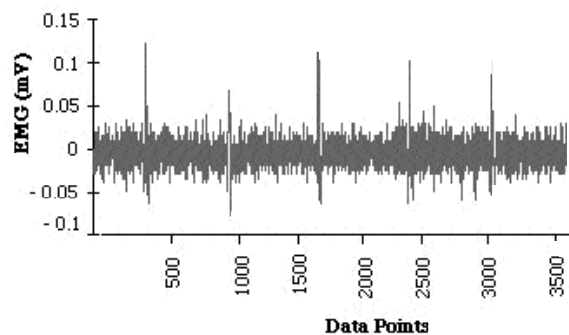


Figure 4a. ECG contamination of EMG in trapezius muscle, 1 point = 1.25ms

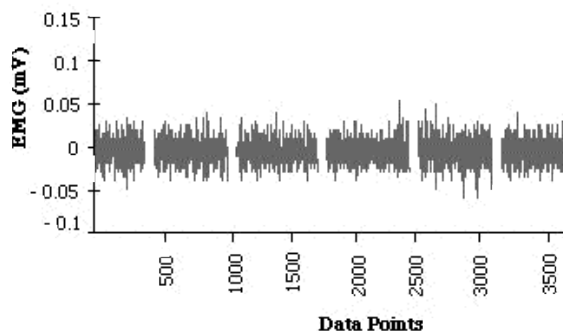


Figure 4b. EMG after elimination of ECG for trapezius muscle, 1 point = 1.25ms

The RMS of the data before and after elimination of ECG contamination was calculated and compared by using a 2x6 ANOVA with contamination elimination and muscles as factors. The results showed a significant difference between before and after elimination ($F_{1,19} = 29.335, p = .0001$) as shown in *Figure 5* averaged for all muscles.

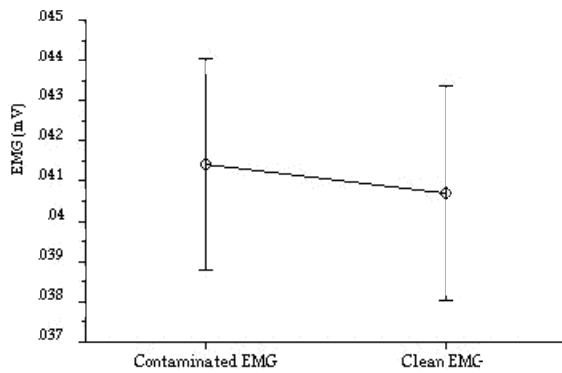


Figure 5. The mean and standard error for all EMG data before and after ECG elimination.

Means comparisons were performed to examine the contrast between the data before and after ECG elimination for each muscle. The results are shown in *Table 2* with means and standard deviations. The significant differences were in left trapezius and left and right thoracic erector spinae muscles.

Table 2. The descriptive and statistical results of EMG data before and after ECG elimination in each muscle.

Muscles	EMG Mean (SD) (mV)		F	P
	Before	After		
Ltrap	0.05153 (0.039)		0.04969	(0.04)
	91.32	*.0001		
Rtrap	0.04117 (0.038)		0.04082	(0.039)
	3.24	.0751		
LCES	0.03589 (0.015)		0.03564	(0.015)
	1.75	.1896		
RCES	0.03648 (0.012)		0.03642	(0.012)
	0.09	.7616		
LTES	0.04089 (0.028)		0.03983	(0.029)
	30.29	*.0001		

DISCUSSION

The EMG from left trapezius and left and right thoracic erector spinae muscles were significantly different after ECG elimination compared with before ECG elimination. The data for right trapezius showed a tendency for being different, and both sides of cervical erector spinae muscles showed no difference. This pattern of results can be explained as the ECG artifacts in the left trapezius and TES muscles were greater than the EMG signal. Whereas the EMG data from cervical erector spinae muscles appeared to possess less contamination, possibly because this muscle is further from the heart. The right trapezius is also further from the noise source than left trapezius which may explain the difference for left, but not right, trapezius muscles. These results suggest that the EMG data of trapezius and thoracic erector spinae should be processed to remove the ECG contamination before further analysis. To allow time based comparisons across muscles the CES EMG would also need to be processed in the same manner, though ECG contamination was not a problem in this study.

Using the gating technique developed in this study the elimination of ECG contamination in EMG signal was simple, relatively quick and retained sufficient high quality data for analysis. It also enabled the processing and comparison of several muscles simultaneously. Using a separate ECG channel allowed removal of contaminated EMG even when it was impossible to see the ECG in the EMG.

This technique can be used with high heart rates because the QRS interval used was 104 ms. This means that more than half the data would remain after processing with a heart rate of 180 bpm. The QRS interval used in this study as a template gating was in between 50 ms used by Choukroun et al, (1990) and 380 ms used by Schweitzer *et al*, (1979).

This gating technique can be applied where there is an irregular R wave amplitude or ECG frequency. However this gating technique is not suitable for

use with dynamic activity as important information during movement may be lost due to being deleted.

CONCLUSION

This study supports the necessity of ECG elimination in the EMG data of thoracic erector spinae and trapezius muscles. The gating technique developed in this study can be used to eliminate the ECG contamination, and is particularly suitable when several muscles are examined during static activity.

REFERENCES

- Aaras, A.** 1994 'The impact of ergonomic intervention on individual health and corporate prosperity in a telecommunications environment' *Ergonomics* **37**, 1679-1696
- Bartolo, A., Dzwonczyk, R. R., Roberts, C. and Goldman, E.** 1994 'Description and validation of a technique for the removal of ECG contamination from diaphragmatic EMG signal' *Medical & Biological Engineering & Computing* **34**, 76-81
- Bloch, R.** 1983 'Subtraction of electrocardiographic signal from respiratory electromyogram' *Journal of Applied Physiology* **55**, 619-623
- Choukroun, M. L., Kays, K. and Varene, P.** 1990 'EMG study of respiratory muscles in humans immersed at different water temperatures' *Journal of Applied Physiology* **68**, 611-616
- Fox, R. E., Kosch, C., Feldman, A. and Stark, A. R.** 1988 'Control of inspiratory duration in premature infants' *Journal of Applied Physiology* **64**, 2597-2604
- Hagemann, B., Luhede, G. and Luczak, H.** 1985 'Improved "active" electrodes for recording bioelectric signals in work physiology' *European Journal of Applied Physiology* **54**, 95-98
- Hampton, J. R.** 1986 'The ECG made easy' (3 ed.) Churchill Livingstone, London
- Lannersten, L. and Harms-Ringdahl, K.** 1990 'Neck and shoulder muscle activity during work with different cash register systems' *Ergonomics* **33**, 49-65
- Levine, S., Gillen, J., Weiser, P., Gillen, M. and Kwatny, E.** 1986 'Description and validation of an ECG removal procedure for EMG power spectrum analysis' *Journal of Applied Physiology* **60**, 1073-1081
- Marras, W. S.** 1987 'Preparation, recording and analysis of the EMG signal' *Proceedings of the Annual International Industrial Ergonomics and Safety Conference*, Miami, Florida, U.S.A., 701-707
- Mekhora, K., Straker, L.** 1999 'An evaluation of visual display unit placement by electromyography, posture, discomfort and preference' *International Journal of Industrial Ergonomics*, (In Press)
- Pang, P. C. W., Pepper, M. G. and Ducker, D. A.** 1995 'Monitoring respiratory activity in neonates using diaphragmatic electromyograph' *Medical and Biological Engineering and Computing* **33**, 385-390
- Redfern, M. S.** 1987 'Elimination of EKG contamination of torso electromyographic signals.' *Proceedings of the Annual International Industrial Ergonomics and Safety Conference*, Miami, Florida, U.S.A., 725-729
- Schweitzer, T. W., Fitzgerald, J. W. and Bowden, J. A.** 1979 'Spectral analysis of human inspiratory diaphragmatic electromyograms' *Journal of Applied Physiology* **46**, 152-156
- Sharp, J. T., Hammond, M. D., Aranda, A. U. and Rocha, R. D.** 1993 'Comparison of diaphragm EMG centroid frequencies: Esophageal versus chest surface leads' *American review of respiratory disease* **147**, 764-767
- Westgaard, R. H.** 1988 'Measurement and evaluation of postural load in occupational work situations' *European Journal of Applied Physiology* **57**, 291-304

Electronic Resources

NURSING HOMES

Some useful resources related to OH&S in nursing homes from OSHA (USA)

<http://www.osha-slc.gov:80/SLTC/nursinghome/index.html>

POSTURAL CONTROL

Abstracts of the proceedings of the satellite to the November, 1998 Neuroscience meeting, "Identifying Control Mechanisms for Postural Behaviors" are now available on the web at

<http://www.smpp.nwu.edu/~jim/proceedings/>

BIOMECHANICS THESES ABSTRACTS

The Biomechanics Thesis Abstracts page on the ISB website has been updated to include thesis abstracts from the years 1995-1998. The abstracts in this searchable database at

<http://isb.ri.ccf.org/literature/UMIsearch.html> have been downloaded from Dissertation Abstracts Online produced by University Microfilms International (UMI).

HUMAN FACTORS DESIGN GUIDE

<http://www.tc.faa.gov/hfbranch/hfdg/index.html>

Human Factors Design Guide for Acquisition of Commercial Off-the-Shelf Subsystems, Non-Developmental Items, and Developmental Systems by

Dan Wagner (ACT-530)

Joseph A. Birt and Michael D. Snyder (SRC)

James P. Duncanson (CTA)

This work was sponsored by the FAA Human Factors Program (AAR-100) and was accomplished under the direction of Dan Wagner, ACT-530. This work is part of the Airway Facilities Program under Brenda Boone, ALM-100, and Lawrence Cole, AAR-100. Technical consultation was provided by Kermit Grayson.

The Human Factors Design Guide is available through the National Technical Information Service (NTIS), Springfield, Virginia 22161. Document number PB96-191267.

Overview

The Human Factors Design Guide (HFDG) is a seminal work in the field of Human Factors. Recently published, it provides the most exhaustive compilation of human factors practices and principles integral to the procurement, design, development, and testing of FAA systems, facilities, and equipment. Jointly sponsored by the US Department of Transportation, the Federal Aviation Administration, and the Office of the Chief Scientific and Technical Advisor for Human Factors AAR100, the HFDG is now available in electronic format on CD-ROM and the Internet.

Representing a three-year effort, this edition incorporates expert comments that were collected from selected reviewers. It is primarily focused on FAA ground systems and equipment such as those that are managed and maintained by Airway Facilities, but has general applicability also. It covers a broad range of human factors topics that pertain to automation, maintenance, human interfaces, workplace design, documentation, system security, safety, the environment, and anthropometry.

Available now as an indispensable reference tool in academic research or engineering development, the goal of the Human Factors Design Guide is the betterment of the human factors design across all engineering disciplines.

Conference Calender

1999

March 11-13. Work, Stress and Health 99: Organization of Work in a Global Economy. Baltimore Md, USA.

contact: wbaker@apa.org;

<http://www.apa.org/ou/niosh/html>

April 7-9. UK Ergonomics Society Annual Conference University of Leicester.

email: ergsoc@ergonomics.org.uk;

<http://www.ergonomics.org.uk>

May 9-12, 3rd National Conference on Injury Prevention and Control, Brisbane, Secretariat: IPC 99 C/ Intermedia PO Box 1280 Milton Qld 4064 Tel: 07 3369 0477 Fax: 07 3369 1512 Email: ipc99@im.com.au Web: www.nisu.flinders.edu.au/aipn/3ncipc/ http://www.nisu.flinders.edu.au/aipn/3ncipc/

May 12-15, 9th European Congress on Work and Organizational Psychology, Espoo-Helsinki, FINLAND. Contact Sanna-Leena Savola, FIOH, Topeliuksenkatu 41 a A, FIN-00250, sasa@occuphealth.fi

May 19-21 4th Int. Computer-Aided Ergonomics and Safety Conference, Barcelona SPAIN. Contact Markku Leppanen, PO Box 541, FIN-33101 Tampere FINLAND; mleppane@cc.tut.fi; http://www.caes99.org

June 6-9 14th annual Int. Occupational Ergonomics and Safety conference, Orlando, FL, USA. Contact Prof. Gene Lee, Dept. of Ind. Engineering, Univ. of Central Florida, Orlando, FL 32816; GLEE@mail.ucf.edu

June 15-17, TQM and Human Factors, Linkoping, Sweden. email pjaio@udv.liu.se; fax: + 46 13 122299

June 16-19 European Conference on Transport Psychology, Angers, FRANCE. Contact Secretariat AEPSAT, BP808, Place Andre Leroy 49008 Angers Cedex 01 FRANCE; europsyt@uco.fr; www.inrets.fr

June 21-23, People in Control - International Conference on human interfaces in control rooms, cockpits and command centres, Bath, UK. Email: PIC99@iee.org.uk; http://www.iee.org.uk/Conf/PIC99

August 8-13. International Society of Biomechanics Congress. Calgary, Canada. Contact: Ph. +1 403 220 6229, Fax +1 403 284 4184, email: mastroh@acs.ucalgary.ca, http://www.kin.ucalgary.ca/isb99

September 15-17, European Symposium on Safety in the Modern Society Helsinki FINLAND. Contact Ms Kristiina Kulha, FIOH, Topeliuksenkatu 41 a A, FIN-00250, Helsinki FINLAND; Kristiina.Kulha@occuphealth.fi

October 11-13th, 35th Annual ESA Conference. Fremantle, WA. Contact Keynote Conference, PO Box 1126, West Leederville, WA 6901. Ph +61 8 9382 3799 Fx +61 8 9380 4006. Email: keynote@ca.com.au.

2000

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

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

2002

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

Information to Contributors

SUBMISSION DEADLINES

The deadline for each issue is the 15th of the previous month etc... **the deadline for the April issue is February 15.** All submissions must be by email. Submissions may be made for later issues by fax or mail, but if you have items of an urgent nature and no easy access to email, please mail a floppy disc with the information to Margot Lynch at the Federal Secretariat, The Ergonomics Society of Australia Inc., Canberra Business Centre, Bradfield St., Downer ACT; Ph. 02 6242 1951; Fx 02 6241 2554; email: esa@ozemail.com.au

CONTRIBUTIONS

Contributions to Ergonomics Australia are always welcomed and encouraged.

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.