# International Society of Biomechanics Newsletter

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# ISB news

## XIIIth INTERNATIONAL CONGRESS ON BIOMECHANICS - UPDATE

Preparations for the XIIIth Congress of ISB to be held in Perth, Western Australia in December, 1991, are well in hand. The *Second Announcement and Call for Papers* material will be distributed early in October. This material will be automatically mailed to all members of ISB, as well as to the members of all current affiliate societies of ISB (see list on front cover). There are several Satellite Symposia planned as lead-ups to the ISB Congress, the details of which are contained on page 14 of this Newsletter. The Executive Council of ISB has also undertaken to promote an Educational Programme comprising tutorial workshops on various biomechanical topics as part of the Perth schedule of events. Details of these will be announced following the Executive Council meeting in San Diego later this month, and will be published in the next Newsletter.

In all, you are promised an exciting programme 'down under' in 1991, but please remember to make your travel arrangements early as December is peak season time. Also, we encourage you to allow sufficient flexibility in your schedule to be able to indulge in some of the pre- and post-Congress activities. To assist you here we are offering very flexible accommodation arrangements at the University's Residential Colleges, and have arranged for **Qantas Airlines** and **ORBA Travel** to provide you with very attractive rates and services.

Now, if I can put the Editor's hat on for a moment, there is just one thing that I want to say . . .

Start mailing that Newsletter material to me folks !

Material submitted for publication should be good quality type with black-and-white photos or artwork, but the layout is not overly important as the material will be scanned to computer disk for desktop publishing and laser printing of camera-ready copy. Alternatively you may wish to send in material by electronic mail, Fax, or on a floppy disk (ASCII file). And here's how you reach me:

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## REPORT OF THE ISB WORKING GROUP ON COMPUTER SIMULATION (WGCS)

Almost a year has passed since the first official meeting of our Working Group took place in Los Angeles during the XIIth ISB Congress. In making a brief report of our activity I would like to summarize the following events and achievements:

1) International Symposium on Computer Simulation in Biomechanics

The 2nd ISCSB was a success mainly due to the high quality of presented papers and to the significant efforts and great hospitality of local organizers (Symposium chairman: Prof. Mont Hubbard). Twenty-five papers supported in most cases by extended software demonstrations were presented by about 60 participants from 9 countries. The excellent keynote lecture on a new symbolic manipulation approach to motion equations derivation given by Dr Levinson form Lockheed Palo Alto Research Center was a highlight of the symposium.

Once again the symposium format of extended computer workshops with a lot of participant interaction, the informal atmosphere, the almost unlimited access to many types of computers gave a unique feeling to this very specific and valuable scientific event. The variety of software demonstrated on PC's, workstations and mainframe computers demonstrated the growing maturity of computer simulation applications in biomechanics.

A new team of organisers is under way with the preparation of the next, 3rd Symposium, of our Working Group which will take place in Perth as a satellite meeting to the XIIIth ISB Congress in 1991 (symposium chairman: Dr R Marshall). The general outline of the symposium will remain the same: the computer workshop formula, informal atmosphere, and direct access to a variety of computers. The WGCS has donated for the first time an award (US$ 250) for the best presentation supported by software demonstration.

2) Working Group statistics

Our Working Group has 44 members from 15 countries. We have the following number of members from each country: 11 - USA; 5 - Italy, Japan; 4 - Germany, the Netherlands and Poland; 2 - Great Britain and Canada; 1 - Australia, Austria, Belgium, Romania, Sweden, Switzerland and USSR.

The majority of our members represent universities (29); 13 of them come from research institutions and two from industry.

The spectrum of our interests can be classified as follows: modelling of various aspects of musculo-skeletal system (35 members); man-machine systems (2 members); other applications ( e.g. computer simulation in education ) (2 members).

From the view point of simulation approaches three of our members focus their attention on inverse dynamics analysis, 10 deal with direct simulation approach while 7 are interested in optimization techniques. Finally, 2 of our members specialize in finite elements analysis.

3) WGCS Data Base Management System

All the details of our members activities, including computers used, the use of commercial packages and own simulation software developed, are stored in our DBMS. The WGCS DBMS (DBASE III structure, IBM-PC) is available on request in the form of a printout or DBASE file. We hope that all our members have received the first update of WGCS DBMS recently.

We also hope that the information included in the WGCS DBMS will help in the exchange of experience in using various software packages amongst our members and will also help in creating better collaboration in solving particular problems of mutual interest.

4) E-mail network

We plan as an ultimate goal to publish our Newsletter and to exchange all information via an E-mail network and a WGCS BBS (Bulletin Board Service). Unfortunately, only 14 of our members have access to E-mail right now. However, we recommend using the bulletin BIOMCH-L@HEARN.BITNET (official name: An Electronic Mail Discussion List For Biomechanics and Human/Animal Movement Science) managed by Dr Herman Woltring (his personal E-mail address: wwtmhjw@heitue5.bitnet).

Users on EARN/BITNET/NETNORTH may subscribe to the list by electronic mail or by sending one of the following interactive commands :

VAX with VMS:
SEND LISTSERV@HEARN SUB BIOMCH-L <name>
VM/SP:
TELL LISTSERV AT HEARN SUB BIOMCH-L <name>
MVS with TSO/E:
TRANSMIT HEARN.LISTSERV NOPROLOG and enter
SUB BIOMCH-L <name>

Activities of BIOMCH-L@HEARN bulletin include discussions, congress reports, calls for help, calls for papers and anything else relevant to the target domain of biomechanics. All editions of our Newsletter including this one will also be published simultaneously via BIOMCH-L@HEARN until our own BBS can be established.

5) Software review

As has been written into the WGCS statutes, the extensive exchange of information (methods, software, hardware and applications) is one of the main goals of our Working Group. The software particularly important for computer simulation can be distinguished as follows:

a) symbolic manipulation packages (SMP) - software mainly dedicated to automatic derivation of system differential equations. The use of SMP is particularly important if simulation of complex dynamic systems is considered,

b) integrated simulation packages (ISP) - packages containing the integrated simulation environment for efficient simulation process control (input and output data handling, adequate integration routines, graphic support, etc.)

c) optimization packages (OP) - software packages for solving optimization problems (primary or dynamic optimization).

d) graphic packages (GP) - considering the specific direct users of computer simulation results in biomechanics (physicians, coaches, patients, athletes) it is particularly important to present the simulation results in clear and easy to understand form.

We plan to present extensive reviews and technical comments about the software packages which seem to be the most useful for our purposes. Included in this Newsletter are the first such reviews submitted by Prof. Hubbard (brief review of symbolic manipulation packages) and by Dr van den Bogert (musculoskeletal modelling with the use of the DADS package).

We encourage all ISB and WGCS members to submit short reviews and articles about their experience with commercial or self-developed simulation software. As is also stated in the WGCS goals, we plan to establish a system of exchange of software developed by WGCS members in order to prevent duplicating efforts. Prof. Herbert Hatze has agreed to prepare a set of rules for such exchange and these will be published in the next WGCS Newsletter.

6) Publications policy

Following ISB policy to begin an ISB Monograph series we plan publish the full proceedings of our ISCSB in the form of an ISB Monograph. More details will be given after the ISB Council meeting in San Diego in August. We also encourage our members to propose topics and to prepare non-periodic monographs related to computer simulation in biomechanics. The WGCS offers support and help in contacts with publishers and in other matters in order to extend this form of activity of our Working Group and ISB.

7) Other affairs

Our Working Group activity has been appreciated by ISB Executive Council during its last meetings. We have been supported in the form of a US $ 550 grant for improved FAX facilities for our Secretariat, which in fact is extensively used for our communication.

WGCS has been asked to take part in the organization and to sponsor the 1st International Conference on Computers in Biomedicine , 24-27 September 1991, Southampton, UK, organized by Wessex Institute of Technology. We consider this conference as an interesting event as a significant part is dedicated to simulation and computational methods in biomedicine. More details can be obtained by an enquiry to:

Biomed Conference Secretariat,
Computational Mechanics Institute,
Wessex Institute of Technology,
Ashurt Lodge, Ashurst, Southampton,
SO4 2 AA, UK

Fax: 44 703 292853

Andrzej J.Komor, Ph.D
WGCS Chairman

# Special articles

## REVIEW OF SYMBOLIC MANIPULATION SOFTWARE

by

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As the complexity of biomechanical models has increased so has the difficulty of the derivation of the equations which describe them. Now however, the same computers which have made the mode complex models tractable have also made it possible to derive the equations automatically. The granddaddy of these so called "symbolic manipulation" programs is MACSYMA (available from Symbolics, Inc., Cambridge, MA, 02139,USA) which is well described in the book by R.N.Rand ("Computer Algebra in Applied Mathematics: An Introduction to MACSYMA", Pitman Publishing , Inc., Boston, 1984). These programs allow symbols as well as numbers to be manipulated. They are thus well suited to the tedious calculations such as Lagrange's method entails, which can be extremely error prone if carried out by hand, to say nothing of the human effort and time which they require.

A more recent version of this kind of program is Mathematica (Wolfram Research Group, Champaign, IL 61821, USA) which runs on nearly every conceivable high-powered computer now, including personal (IBM MS-DOS 386 and Macintosh MacII) as well as mainframes. Its advantages are that graphics and numerical computation and a wide variety of special functions are included. A newer competitor to Mathematica is the program Theorist (Prescience, San Francisco, CA 94114, USA).

According to a recent review in MacUSER this program is superior to Mathematica in ease of use, practical functionality and, in some cases, accuracy. Symbolic programs have also appeared which shape their symbolic manipulation capabilities to the job of derivation of differential equations for mechanical systems. Two of these are AUTOLEV (Online Dynamics, Sunnyvale, CA 94807, USA) and SD/FAST (MGA iNC., Concord, MA 01742, USA). Both are based on Kane's approach to dynamics. In these programs, the user interactively and symbolically specifies the kinematic and inertia essentials of the system so that the program can perform the long and otherwise tiresome differentiations necessary for the calculation of the equations of motion. An exceptionally useful aspect of the programs is that, in addition to deriving the correct equations, they are also able to write transportable FORTRAN code. For example, the final result of the AUTOLEV program is another entire, compatible FORTRAN program which can be easily used in simulation.

WGCS Chairman's remark: A comprehensive review of general purpose symbolic manipulation packages was published in PC Magazine ,May 29, 1990, pp. 323-336 ("The New World of Higher Math" by B.Simon).

## MUSCULO-SKELETAL MODELLING: THE DADS EXPERIENCE

by

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### Introduction

In forward dynamics simulation studies of the musculoskeletal system, the formulation and numerical solution of the equations of motion has always been a major stumbling block. Many methods have been proposed in the biomechanical literature, but not one has been adopted for general use. This is very different from the situation in mechanical engineering, where there is a tendency to develop general-purpose software packages. This means that modellers need not to worry about solution methods, but can concentrate on the model instead. A good example is finite element modelling software. The essential non-linearity and other mathematical difficulties have delayed the appearance of good rigid-body modelling packages. The DADS-package, available since the spring 1986, is one of the latest developments in this field.

### Theoretical Background

Existing solution methods used in biomechanics can roughly classified as follows (Nikravesh, 1984):

First, there are methods that formulate the equations of motion as Nf second order ordinary differential equations (ODE's) in the independent kinematic variables (e.g. Marshall et al.; Pandy and Berme, 1989), where Nf is the number of degrees of freedom of the system. A major disadvantage is, that the independent variables can only be properly identified in tree-structured systems (also called open-chain models). When closed loops exist in a model, as during double stance, loops be cut by replacing a "hard connection" (a joint) by a stiff spring-damper combination. Such a fix is often methodologically inelegant, or numerically disadvantageous because high natural frequencies are created (Onyshko and Winter, 1980). Another disadvantage is, that a large effort is required to transform the Newton-Euler equations into a set of ODE's. To certain, symbolic manipulation programs such as AUTOLEV can help here.

On the positive side, once you have ODE, it can be solved very efficiently and reliably by standard solution algorithms. Secondly, it is possible to use the Newton-Euler equations in decoupled form, i.e. for each segment separately. Additional algebraic "constraint equations" must then be formulated to ensure that the movements are restricted to those allowed by the joints. The derivation of this system of differential/algebraic equations (DAE) can be done very systematically and is therefore easily automated. The process involves no symbolic manipulation, and is hardly more than collecting the coefficients (Haug, 1989). Unfortunately DAE's are difficult to solve. This exemplified by the fact that no general DAE solver exists in the standard numerical software libraries. It is in this area that DADS is new; its DAE solver-though restricted to mechanical systems-never fails, and the result is absolutely reliable. The negative side is, that solution of the DAE by such a general-purpose program is very inefficient, compared to solving the equivalent ODE.

A third, hybrid form has been used by Hatze (1981). An ODE system for the whole tree-structured systems was derived, and ground contact was represented by additional constraint equations. The resulting DAE system (with considerably more D than A) was solved by an algorithm from Baumgarte (1972). Basically, this method involved differentiating the constraint equations twice, so that the system then consists of differential equations only and the standard ODE solver can be applied. The problem is, that only acceleration constraints are used and build-up of small integration errors would cause more and more violation of original constraints. This rather inelegant fixed by adding terms proportional to the constraint violation (e.g. the penetration of the foot into the ground) and its first derivative, to the driving forces of the system. In effect, this resembles a damped spring connection which has a finite time constant. This time constant depends on the constants of proportionality in the added term, which must be chosen carefully for simulations of fast phenomena.

### DADS

DADS was originally developed at the University of Iowa by the research group led by Dr Edward Haug. Its DAE solution method handles all closed loop systems correctly because its choice of independent kinematic variables is not constant, but may change during the simulation (Mani et al., 1985). Since the spring of 1986, DADS is commercially available. Important features of the package are:

* Model-oriented input: Input is essentially a list of parts and a list of connections, with their respective parameter values. A large number of standard kinematic connections can be used, from ball-and socket joints to cam-followers.

* Extendable: In the standard package, forces can be generated by spring-damper-actuator elements, or by more specialized components such as rubber tires with complex friction characteristics. Other force-generating elements (such as muscles) are easily implemented by writing a short piece of FORTRAN code, which can be linked to the main DADS program.

* Flexible bodies: Force-deformation characteristics of the components, obtained by the finite-element analysis, may be entered. This feature allows the prediction of vibrations, which is important in robotics and automobile design.

* Pre- and postprocessors: The preprocessor is a great help for entering and editing models. Advanced users may find the preprocessor to slow restricted for complex models. The file formats are well documented however, so it is easy to develop your own preprocessor for a specific type model. Results can be viewed graphically by two postprocessors, one for graphs, one for graphs and one animations. As with the preprocessor, more specialized programs can be developed for advanced applications.

* DADS is available for every (well, nearly every) computer, including VAX, Sun, Apollo, MSDOS and generic UNIX. For real applications, use a machine with a high FLOPS (floating point operations per second) rating (see below). At the time of writing (July 1990), the use of DADS is classified into 40% transportation, 35% aerospace, and 25% mechanical machinery. Pricing for industry is around \$ 50k, but significant reductions (depending on specific use) are possible for universities. For biomechanical research groups, collaboration with a mechanical engineering department where DADS is already used may be a viable option.

### A User's View

I have used DADS for my PhD work, simulating movements of the horse. The main reason for using DADS was, that it allowed me to concentrate on the musculoskeletal system model, instead of the mathematical/numerical details of solution methods. Due to the strict error control, the results of DADS are absolutely reliable, at least in the 2D, rigid-body mode that I have used.Apart from the high price , some other disadvantages and limitations should be mentioned:

* It is not (yet) possible to add or remove constrains during the simulation. This would be needed to create a "hard" connection between foot and ground that exists only during the stance phase (as done by Hatze and Venter, 1981). Presently such a connection has to be simulated by a stiff visco-elastic model for the contact force. An algorithm for addition and detection of constraints in DADS has been described by Wu et al. (1984), but is not implemented in the commercial version.

* Stiff visco-elastic contact models would not be a problem if the ODE solver of DADS was suitable for "stiff" equations, i.e. systems with two widely different time scales. Ground contact has a time scale in the order of one millisecond, while gross locomotion is about 1000 times slower. DADS uses the non-stiff DE/STEP algorithm (Shampine and Gordon, 1975), so integration intervals always integration intervals always stay below the shortest time scale. DADS does a lot of work in each integration step (solve a system of non-linear equations, sometimes a full singular value decomposition), resulting in a very s-l-o-w execution. The horse model walked for one second in 10 hours CPU time on an Apollo DN 4000 ($\approx$ 0.5 MFLOPS) workstation. The good news: CADSI is working on a stiff solver, and it should be ready in September 1990. Also, computers are getting faster. Apollo now sells a 22 MFLOPS machine for 1/10th of original price of the DN4000.

* Differential equations cannot be used in ‘userforce’-routines, the FORTRAN code written to implement your own force generators. A muscle model with a force-velocity relationship in the contractile element, connected to a series elastic element will have a state equation that is a first-order differential equation. DADS already has the option to use a built-in integrator module, but the interface with userforce routines is (as yet) non-existent. The potential is there, but the internal organization of software does not allow to use it. Will probably be fixed if enough users complain.

## Conclusion

DADS is expensive and slow, but very general-purpose and very reliable. Because biomechanical research is not important from a commercial point of view, the developers may not be inclined to implement certain features required for this type of application. On the other hand, industrial users will in future require the same features, once they get around to simulating machinery as complex as the human body.

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# THE CAMARC PROJECT - AN ATTEMPT TO BRIDGE THE GAP


by

Tommaso Leo and Herman J. Woltring



Workshop: *Gait Analysis - A Clinical Tool ?*

"De Hartenark", Bilthoven (The Netherlands), 27-28 November, 1989


Movement Analysis (M.A.) techniques have received limited clinical acceptance, at least in Europe. This suggests that there are significant factors hindering the transfer of laboratory-based research findings into clinical practice. There are four kinds of questions that seem particularly relevant in this respect:

1. Misunderstandings about the *application domain* of M.A.

2. Lack of (and difficulties in building) an *accredited Knowledge Base* from quantitative M.A. findings.

3. Perplexities about the *reliability* of M.A. methods and techniques in managing relevant and intrinsic measurement inaccuracies.

4. Claims against the *validity* of current M.A. techniques for assessing impairments and concomitant inabilities.

1. M.A. is a tool for quantitative, functional movement assessment, usually in already diagnosed motor diseases. To date, it has had limited diagnostic capacity, albeit that M.A. facilities distinguishing primary, pathological phenomena from secondary, compensatory ('coping') effects. More results seem available on understanding what level of motor ability can be attained by the motor-impaired patient, and on how such a level can be improved. In clinical practice, these are as useful and desirable as diagnostic capabilities.
In this context, M.A. helps in clinical decision making and in monitoring the effects of conservative and surgical treatment (pre- and post-operative assessment). Whether such results are deemed satisfactory depends largely on the availability of a consensus on what motor ability really is.

2. Many significant results, both in theories of motor ability and in motor pathology have been obtained during the past century, and especially during the last two decades. However, this wealth of information cannot be put into practical use, largely because of lacking standardization in the clinical and experimental protocols through which this information has been obtained (cf. Shiavi, 1988). By consequence, results obtained in individual laboratories are poorly or not at all communicable to others. Attempts to standardize and to embed existing, fragmented information into a suitable Knowledge Base is thought to provide one way to solve this problem.

Another factor should be mentioned in this context: functional motor assessment is a multifactorial task, with elements on, e.g., the time-distance, kinematic, kinetic, electromyographic, and energetic/metabolic levels. Even in the context of mature protocols as practised in truly clinical M.A. laboratories (cf. Sutherland *et al.*, 1988; Gage, 1989), evaluation of these data is a time-consuming activity involving a variety of disciplines. Embedding such information into a suitable Knowledge Base that assists the clinician in navigating through the large sea of numerical results should provide a valuable tool for bridging the gap between research laboratories and clinical practice.

3. The main objections with respect to the reliability of M.A. studies, also addressed during the previous communications at this workshop, concern:

* Skin motion artifacts (cf. Van Weeren, 1989) in photogrammetric of electrogoniometric analysis of movement via skin-mounted devices,

* the assumption of fixed joint centres or axes in the knee and ankle,

* The indeterminacy problems associated with co-contracting, single and / or multiple joint muscles (however, see Van Ingen Schenau, 1989).

In these aspects, the differences between biomechanicians and electrophysiologists constitute another challenge for arriving at a consensus in the creation of a concerted Knowledge Base.

It should be emphasised that relevant findings are continuously appearing in the literature, and that two conditions should be met for their integration into clinical practice: clinicians should become more familiar with M.A. technology and with the basic principles of biomechanics (Gage, 1989), and they should be familiarized in a not-too-technical-way with the significance and practical relevance of suitable modelling and digital signal processing (DSP) techniques.

Furthermore, Artificial Intelligence and graphical display techniques in a friendly user interface" environment should help to overcome the reluctance of clinical practitioners to rely on M.A. methods.

4. The most fundamental criticism against M.A. techniques is directed at their validity (cf. Rozendal, 1989). The current lack of a satisfactory theory of motor ability is matched, in these objections, with the observation that M.A. techniques seem capable of assessing impairment but not disability. The subject or patient is asked to accomplish simple, standardized motor tasks (such as straight-line, level walking) which are quite remote from more complex, everyday tasks like negotiating stairs, sitting and standing up, and changing directions. Only through these latter activities can their level of disability can be properly assessed.

A partial answer to this basic challenge can be found in the development of portable instrumentation for long-term monitoring of motor behaviour during activities of daily life (ADL), and of more flexible instrumentation that allows motor performance assessment in a more realistic setting, even in a laboratory context. Thus, the man-machine interface should be designed not only for the clinical user, but also for their patient.

The above considerations have induced a consortium of British, French, Dutch and Italian partners to propose to the European Communities the development of an exploratory investigation under the Advanced Informatics in Medicine (AIM) action. CAMARC, for *Computer Aided Movement Analysis in a Rehabilitation Context* has been approved and is currently running. Partners in the project have an academic, public-health and/or industrial orientation. They are currently concerned with a number of work packages including:

1. Assessment of existing Biomedical M.A. Knowledge,

2. Standardization of Test Protocols,

3. Assessment and implementation of relevant DSP algorithms,

4. Design criteria for new devices.

While the authors have a general view of activities under CAMARC, their specific domains of competence are largely concerned with biomechanical modelling and DSP and with the development of software tools to help the user in finding his way between algorithms and results. Accordingly, some specific hints will be given on the two above topics, together with a more detailed discussion of the short- and long-term objective of CAMARC.

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# Laboratory feature

**Sensomotorik-Laboratory**
**Faculty 11, Ergonomics and Pedagogics**
**University of Bremen**

The University

The University of Bremen was founded in 1971 and has - like other German Universities built in the 1970's - found new conceptions of conducting research and instructions compared to the traditional academic institutions of Germany. Bremen is a state of 570,000 inhabitants in the north of Germany and consists of two parts, the town of Bremen and the town of Bremerhaven.

Bremen's University fits almost everyone's idea of how a campus university should look - modern structures, residential buildings, trees, lawns, in and outdoor athletic facilities. Just 15 minutes bike ride away from the city centre, jet far enough to allow quiet and thoughtful studies in humanities, social sciences, natural and mathematical sciences and engineering. The University of Bremen is the scientific centre of the region with 900 Faculty members, 12000 Students, and about 1000 staff members in administration and technical divisions.

The "Sensomotorik" Laboratory

*** General Information**

"Sensomotorik" is the science of sensorimotor systems which is, when applied to human beings , the science of human perceptual motor systems in a more general approach. That means, the act of perception, the subsequent information processing, the decision making procedure and the resultant motor actions (e.g. verbal or manual response) is studied as a process within a complex, closed loop, error correcting, time variant and self-learning man-machine system.

The "Sensomotorik" Laboratory is an interdisciplinary organization devoted to research in sensorimotor systems and partly devoted to education in Sport Science. It was founded by Professor Dieter Ungerer in 1978. During its first years of activities, the late 1970's and early 1980's, the laboratory's research was focused on the investigation of the *Cause and Prevention of Accidents in Private Homes and during Leisure Activities* in general, and *Cause and Prevention of Children Accidents* specifically. The Laboratory research provided the basic information needed for educational campaigns in different media (TV, Radio, etc.) with the intention of reducing the number of accidents in the area under investigation.

In 1981 a large research project *Sport at Vocational Schools* was supported through federal fundings. As an outcome the Laboratory provided instructional algorithms and learning programs for risk reduced teaching and learning of hazardous skills (e.g.white water kayaking)

In 1985 a four years project *Performance Optimisation of Rowing Teams through Mathematical and Physical Modelling* had been started with Bremen's Rowing Clubs. The research project was funded by the Federal Institute of Sport Science, Cologne; the outcome will be presented in details later in this report.

Since early 1989 the laboratories main research capacity is focused on *Human Information Processing as Risk Factor in Man-Machine Systems - The Sensorimotor Information Flow in Road Aviation.*

Though the Sensomotorik Laboratory is first of all a research organization with interdisciplinary research subjects ,its director Professor Dieter Ungerer offers 8 hours per week and term of instruction in Theory of Sensorimotor systems and Movement Theory to about 100 Students in Sports Science each year and supervises final theses in that field.

*** Its Members**

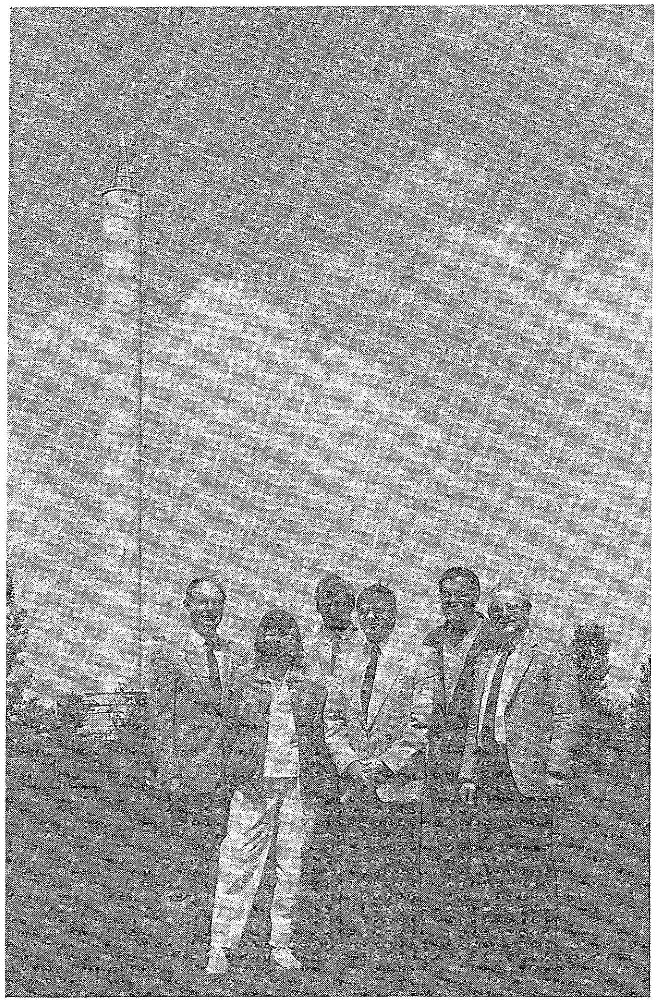

Figure 1. (From right to left) Director Professor Dieter Ungerer, Dr. Ulf Morgenroth, Dr W. Lutz Bauer, Hartmut Hesel, Jutta Weymann, Hans E. Holm. (Background: Drop Tower of the Centre of Applied Space Technologie and Microgravity).

*** Research Interests/Activities**

Professor Ungerer: Human's information processing in risky situations under stress; safety strategies for perception, avoidance and surmounting of precarious or hazardous situations; design and validation of educational concepts for traffic safety training; advanced training of driving instructors.
Dr. Morgenroth: Pilot, sea captain, mathematics, cockpit resource management, cockpit communication.

Dr. Bauer: Electronics and automatic control, biomechanics, mathematical and physical modelling, simulation, performance optimization in team rowing.
H. Hesel: Human Biology, human information processing capability in stress situations, risk and action errors in firefighting J. Weymann: Secretary.
H.E. Holm: German linguistics, pedagogics, coordination of scientific activities, transfer of the scientific findings for application, statistics, learning programs, teaching algorithms.

*** Current Projects**

## THE SENSORIMOTOR INFORMATION FLOW IN ROAD TRAFFIC AND AVIATION.

Often accidents with man-machine systems found in traffic and in aviation can result from misunderstanding and misinterpreting audio-visual information, verbal communication and displays. This happens due to the limited perceptual, information processing and motor performance of the human being, when confronted with high density information, complex coding and displays with plenty characters and signs.

The project is an attempt to determine:
- Causes of accidents due to misunderstanding and misinterpreting of audio-visual information.
- Causes of accidents due to cardio-vascular stress and information overload.
- Limiting cerebral factors of the human information processing and decision making performance.
- Strategies, algorithms and programs for learning safety procedures and risk reducing behaviour in road traffic and aviation.
- Criteria for the design of human sensory compatible risk reducing interfaces.
- Methods for improving human's information and decision making performance in risk-scenarios by including prospective information and self-guidance strategies.

The aim of the project is to decrease the number of accidents by adapting interfaces to the human limited sensorimotor performance on one side and by improving his cerebral performance through specifically designed learning algorithms and safety procedures on the other side.

Principal Investigators are: Professor Ungerer, Dr. Morgenroth, Ph.D. candidate H. Hesel, Hans-E. Holm.

This research is supported by: ADAC, München und Gau Weser-Ems; Deutscher Verkehrssicherheitsrat, Bonn; Fliegerschule der Deutschen Lufthansa, Bremen; MBB/ERNO, Bremen; systemhaus König und Partner, Oerlinghausen; K.-A. Blendermann, Bremen; Verlag für Psychologie, Apparatezentrum, Dr. Hogrefe, Göttingen.

## PHYSICAL MODEL OF AN EIGHT OAR RACING SHELL - DEVELOPMENT OF A VARIABLE EIGHT SEAT ROWING ERGOMETER.

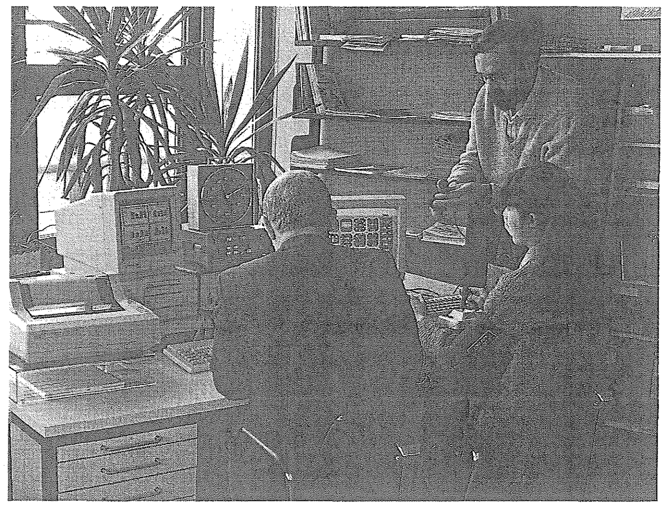

Figure 2: A subject's perceptual, information processing and decision making performance is being studied.

A device was built , which simulates relevant factors of the longitudinal dynamics of a team boat of up to eight persons, which can be used for team boat training during off season, for monitoring team performance and for showing each crew member's con.ribution to the total workout (Figure 3).

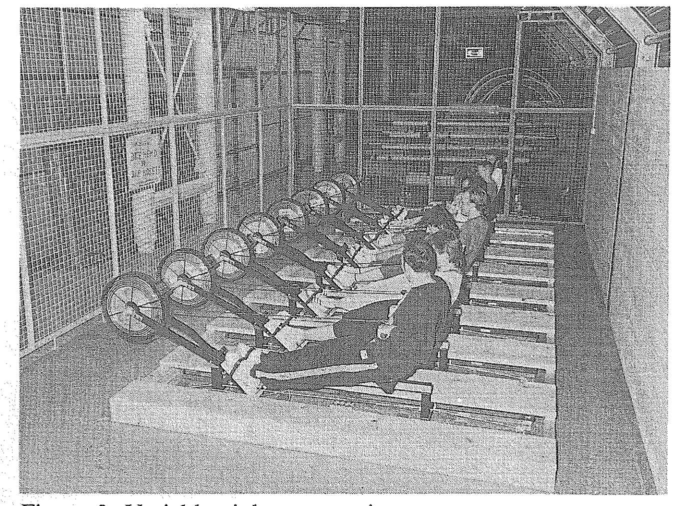

Figure 3: Variable eight seat rowing ergometer.

The eight seat rowing ergometer of Figure 3 is actually a real size physical model of a team boat which had been developed with the methods of mathematical and physical modelling. The individual steps were: Basic theoretical considerations with respect to the dynamics of a racing shell, setup of the mathematical equations of its longitudinal dynamics, transformation of the system equations into the equation of an equivalent rotating system, selection of an appropriate available rowing ergometer, setup of the mathematical equations of the team boot simulator, design, computing and manufacture of the mechanical parts for coupling of two ergometers, validation, test of reliability and acceptance through high performance rowers, manufacture of a variable eight seat rowing ergometer cascade.

The basic module of the team rowing device consists of a Concept II rowing ergometer, which is a one seat ergometer working with a wind resistance flywheel and an electronic performance monitor. The ergometer was equipped with wheels and placed on rails 2.50 meters long to prevent it from roaming about when in use. In addition was it attached to the rails with a nonlinear spring-damper-tem, which forced the system to swing back and force symmetrically to the center of the rails when in use.

Its chain driven free-wheel axle was newly constructed to allow moment addition during the drive when flywheels of two or more Concept II ergos were mounted in cascade by removable universal joints (Figure 4).

With wheels the Concept II ergo feels more like a boat because it similarly accelerates backward and forward. This is mostly felt during recovery and it is a must when connecting two or more ergos together to form a team rowing device on which each rower is to feel the roll feedback of his team members. The subjective feeling is improved, when mounting the flywheels to a common axle, because this makes the total driving moment the sum of the individual moment, which is similar to the addition of the individuals blade force to the total propulsion force of a team boat.

The team boat simulator is variable. It can be used as 8 single ergos on wheels or as 8 ergos fixed to the ground or in combination of fixed and wheeled devices. By mounting ergos together with a few manipulations, it is possible to have 4 TWOS, 2 FOURS, 1 EIGHT or other arbitrary combination of seats. The team boat model can be mounted to have just roll feedback (flywheels not connected) or to simulate roll and propulsion feedback (ergos and flywheel connected)

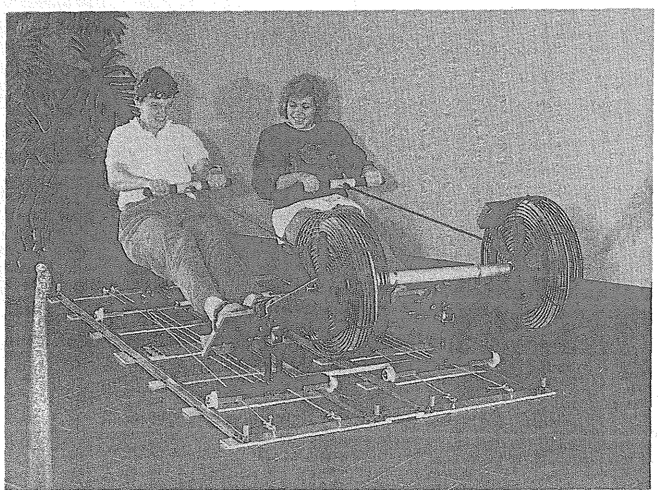

Figure 4: View of the coupled flywheels.

The idea of putting rowing ergometers on wheels is not new. However in earlier attempts they were not put on rails. Consequently the machines drifted several feet around depending on the surface conditions of the floor. New is also the tuning with a nonlinear spring damper system which makes it a highpass filter to the cyclic rowing motion. New is also the coupling of the flywheels which introduces the dynamics of blade force addition to the total propulsion into the physical model.

During steady state rowing motion, the system behaves like a second order highpass with a resonance frequency of about 10 strokes per minutes. The nonlinear damping mechanism prevent the ergometer from touching the ends of the railtrack. It comes into effect during the first few strokes (transient phase) or when disturbing the cycling motion.

FOURS and TWOS have been successfully tested from high performance rowers of Bremen's rowing clubs during two periods of off season training in winter 1988/89 and 1989/90 and have proven to be an useful enrichment to the rowing training. The EIGHT was inaugurated in April this year.

Principal investigators: Dr.-Ing. W.L. Bauer, B. Bandura (Coach) The research was supported by: Bundesinstitut für Sportwissenschaft, Köln.

W.L. Bauer

Sensomotorik-Laboratory
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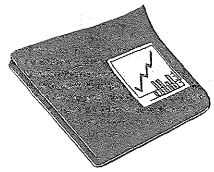


# Thesis abstract corner

## THE INTERACTION BETWEEN THE SKATE BLADE AND THE ICE AND SIMULATION OF SLIDING IN FIGURE SKATING

by

Minenkov A. O.

A dissertation submitted to the Kalinin Polytechnical Institute, USSR

Supervisor Prof S. S. Grigoryan

The aim of the study:

1. To design a mathematical model of the athlete's sliding in skating.
2. To investigate the skate/ice interaction and its contribution to resistance in sliding.
3. To work out an interactive graphic software to solve the problem of optimisation of sliding in skating.

The first part of the work is devoted to the experimental study and theoretical description of interaction between the skate, sliding along the arc, and the ice. In order to analyze the sliding process, the mechanisms of ice deformation under the skate must be investigated. This investigation is difficult because: ice deformation is inherently three-dimensional, with the blade's complex geometry adding to the problems; the ice is deformed due to many mechanisms, including plastic/elastic effects and partial ice fracture; the ice is a medium with complex rheological properties that are as yet far from understood. It is evident from the above, that a detailed description of ice deformation under the skate is not possible at present. This part of work offers, therefore, a rather simple theoretical model of the process, which includes only the principle features. On the other hand, the model can be used to analyze a number of important problems of sliding, both qualitatively and quantitatively.

Experiments were carried out to investigate the force interaction between the skate blade and the ice on a specially designed test device. The device could be used to study the trajectories, which were formed by a figure skate blade and the specimens with fixed and predetermined geometry. This device enabled the change the incline degree of blades, weight of construction; to change blades during the experiments. Being moved with low and constant speed (v=0.1 m/s), the skate followed the circle trajectory, with the radius changed due to the conditions of experiment.

After the experiments had been completed and the results interpreted in physical terms, a theoretical model, describing the force interaction between the ice and the skate blade, sliding along a curved trajectory, was developed. Then dynamic equations were written for the athlete sliding along the circular arc.

Chapter 2 was devoted to experimental investigations of the kinetic friction of ice and samples, prepared from different steel grades with the general purpose to identify the metals with the best antifrictional performance and to formulate recommendations for producing winter sports equipment. Special attention was paid to temperature conditions typical for artificial indoor stadiums and to estimation of thermal process influence within the contact area of sliding friction.

The antifrictional performance of samples was analyzed according to the intensity of slowing down. The sliding speed could be changed from 0 to 10 m/s; the nominal pressure in the contact area was $4x10^5$ - $8x10^5$ Pa. Temperature of figure skate, metal sample and the air over ice was also measured during experiments.

As a result of these experiments the sample, possessing the best antifrictional performance was found. The composition of steel, which could be recommended for producing of skate blades, was also determined.

Chapter 3 was devoted to assessing of aerodynamic resistance of the skater's model in the typical skating postures. The complex methods of study enabled to make combined experiments in wind and hydro tunnels with the same models and equal Re.

These experiments with the model of skater, enabling to change its posture, consisted of two stages, viz: (i) qualitative - undertaken in the hydrodynamic tunnel to study the structure of flowing the model round by the water; (ii) qualitative - undertaken in the low speed wind tunnel to assess the force of aerodynamic resistance of the model.

The visual flow technique based on the method of "air-cavitational bubbles" was used to make a picture of hydrodynamic flowing round. This technique enabled to make visual the lines of the flow and to fix the contact ranges of the flow and the model. Cd coefficient was accounted for using direct weighting on a two-component balance.

During the experiments mechanic similarity was provided by geometric similarity and equality of Re.

The analysis of results showed that in the speed range from 3 to 7 m/s the Cd coefficient could considerably differ according to the pressure of the athlete and faintly depends on speed.

In Chapter 4 the algorithm of optimising of skate sliding was described.

## ESTIMATION AND CHOICE OF PHYSICAL EXERCISES ACCORDING TO THE BIOMECHANICAL RISK FACTORS OF LOW BACK PAIN SYNDROME

by

Vladimir Sazonov

A dissertation submitted to the Central Institute of Physical Culture (Moscow), USSR

Supervisor: Prof V. M. Zatsiorsky

The aim of this study was to measure the mechanical load on the lumbar vertebral region during physical exercises and to work out the preventive measures of the low back pain syndrome of athletes.

Tasks:

1. To measure abdominal pressure during different resistance exercises and the force of intra-abdominal support of vertebral column (Fs).
2. To estimate the forces and force moments, acting upon vertebras and inter-vertebral discs of the lumbar region during resistance exercises (in particular, upon the most traumatisable third one).
3. To work out the preventive measures for trauma to the lumbar vertebral region, by (i) determining the potential probability of injury during resistance exercises, (ii) developing recommendations on how to choose the exercise and how to perform it optimally, and (iii) choosing biomechanically safe sport facilities to be used by athletes during resistance exercises.

Methods of study: interview and questioning; measurement of intra-abdominal pressure (by intragastral probe using polydigestrograph); plane photography; anthropometry; spirometry; curvimetry; roentgenography; goniometry; dynamometry; mechanico-mathematical simulation of physical exercises with calculation of loading, acting on the lumbar vertebral region (using modified and developed by us - V.M. Zatsiorsky, V.P. Sazonov; 1985 - model of N. Eie, 1986, that enables now to take into account the force of intr-abdominal support, provided by intra-abdominal pressure); comparative experiments.

The number of subjects was 120 (79 male and 41 female); 16 persons were tested repeatedly. Nine experiments were performed, where particular tasks were solved in several experiments simultaneously.

Results: During the metrological experiments, where influence of the moving transducer and the inspiratory volume upon the intra-abdominal pressure ($P_j$) was examined, it was revealed that $P_j$ was not affected by the transducer, being localized in the stomach. The pressure in the oesophagus was appreciably less ($P < 0.05$), than in the stomach, and tended to lower when the transducer was moved towards the oral cavity. Because we were interested in the intra-abdominal pressure, which has been previously shown to be practically equal to intragastric pressure (Eie, 1966; Nordin, 1984; Hemborg, 1985), we measured only intragastric pressure, under the inspiratory volume of about 1 litre to lower Valsalva reflex.

After comparing the area of pelvic transverse section with roentgenographically measured area of the third lumbar disc, regression equations were written. These equations enabled the estimation of the support surface area of the third lumbar disc.

In the next series of experiments the mechanical load on the lumbar vertebral region during different physical exercises was measured. For instance, in weight-lifting two methods were compared, viz: "by back" with legs straightened at the knee joints, and "by legs and back" with legs bent at the knee joints. Both methods showed that the pressure on the disc extended as the rotary moment increased. The pressure extended due to the enlarged force arm, so because of action force improvement. The intra-abdominal support reduced the pressure on the first and third discs by 20%.

When equal weights were lifted by two groups of athletes, the intra-abdominal support was higher in the group of untrained athletes. But during he maximal force experiments the intra-abdominal pressure and corresponding intra-abdominal support of vertebral column were higher in the group of highly trained athletes.

When external force is constant, there is a negative correlation between the pressure on vertebral discs and intra-abdominal pressure. When external force is changed correlation between these two kinds of pressure is positive.

After these experiments some ergonomic means of artificially increasing of the intra-abdominal pressure were suggested (special rollers and corset-belts). These can reduce mechanical load on the vertebral discs to 20% and lower the possibility of vertebral trauma.

On the basis of this research some practical recommendations were made and checked during two separate experiments (with rowers and weight-lifters) over a 10 months period.

# MODELLING OF RUNNING TECHNIQUE OF ELITE SKATERS BASED ON MINIMUM MECHANICAL ENERGY EXPENDITURES


by

Voronov A. V.

A doctoral thesis presented to the Central Institute of Physical Culture, Moscow, USSR

Supervisor: Prof V. M. Zatsiorsky


The aim of this study was to develop effective variants of speed skating technique on the lines. Chapter 1 contains a literature review. Methods and tasks of investigation are described in Chapter 2. Chapter 3 presents the input parameters of the model, viz: aerodynamical factors, mass-inertial characteristics of speed skaters body, kinematics of running on the lines, and the results of investigation of double-support phases. In Chapter 4 and 5 the results of 2-D and 3-D modelling and simulating of speed-skating on the lines are presented.

In order to obtain the effective variants of running on the lines, it was necessary to determine the biomechanical parameters of speed skating, namely: aerodynamic forces, and, kinematical data of running on the lines (velocities of centres of gravity of segments and whole body).

The peculiarities of double-support phase should also be known and mechanical models of speed-skating (2-D and 3-D cases) must be developed and computerised.

Determination of Input Parameters of Speed Skating Model: On the basis of film analysis of speed-skating running (20 skaters) it was possible to divide skaters into two groups: in the first group there are skaters who increased velocity of the body's CG in single and double support phases (elite skaters); in the second, the velocity of CG in double support phase decreased (middle-range athletes). According to the results of our investigation the velocity of running increased in double support phases when the time of this phase was not less than 30% of total step time. The air resistance forces in different body postures (free gliding on the skate, the beginning of double support phase, and ending of double support phase) were measured on phantoms. The investigation showed that the drag coefficient strongly depends on the kind of touch-down. The range variability of the drag coefficient in three variants of touch-down was 18%. The magnitude of drag force lies between 14-23 N when the speed of running is 11 m/s.

Regression equations were developed to obtain drag depending on style of touch-down, anthropometrical data and velocity of running. Mass and inertial characteristics were obtained using regression equations [1].

Speed Skating Model: A twelve-segment body model was developed and computerised. Body segments were assumed to be rigid, joints - ideal. Joints were modelled as spherical (ball-and-socket) - at hip, ankle, lowest support of torso and at the shoulders; and hinge - at knees and elbows. Double support was modelled by two possible variants of the shift of the body on the support leg. Mechanical energy was calculated by multiplying the absolute value of moments by the change in joint angle. To obtain moments of forces, forces and power in joints the inverse problem of dynamics was solved. The mechanical work output for one meter of distance covered was used to estimate the techniques efficiency.

Data Input to Model:
1. Anthropometric data of speed-skater.
2. Position of body at touch-down (three positions): beginning of free skate phase; beginning of double support phase; ending of double support phase.
3. Kinematics: step length; time of step; duration of phases (in percent of step length); average speed in phases of one step; back-side movement.

Data Output of Model:
1. Motion pictures (stick-body diagrams) of skating in three planes.
2. Joint forces, moments, work, and power.
3. Angular kinematics
4. Speeds of shortening and lengthening of 38 muscles acting in lower leg.

Some Results:
The general mechanical work per stroke of three different variants of running on the lines were 476J, 523J and 310J respectively. The average speed in all investigated variants was the same (10 m/s), while the step lengths were 9.78m, 8.2m and 8.33m. Thus the efficiency rose by 70% under the third variant of running. The most efficient variant of running (3) had a time of single support take-off which was one-half that of variant 2. It was concluded that (i) the increase time of double support push-off and decreasing time of single support push-off leads to decreasing mechanical energy expenditure per stroke; (ii) the decreasing amplitude of leg swing movement reduces the negative value of the support reaction in ending of single-support push-off almost by half, and mechanical energy in step decreases 1.5 or more times.

References:
Zatsiorsky, V.M., Aruin, A.S., Selujanov, V.N. (1981) Biomechanics of human motion systems,-M.,FiS (in Russian).

# Announcements

## CALL FOR BIOMECHANICS PROJECT APPLICATIONS DURING BARCELONA SUMMER OLYMPIC GAMES 1992

Following the practice of other Olympic Games the Medical Commission of the International Olympic Committee will sponsor biomechanical research studies during the Barcelona 1992 Games.

The specific projects will involve 3D studies of selected Olympic Sports.

The Sub-Commission for Biomechanics and Sports Physiology of the I.O.C. Medical Commission requests project applications from various scientific laboratories and institutes which have experience in biomechanical research and interest in conducting research in specific sport events during the summer Olympic Games in 1992.

The project application should specify the purpose and methodology according to normal scientific procedure, as well as personnel, technical and financial means and needs. The length of the proposal should not exceed 10 pages. The deadline for submission is February 1, 1991. The I.O.C. Medical Sub-Commission will review the proposals and will make the final selections in March, 1991.

Each research group is expected to finance the major portion of expenses. The I.O.C. Medical Sub-Commission and the COOB'92 can provide partial support in some cases, where appropriate. The accreditations, room reservations as well as local transportation will be arranged by COOB'92 in Barcelona.

Proposals should be sent to:

Joan Antoni Prat
Centre d'Alt Rendiment
Apt. 129
08190 Sant Cugat del Valles
Barcelona, Spain

### EDITOR'S NOTE

Thesis abstracts should be submitted with full details of:

Title, Student's Name, Department, Name of Degree and Conferring Institution, together with Supervisor's Name.

Abstracts should not be more than 500 words in length, and any complex equations or graphics must be in good quality black and white form for ease of reproduction.

# Conferences

*SATELLITE SYMPOSIA TO XIIIth ISB CONGRESS*

## HUMAN PROPULSION - AN INTEGRATION OF MAN AND MACHINE

Cumberland College of Health Sciences
Sydney, Australia

5 - 6 December, 1991

The Rehabilitation Research Centre and The Biomechanics Division of the Department of Biological Sciences, Cumberland College of Health Sciences, The University of Sydney, are planning to hold a scientific symposium on Human Propulsion - An Integration of Man and Machine.

The aim of this symposium is to integrate the physiology, biomechanics and motor control of ***Rowing, Cycling and Wheelchair Propulsion***, thereby raising our understanding of human propulsion in general and each activity in particular. This symposium will be highly interactive so registrations will be limited to 40 persons. To get the most out of this Symposium it is expected that participants have a good understanding of either physiology, biomechanics, motor control or be involved in top level coaching of either Rowing, Cycling or Wheelchair Athletics.

Arrangements are being negotiated with the scientists listed below to attend the Symposium as guest speakers:-

* Dr Luc Van Der Woude, Faculty of Human Movement, Free University, Amsterdam.

* Professor Peter Engel, Institut fur Arbeitsphysiologie, University of Marburg, Federal Republic of Germany.

The fee for the two day Symposium is $A200, and will include lunch, morning and afternoon teas, and an information package. If you are interested in attending, either write to the rehabilitation Research Centre, PO Box 170, Lidcombe, NSW 2141, Australia, or 'phone (61-2-646 6403) or Fax (61-2-646 4853) Sydney, providing name and address and an information package including registration form will be sent to you.

PRELIMINARY ANNOUNCEMENT

## INTERNATIONAL SYMPOSIUM ON OCCUPATIONAL ELECTROMYOGRAPHY

December 3-5, 1991
LaTrobe University, Melbourne, Australia

The Department of Human Biosciences and the Ergonomics Research and Design Centre of LaTrobe University are proposing to sponsor an International Symposium on Occupational Applications of Electromyography in Conjunction with the XIIIth International Congress on Biomechanics. Topics would include: Instrumentation and recording techniques, theory and methodology and applications in occupational investigations. The possibility of holding a portion of the symposium in conference facilities on the Trans-Australian Railway en route to Perth for the ISB Congress is being considered. As registrations will be limited, individuals interested in participating are encouraged to register their interest by contacting the organisers as soon as possible. Information will be sent to interested individuals when details are finalised.

Symposium Organisers: O.M. Evans and T.M. Bach

Occupational Electromyography Symposium
Department of Human Biosciences
LaTrobe University, Carlton Campus
625 Swanson St., Carlton 3053
Australia

Fax: +61 (03) 347-9939
E-Mail (ACSNET):LHSTMB@LTU.LATROBE.EDU.AU

## THIRD INTERNATIONAL SYMPOSIUM ON COMPUTER SIMULATION IN BIOMECHANICS

Perth, Western Australia, 5-6 December, 1991

(See details on page 8 of last Newsletter, or Calendar of events)

YOU SHOULD KNOW . . .

* It's summer time in Australia in December ! (*"No kidding, the water's beaut mate !"*).
* Your $'s, £'s, ¥, DM etc have a lot of buying power in Australia (US$1 ≈ A$1.3, *"Strike me pink !"*).
* The Satellite Symposia, Educational Workshops, and the XIIIth Congress itself are too good to miss (*"A real bonzer show"*).
* Qantas Airlines have one of the world's best safety records ! (*"Fair dinkum, they aint half bad"*).
* Australian hospitality is world renown (*"You'll 'av a real pearler of a time cobber, bloody oath you will !"*).
* ORBA Travel will arrange any tourist venture you wish (*"You ain't seen nothing 'til yer seen the back of beyond"*).
* Your colleagues will be envious of you (*"Starve the lizards, mate - a guy'd 'av to be a real dill to pass this one up !"*).

SO . . . *"Put the bite on your travel grant blokes; suss out all the perks; put the hard word on some well-heeled bloke whose good for a bite; spin them a good yarn about the top show 'down under'. A bloke'd have to be a real dingbat to want to give this one a miss. Bring the ankle biters and Cheese and Kisses if you like. Good onya mate !"*

# Calendar of scientific events

*August 30-September 4, 1990*
**First World Congress of Biomechanics**. Secretary General: Dr. Geert W. Schmid-Schonbein, First World Congress of Biomechanics, AMES-Bioengineering R-102, University of California, San Diego, La Jolla, CA 92093, USA. Tel: (612) 534-4272; Fax: (619) 534-5722.

*September 7-11, 1990*
**Sixth International Symposium on Biomechanics and Medicine in Swimming**. The Liverpool Polytechnic (UK). Congress Convenor: Don MacLaren, Centre for Sport and Exercise Sciences, Liverpool Polytechnic, Byrom Street, Liverpool L3 3AF, England. Tel: 051-207 3581; Fax 051-709 0172.

*November 5-8, 1990*
**European Conference on the Advancement of Rehabilitation Technology (ECART)**, in cooperation with The International Society for Prosthetics and Orthotics (ISPO), The International Society for Augmentative and Alternative Communication (ISAAC) and The International Society of Electromyographic Kinesiology (ISEK). Information: ECART, Congress Organization Services, Van Namen & Westerlaken, P.O. Box 1558, 6501 BN Nijmegen, The Netherlands.

*November 15-16, 1990*
**14th Meeting of the American Society of Biomechanics.** University of Miami, Coral Cables, Florida. Meeting Chairperson: Tarek Khalil, Industrial Engineering, University of Miami, P.O. Box 248294, Coral Gables, FL 33124. Tel: (305) 284-2344.

*November 19-22, 1990*
**North Sea Conference Biomedical Engineering 90**. Regional meeting of The International Federation for Medical and Biological Engineering (IFMBE), University of Antwerp, Universiteitsplein 1, B-2610 Wilrijk (Antwerp), Belgium.

*April 8-13, 1991*
**Second World Congress of Science and Football**, Maastricht, The Netherlands. c/o Prof. J.M. Greep, Dept. of Surgery, Academic Hospital St. Annadel, Maastricht, The Netherlands.

*July 28-31, 1991*
**International Synposium on 3-D Analysis of Human Movement**, Hotel des Gouverneurs, Montreal, Quebec, Canada. Secretariat: Laboratoire d"tude du mouvement, Centre de recherche p'diatrique, Hôpital Sainte-Justine, 3175 Côte Ste-Catherine, Montr'al, PQ H3T 1C5, Canada.

*July 28-August 2, 1991*
**11th International Congress of the World Confederation for Physical Therapy**, Barbican Centre, London. Congress Secretariat: Conference Association WCPT, 27 A Medway Street, London SW1P 2BD, England. Tel: 01-222-9493.

*December 5-6, 1991*
**Symposium on Human Propulsion - An integration of Man and Machine**, Cumberland College of Health Sciences, Sydney, Australia, c/o Rehabilitation Centre, PO Box 170, Lidcome, NSW 2141, Australia. Tel: 61-2-646 6403; Fax: 61-2-646 4853.

*December 5-6, 1991*
**Third International Symposium on Computer Simulation in Biomechanics**, Perth, Western Australia. Congress Secretariat: Ms Rosemary Ingham, Department of Human Movement Studies, The University of Western Australia, Nedlands, WA 6009, Australia. Tel: 61-9-380 2360; Fax: 61-9-380 1039.

*December 9-13, 1991*
**XIIIth ISB Congress on Biomechanics**, Perth, Western Australia. Congress Secretariat: Ms Rosemary Ingham, Department of Human Movement Studies, The University of Western Australia, Nedlands, WA 6009, Australia. Tel: 61-9-380 2360; Fax: 61-9-380 1039.

# ISB membership news

### CAN YOU HELP US FIND THESE MEMBERS ?

The following addresses are no longer correct for these active members and we have not been able to locate them.

If you know the current address for any of these members please forward that information to:

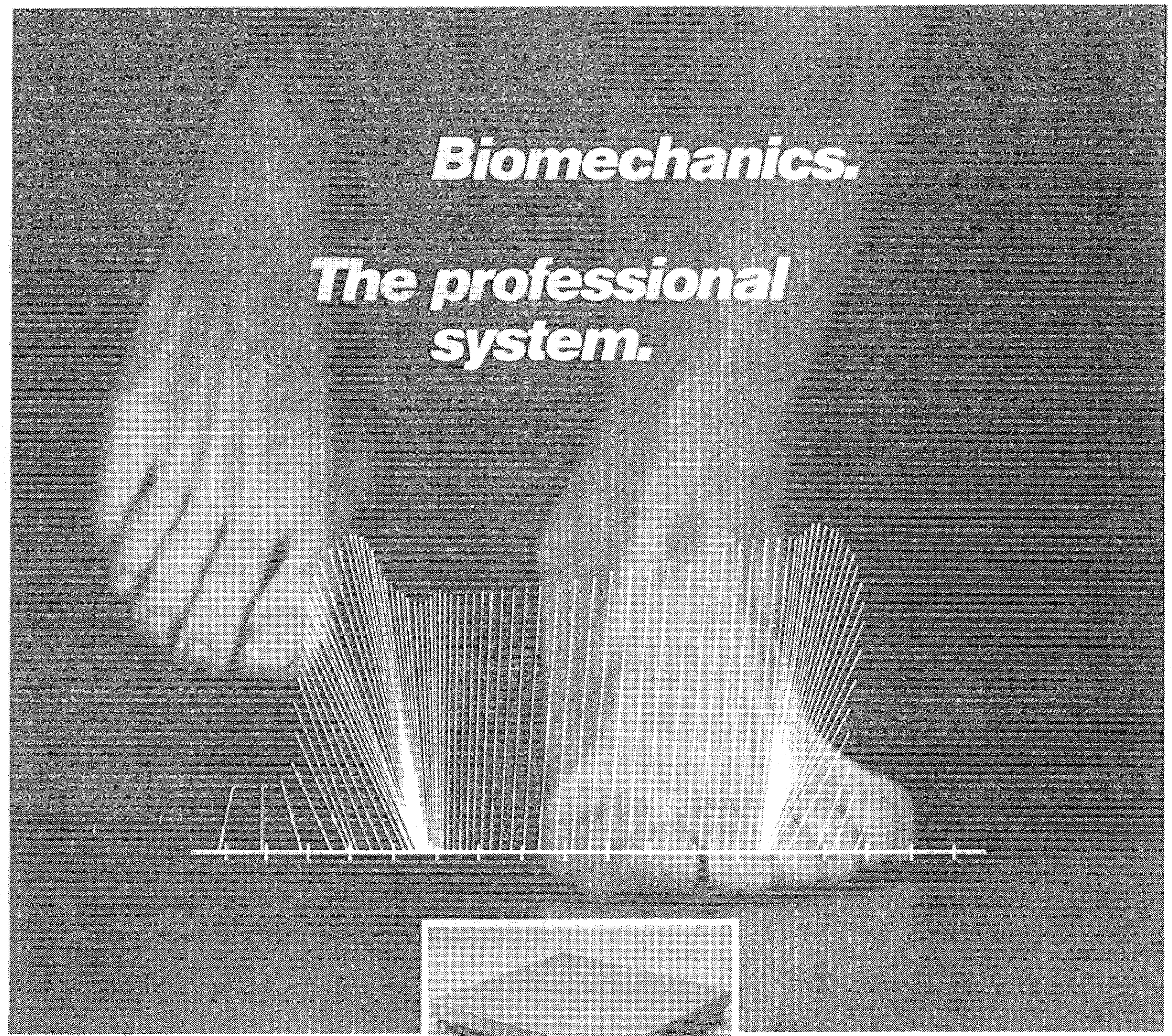
Richard C. Nelson
ISB Treasurer
(address on cover)

Heikki Arimo Kyröläinen
Viitaniemente 8C26
40720 Jyväskylä
FINLAND

Manabu Tanaka
2-2-6-705 Fuda
Chofu-Shi, Tokyo 182
JAPAN

Hans Ekstroem
Linkoeping University
S-58183 Linkoping
SWEDEN

Simon M. Luethi
Inder Fadmatt 94
8902 Urdorf
SWITZERLAND


Biomechanics.
The professional system.