International Society of Biomechanics Newsletter

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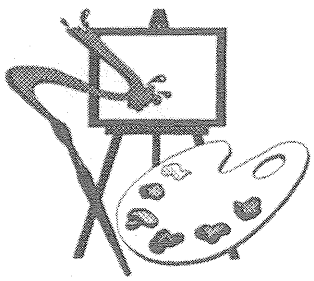
AFFILIATE SOCIETIES OF ISB:
American Society of Biomechanics; British Association of Sports Science; Canadian Society of Biomechanics; China Sports Biomechanics Association; Czechoslovak Committee on Biomechanics; French Société de Biomécanique; Korean Society of Biomechanics; Polish Society of Biomechanics; Sports Commission of the Soviet Union.

ISB news

THE SOCIETY'S LOGO COMPETITION



The last issue of this Newsletter displayed a new-look logo. While those efforts were applauded, they also prompted the suggestion that the Society could be even more adventurous and adopt a completely new logo which more strongly portrays the full breadth of the Society. It has been decided therefore to hold a **Logo Competition**, to see what creative talent can be drawn from the membership (and their artistic spouses and friends). Entries (either in draft or finished art form) should be mailed to the Secretary-General, and it must be understood that the Executive Council reserves the right to ultimately adopt an amended version of the winning entry.

THE ISB RECOMMENDATIONS FOR STANDARDIZATION IN THE REPORTING OF KINEMATIC DATA - THE NEXT STEP

by Peter Cavanagh, Ph.D. Chair,
ISB Standardization and Terminology Committee.

Readers may recall the appearance of a draft Recommendation for Standardization of the Reporting of Kinematic Data in the February/March issue of the ISB Newsletter which was accompanied by a request for feedback. Since that time, it has become clear that the effort expended in generating this draft was extremely worthwhile, since it resulted in a number of thoughtful responses from ISB members. In reviewing these responses, the Committee (Professors Grieve, Paul, Winter and Cavanagh) has been fortunate to have the help of Dr. Ge Wu, an Assistant Professor in PennState's Center for Locomotion Studies. Dr. Wu has grouped and summarized the responses received (see below) and the Committee is most grateful to her for these efforts. At the present time, there are no responses from members of the European Community CAMARC committee who are also charged with developing standardized approaches to a variety of biomechanical problems. This is principally due to problems with timing, since the CAMARC group is working towards a September deadline. We look forward to sharing their views on the document and on other standardization issues with our members in the near future. The comments received on draft 4.1 of our own Recommendation are summarized below without response from the Committee in order to allow members the opportunity to have their views heard. Many of the comments were posted publicly on BIOMCH-L and they can be retrieved in their original form from the BIOMCH-L archives. The committee has considered all the views expressed and will be progressing, in the near future, towards a final version of the Recommendation. A number of journals have expressed interest in publishing the Recommendation and vendors of kinematic equipment are also interested in both underwriting the effort and adding postprocessing "filters" to generate output in the ISB Recommended conventions. It would seem, therefore, that there is considerable interest in and need for the Recommendations and members can look forward to seeing the ISB take a leading role in further developments in this area.

Summary of comments on the ISB Recommendations for Standardization in the Reporting of Kinematic Data

by Ge Wu, Ph.D.
The Center for Locomotion Studies
Penn State University, Room 10 Intramural Building, University Park, PA 16802

The Standardization and Terminology Committee of the International Society of Biomechanics distributed a draft (version 4.1) of Recommendations for Standardization in the Reporting of Kinematic Data in April, 1992. Since then, the Committee has received a number of responses from different research groups and individuals regarding this issue. Those comments are summarized in this report.

<u>List of respondents:</u>

1. M. Truppe, ARTMA Medizintechnik Gmbh, Austria, April 2, 1992
2. H. Woltring, The Netherlands, April 3, 1992
3. H. Woltring, The Netherlands, April 15, 1992
4. J. Andrews, University of Iowa, USA, April 25, 1992
5. P. de Leva, Indiana University, USA, May 7, 1992
6. J. Dapena, Indiana University, USA, May 7, 1992
7. T. van den Bogert, G. Cole, J. Ronsky and G. Hamilton, The University of Calgary, Canada, May 17, 1992
8. V.P. Stokes, Karolinska Institute, Sweden, May 26, 1992
9. M.J. Pearcy, Royal Adelaide Hospital, South Australia, June 24, 1992
10. H. Hatze, University of Vienna, Austria, June 26, 1992.
11. D. Baker, University of Utah, USA, July 7, 1992

General comments:

1. Add a separate section which more specifically defines terminology such as: poses and displacements; positions and translations; attitudes and rotation; Cardanic and Euler angles; finite and instantaneous helical, screw, and rotation axes. (by H Woltring, point A)

2. Replace the term "global'' with "absolute". (by H Woltring, point A)

3. Assess the Recommendation in terms of its contribution to the understanding and communication of 3D movements to those individuals without a mathematical background. References [1] and [2] included. (by MJ Pearcy)

Specific comments:

Part 1: Definition of a Global Reference Frame

1. In 3D study, X should be horizontal and pointing toward right, Y horizontal and pointing forward, and Z vertical. In 2D study, the Y-Z reference frame should be used.

Rationale: (1) the vertical axis is the direction in which the gravity acts and is traditionally denoted by Z from a mechanical standpoint; (2) the global coordinate system could be classified into two categories: the horizontal (denoted by X-Y) and vertical (by Z). (by J. Dapena, comment A). (3) This would be the same as the widely used Kistler force platform convention (H. Hatze).

2. Use XY in 2D, and Z for the vertical axis in 3D.

Rationale: there is no real need to link 3D terminology to 2D terminology. (by P. Leva, point 1).

3. The labeling of the coordinate system (XYZ) is of minor importance. It is always a good custom, however, to add information such as 'medial', 'lateral' to help with the interpretation. (by T. van den Bogert et al.).

4. The positive Z axis in aeronautics points downward. The choice of Xg-Yg as sagittal plane seems to indicate a predisposition towards sagittal gait studies, rather than frontal analysis as in posture, sports and ergonomics studies. (by H. Woltring, point C)

5. Change Xg, Yg and Zg into Xo, Yo and Zo to be consistent with the symbol 'O' for the origin of the coordinate system. (by J. Dapena, comment B).

6. The notation Xg, Yg and Zg is not a good choice. Simply use X, Y and Z.

Rationale: All the local coordinate systems have their specific definitions such as Xt, Yt and Zt for the one attached to the thigh. (by P. Leva, point 2 and H. Hatze.)

7. Redefine the directions of the horizontal axes to admit occasional directions that are orthogonal but not aligned with the direction of walking or travel of the subject (such as in the high jump case). (by J. Dapena, comment E).

8. The best orientation of the Global Coordinate System appears to be problem (such as gait) specific. The gait analysis example should be simply presented as an illustration. (by J. Andrews, point 1)

9. 'Direction of travel' is not always a useful definition. (by T. van den Bogert et al.).

10. Select the origin of the global coordinate system such that all the coordinates describing body segmental movement will be positive. For example, the 'important point' for the activity under study is located at (10,10,0) instead of (0,0,0).

Rationale: this could facilitate the interpretation of the data. (by J. Dapena, comment F).

Part 2: Definition of Segmental Local Center of Mass Reference Frames

1. Use X for medio/lateral, Y for anterior/posterior and Z for proximal/distal to be consistent with the definition for the global coordinate system as suggested in Part 1. (by J. Dapena, comment C).

2. Use right-handed reference frames for both left and right body segments. For the segments on the right side of the body, the positive X is pointing laterally, the positive Y anteriorly and the positive Z proximally. For the segments on the left side of the body, the positive X is pointing medially, positive Y posteriorly and positive Z distally. As a result, the three torques will be consistent with the anatomical terms and all three forces on the left side of the body should be reversed in order to be consistent with the anatomical terms.(by J. Dapena, comment D).

3. Define the segment coordinate system to be aligned with the global coordinate system, when the subject is standing in a well-defined 'anatomical' position. Reference [3] included.(by T. van den Bogert et al.). A number of human body models already employ this type of local segment coordinate system (H. Hatze).

4. Replace the word "proximally" with "upward" in defining the Y axis when the subject is in the neutral, anatomical pose. (by H. Woltring, point D)

5. For some body segments (e.g., the abdomino-pelvic segment) a principal axes transformation is required in order to render the inertia tensor diagonal for purposes of dynamic modelling and computer simulation. In practice, this implies a rotation of the segmental coordinate systems passing through the segmental mass centers from their 'original' positions (however defined) to newly oriented positions. (H. Hatze)

Part 3: Global displacements

1. Define one, easily palpated, anatomical landmark to be the center of the reference frame in order to avoid the need for defining the location of the center of mass of the segment. (by T. van den Bogert et al.)

Part 4: Global attitudes

1. Questions were raised about why Cardanic angles with ZYX sequence are proposed and the difficulty of interpreting these angles compared to another sequence. (by T. van den Bogert et al.)

2. Establish the correspondence between Part 3 and Part 4. Such correspondence implies ZXY rather than ZYX decomposition. That is, a corresponds to flexion/extension about Z, b to ab/adduction about X and g to int/external rotation about Y. (by J. Andrews, point 3)

3. The rotation sequence example given in Part 4 does not correspond with the conventional Cardanic/Eulerian sequence. Furthermore, the attitude matrices of the head, upper trunk, neck and the joint between upper and lower trunk are equal to the identity matrix only when all Y axes point upwards in the neutral or anatomical pose. (by H. Woltring, point E)

4. Use the standard 3x3 rotation matrix, rather than 4x4 matrix, to define segment attitudes. (by J. Andrews, point 6)

5. Replace the word "attitude" by "orientation" which is more commonly used. (by VP Stokes)

6. Use a rotation vector rather than Euler angles in the rotation matrix.

Rationale: (1) rotation vector has a very simple physical interpretation since its direction defines the axis of rotation, whereas the Euler angles don't; (2) all rotations can be represented within the rotation vector parameterization, whereas, an infinite number of rotations are excluded from parameterization via Euler angles. Reference [4] included. (by VP Stokes)

7. In Physics, Mechanics , Robotics , Control Theory/Linear Systems and Biomechanics all use the affine transformation, combining rotation and translation, as follows:

$$\text{Displacement} = \left| \begin{array}{ccc|c} rot11 & rot12 & rot13 & transx \\ rot21 & rot22 & rot23 & transy \\ rot31 & rot32 & rot33 & transz \\ \hline 0 & 0 & 0 & 1 \end{array} \right|$$

which is a similar matrix to the ZYX proposed. Why doesn't the ISB opt for the method with the widest usage? (Baker)

Part 5: Relative attitudes

1. The labels of X2 and Y2 in Fig. 3 are mistakenly interchanged. (by J. Dapena, comment G)

2. Figure 3 contains a number of errors. Suggest to list under "Notation" the three Cardanic angles in their proper order for clarity. (by J. Andrews, point 4)

3. Agree with the Committee that Joint Coordinate System angles are probably the best way to quantify joint rotations. Helical angles may be mathematically better, but are possibly too abstracted for clinician. (by T. van den Bogert et al.)

4. Hope that "helical axes" will never be used as standards for describing joint poses (i.e. positions and attitudes). (by H. Woltring, point F)

5. Joint Coordinate System angles are, in fact, as sequence dependent as Euler/Cardanic angles (by T. van den Bogert et al.)

6. Fail to see how the arbitrary choice of some imbedded and floating axes can be anatomically meaningful if no anatomists are being referenced. Others have used terms like "physiological angles" and "orthopedic angles" (by H. Woltring, point F)

Note (a):

1. Use the Segmental Coordinate System, defined in part 2, as the basis for the Joint Coordinate System. One Joint Coordinate System axis should be a coordinate axis of the proximal segment, another

should be a coordinate axis of the second segment, and the third should be perpendicular to the two. (by T. van den Bogert et al.).

2. One possibility to standardize Joint Coordinate System axes is described in Reference [3]. (by T. van den Bogert et al.).

Note (b):

1. The quantification of translation in a joint depends strongly on the choice of the origin , a fixed joint center. State that the instantaneous helical axis' is the only way to obtain insight in translational movements in a joint. (by T. van den Bogert et al.).

Note (c):

1. The Joint Coordinate System should be used to quantify global attitudes (in part 4) simply by pretending that the global coordinate system is the proximal segment and the moving segment is the distal segment. This will be more consistent than the proposed ZYX sequence. (by T. van den Bogert et al.).

Part 6: Joint moments

1. The word 'moment' should be replaced by 'torque' because 'moment' is "the most overused one in mechanics". (by J. Dapena, comment I).

2. Eliminate this part to be consistent with the proposal title which deals with the kinematics rather than kinetics. (by T. van den Bogert et al., J. Andrews, point 5 and H. Woltring, point B). Otherwise, suggest to change the title. (by T. van den Bogert et al.).

3. The decomposition of a moment vector into a set of non-orthogonal components, such as flexion/extension, abduction/adduction and rotation, might be good for presentation purpose only. Those components should not be used for further calculations, such as the calculation for joint powers. (by T. van den Bogert et al.).

4. The decomposition of joint moment vector about different coordinate systems will result in quite different moment patterns. (by H. Woltring, point B).

5. The definition of joint center of rotation is missing. Use the standardized, fixed joint center as the joint center of rotation. (by T. van den Bogert et al.).

6. The standardization of the inertial properties of the segments (mass, center of mass and moments of inertia) is missing. (by T. van den Bogert et al.).

Part 7: Minority report

With reference to Part 1:

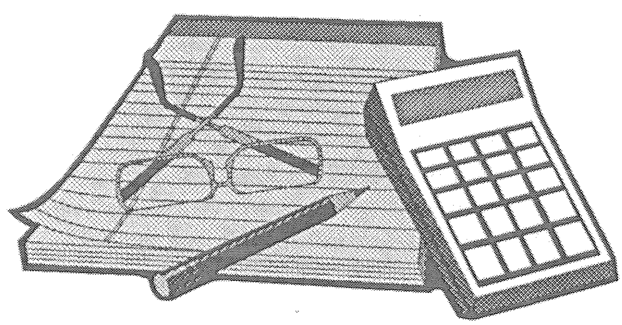
1. Opposed to John Paul's point (by J. Dapena, comment J and T. van den Bogert et al.)

With reference to Part 2:

1. The left-handed coordinate system for the opposite side of the body will be good only in the presentation stage. No further calculations based on those results should be conducted. (by T. van den Bogert et al.).
2. Opposed to the use of left-handed Cartesian reference frame. (by J. Andrews, point 2 and Hatze).
3. The question remains what to do with body parts that are neither right nor left: the head and trunk. (by H. Woltring, point G).
4. Vote for the use of clinical definitions such as flexion/extension, abduction/adduction and internal/external rotation on left and right limbs. (by MJ Pearcy) .

References:

[1] M. Benati et al. (1980): Anthropomorphic Robotics, Biol. Cybernetics, 38:125-140
[2] MJ Pearcy et al. (1987): Dynamic back movement measured using a three-dimensional television system, J. Biom. 20(10):943-949
[3] AJ van den Bogert and BM Nigg (1992): An optimization method to determine anatomical axes of the ankle joint in vivo. VIII mtg. of the European Society of Biomechanics, Rome, Italy
[4] VP Stokes: Minimal representations for rotation, Lecture notes.



Special feature article

The following is a slightly abridged version of Past President Robert W. Norman's address given at the opening ceremony of the XIIIth ISB Congress on Biomecchanics in Perth last December. It is reproduced here by popular request, and for the benefit of those not able to attend that Congress themselves.

Opening Comments - XIIIth Congress of the ISB
Perth, Australia - December 9, 1991

The International Society of Biomechanics has about 700 members from 35 countries. Its members include scientists with formal educational backgrounds in anatomy, biology, engineering, human movement sciences, kinesiology, physical and occupational therapy, physics, and sport sciences, to name some. One of our strengths is our diversity of educational background that brings with it a diversity of perspective on approaches to studying and solving problems related to the effects and control of forces that act on and are produced by living things. For example, it is sobering to reflect on the fact that the fastest way to impair or destroy the quality of one's life is to impair or remove mobility. Hip fractures, as a result of slips and falls, are one of the major killers of the elderly. Of all industrial health problems, mobility impairing musculo-skeletal injuries in the work place are the single largest direct cost to employers and the largest cause of lost productivity in industrialized countries. Biomechanics has a large role to play in reducing problems such as these.

The primary activity, but not the sole purpose, of the ISB is to provide a forum for face to face communication for biomechanists around the world once every two years so that we improve as scientists and improve the science of biomechanics. We have met in Switzerland, Holland, Italy, and as a formalized society since 1973, in the USA, Finland, Denmark, Poland, Japan, Canada, Sweden, again in Holland, again in the USA, and now, here in Australia.

I expressed the opinion, in an ISB Newsletter two years ago, that biomechanics had experienced a dramatic improvement in the quantity and quality of research in the past 20 years. Perhaps a very brief review of the changing character of some types of biomechanics research, that has occurred in the past 100 years or so, is in order. (An authoritative book on the history of the development of some types of biomechanics research will soon be available, edited by Aurelio Cappozzo and his colleagues. Biolocomotion: A Century of Research Using Moving Pictures.) I would even like to speculate a bit as to what we may see in future ISB Congresses.

The late 1800s brought some of the early quantitative biomechanics research on body segment parameters and human locomotion by Braune and Fischer. The advent of photographic methods was technology that made a big difference to animal motion analysis. Very little research appeared again until the 1920s and early 30s when Fenn reported on kinematic and kinetic analyses of running and Bernstein made major contributions and later in the 30s and early 40s when Elftman conducted mechanical energy and resultant joint moment analyses on walking and running.

More biomechanics research on human walking, particularly related to war amputation prosthetic and injury orthotic problems, appeared in the late 40s and early 50s. Most of this was kinematic descriptions of movement patterns but some, notably the painstaking hand calculations of resultant joint moments at several joints reported by Bressler, Frankel and Berry, dealt with the mechanical causes of motion, kinetic variables. Dempster's body-segment parameter data from cadaver dissections, still used to some extent today, were also published early in the 50s.

The first papers on Mechanical energy costs and efficiency of walking and running were reported in the 60s by Cavagna and Margaria. Fairly easy access to mainframe computers in the late 60s and early 70s and the introduction of mini-computers at this time resulted in a flow of descriptive, plane motion, kinematic analyses, of many forms of human and other animal motion, particularly sport movements, and normal and abnormal walking. The availability at very low cost of increasingly high powered computers and opto-electronic data acquisition devices have brought a virtual flood of kinematic analyses of many forms of animal motion in the late 70s, but now the studies are on larger subject pools instead of on one or two case studies. In the last 5 years or so, three dimensional kinematic analyses have begun to appear in increasing numbers not only from laboratory and clinical environments but also in some rather inconvenient or even hostile athletic competition environments.

Plane motion and 3 dimensional kinematic analyses will be presented at this Congress and they have their place in providing basic descriptions of movement patterns. But kinematics alone has never proven to provide very useful diagnoses of movement problems, estimates of risk of occupational or athletic injury or assessment of the effectiveness of therapy, or coaching, or equipment or tool design. Because of the redundancy built into our anatomy and the plasticity of our motor control, the same kinematic patterns can be produced by many combinations of resultant muscle moments, to say nothing of the numerous possible combinations of moments of force of individual muscles, ligaments and other tissues that can produce the same movement patterns. I would suggest that if biomechanists are to make major contributions in the future, to the study and solution of human motion disability, injury, rehabilitation, and high performance movement problems, we will have to use three dimensional kinetic analysis methods. Biomechanical modelling will remain the major approach to problem solving. Inverse models will continue to be important but forward solution models will provide new opportunities for contributing to the analysis and solution of movement related problems. Moreover, validated methods of estimating forces on, and produced by, individual tissues (muscle fascicles, whole muscles, ligaments, cartilage and bone), and distributed, rather than point force estimates, will become the norm rather than the exception in the not too distant future. In the work, energy and power approaches to motion analysis, power generation and energy absorbed by specific sources ~ rather than current restrictions to resultants only, will emerge.

My optimism is based on what has already been achieved. There is a long history of contributions to the science that have contributed to this possibility now, and there are some examples of successful attempts to estimate individual muscle and ligament forces in certain types of movements, although the matter is a long way from ultimate solution.

The muscle physiology and muscle mechanics work of the 1920s by Hill, in the 50s and 60s by Wilkie, Bahler, Gordon, Hanson and the Huxleys, to name some, have provided the <u>beginnings</u> for <u>conceptualization</u>, and <u>data on state and trait variables</u> of the multiple muscle models that began to appear in the 70s and have become increasingly sophisticated in the past ten years or so. Basic and applied research on tissue mechanics has provided, and is continuing to provide information on mechanical properties and load tolerance of tissues represented in the models. Closer attention is being paid to anatomical realism in models, and motor control mechanisms are being woven into current models. Progress is being made in both input discovery and output prediction types of deterministic models of the neuro-muscular-skeletal system. Some examples of this type of work will be presented here.

Current issues of terminology and standards for describing and reporting biological motion in three dimensions will soon be resolved so that we can communicate more effectively.

Resolution will arrive on current issues of whether moments taken about assumed fixed centres of rotation are adequate representations of reality, or whether it is imperative to take moments about instantaneous centres of rotation; or whether it is more relevant to take moments about instantaneous contact points on articulating surfaces.

How do I know? Because the burning issues of a few years ago, such as how to smooth displacement data to get reasonable estimates, via differentiation, of velocities and accelerations, have been resolved and are largely non-issues today. The issues of today will become non-issues of tomorrow and new challenges will arrive.

Methods will be developed to allow routine analyses of deformable members of linked segment models, rather than continuing to use our acknowledged, unrealistic, representations of body segments as rigid. But we have needed rigid body, plane motion models, some stopping at kinematics, to bring biomechanics to the point it is today.

Soon we will be routinely studying distributed rather than point force loads on bones and joints in normal human movements using forward solution models to ask "what if" questions.

Why am I so optimistic? Because initial attempts at studying all of these issues have been published on one joint or another on one simple movement or another. They will become the norm rather than the exception.

It will be interesting for me, and I hope for you, to see what speculative, and possibly highly criticized, papers are presented at this Congress that eventually become routine approaches to solving problems. Let us all contribute as effectively as we can in our own way, by presenting our papers in posters or on the podium; by engaging in challenging but constructive and friendly dialogue during and after formal sessions; if you are senior members of the scientific community, by taking the time to talk with and encourage young scientists; if you are a young scientist, by introducing yourself to people who until now, perhaps, were only well known names to you in the literature; and, if your first language is English, by being patient with, understanding towards, and assist those whose first language is not English, but who have summoned the courage and, in some cases, spent an enormous amount of time preparing their presentation in a foreign language.

Robert W. Norman
President, 1990 - 1992

Announcements

BIOMECHANICS POSITIONS

Applied Science and Engineering Laboratories, Delaware

A. Graduate Studentships in Rehabilitation Robotics

The Applied Science and Engineering Laboratories have an exciting program in rehabilitation robotics with an emphasis on the human-machine interface. The primary focus is on applications of extended physiological proprioception (force reflective control) in rehabilitation, whereby the forces experienced by a slave robot are fed back to the user via a master servo system. This master servo system could be a head, shoulder or elbow controlled. This research is appropriate for both masters level and graduate level student, and work would involve assessing the abilities of the prospective users, developing interface electro-mechanics, and designing control techniques.

Any suitably qualified person can apply for the rehabilitation robotics studentships.

B. Graduate Scholarships in Rehabilitation Engineering

Rehabilitation Engineering is the application of engineering techniques to problems encountered in all branches of rehabilitation medicine. Rehabilitation engineering requires motivated and professional people who are adept at problem solving. Under a grant from the Rehabilitation Services Administration, the Applied Science and Engineering Laboratories has scholarships available for training in rehabilitation engineering. Applicants for these scholarships should have a degree in engineering, computer science, occupational therapy or similar discipline and should be willing to extend and apply their knowledge to finding appropriate solutions for problems encountered inrehabilitation.

The training is at the masters level and above and will require the scholars to acquire skills in both engineering science and in rehabilitation medicine. Scholars will have a substantial clinical practice as part of the rehabilitation engineering scholarship program.

Eligibility for the graduate scholarships in rehabilitation engineering require that :-

* You are a United States citizen or provide proof of lawful permanent residents in the United States.
* You are not be an employee of the Federal Government.
* You are interested in a career that includes vocational rehabilitation practice. This would include professional practice, administration, supervision, teaching, or research.
* Following the degree the you must work for 2 years in an approved rehabilitation agency. Such agencies would include any non-profit organization, any state or federal rehabilitation program, or a for-profit, sole professional practice.

The Affiliations

The training program will be a part of the Applied Science and Engineering Laboratories, a joint research program of the University of Delaware and the Alfred I. duPont Institute. The Laboratories have extensive research programs in rehabilitation technology and are involved in research and development in human/computer interaction, engineering design, computer applications, rehabilitation engineering, biomechanics, and sensory aids.

The University of Delaware is the primary academic affiliation for the Applied Science and Engineering Laboratories. It is a private, state-supported institution located in Newark, Delaware and has has an enrollment of 15,000 students. The Applied Science and Engineering Laboratories has maintained strong ties with the departments of Computer and Information Sciences, Mechanical Engineering, and Educational Studies. These departments maintain research laboratories on artificial intelligence, computer graphics, mechanical design, robotics, and special education technology. The University Library offers the Applied Science and Engineering Laboratories staff access to a collection of 2 million volumes and 21,500 periodicals.

The Alfred I. duPont Institute is located in Wilmington, Delaware and is the primary clinical affiliation for the Applied Science and Engineering Laboratories. It is a full service pediatric hospital serving primarily the Mid-Atlantic region. The Institute was established in 1940 as an orthopedic hospital for children, and although it has maintained strong programs in orthopedics and rehabilitation, services have expanded to cover most medical specialities including clinical services in occupational therapy, physical therapy, communication disorders, and rehabilitation engineering.

For further Information contact:

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Lectureship/Senior Lectureship in Bioengineering

Bioengineering Unit
University of Strathclyde
Glasgow
Scotland

Applications are invited from candidates for appointment to the Bioengineering Unit - a leading centre for research into functional electrical stimulation of paralysed muscle. Candidates should be qualified and experienced in engineering control and instrumentation; should be knowledgeable in the field of biomechanics and have an interest in physiology. Previous experience of collaborative clinical resarch is highly desirable. Appointment will be made either at Lecturer of Senior Lecturer level (Salary up to 28,000 pounds per annum).

For application form and further particulars (Ref 87/92) contact Personnel Office, University of Strathclyde, Glasgow, G1 1XQ, Scotland, UK.

Applications Closing date: 29th September 1992.

Post-Doctoral Research Fellowship

The Department of Orthopaedics and Rehabilitation, at the University of Vermont, has a post-doctoral fellowship position which is available immediately. The fellowship will concentrate on biomechanics of the spine or the knee joint. If interested, please contact:

Malcolm H. Pope, Dr. Med. Sc., Ph.D.
Director of Research
Department of Orthopaedics and Rehabilitation
University of Vermont, College of Medicine
C417 Given Building
Burlington, Vermont 05405-0068
Internet address: pope@uvm-gen.uvm.edu

or write to:

Carole Godbout
Department of Orthopaedics and Rehabilitation
University of Vermont, College of Medicine
Given Building, Room C413
Burlington, VT 05468-0068

Head of Research, Orthopaedic Biomechanics

M.E. Mueller-Institute for Biomechanics
University of Bern, Switzerland

To commence in Autumn/Winter 1992.

Applicants should be experienced in orthopaedic biomechanics research (three or more years experience at the post doc or assistant professor level). The applicant is expected to lead a research group of about 5 - 6 persons. The research field should relate to basic and applied orthopaedic biomechanics (osteosynthesis, implant studies, material science, functional biomechanics, mathematical modelling). Interest in collaborative projects with the two other research groups at the Institute (microbiomechanics and cell biology) as well as clinical and industry-related projects is expected. A basic research budget as well as three permanent positions are available as part of the departmental budget, but the successful applicant is also expected to obtain external funding.

Persons interested and qualified for this position should submit (before October 31, 1992) an application with their C.V., a list of publications, name and phone number of two references and a statement of research interests to:

Dr. Ernst B. Hunziker,
M.E. Mueller Institute for Biomechanics
University of Bern,
P.O. Box 30, 3010 Bern
Switzerland.
Fax (+41 31) 25 02 59.

Research Assistant in Biomechanics

Laboratoire d'Etude du Mouvement
Hopital Sainte-Justine, Montreal

Job Description
The candidate will be responsible for conducting 3-D bilateral gait studies of lower limb amputees.

Requirements
The candidate must have a M.Sc., preferably a Ph.D. degree in kinesiology or physical therapy. She or he must have experience in gait analysis. Familiarity with a 3-D system as well as working knowledge of Pascal and Unix are an asset.

Term Duration
Pending funding which should be known before the end of September 1992, the candidate must start full time employment shortly afterward for a maximum duration of

36 months, non renewable.

Annual Salary
CAN$30,000 to 40,000

Place of Employment and Further Information

Dr. Paul Allard, Ph.D., P. Eng.
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Tel: 1 (514) 345-4740
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Postdoctoral Positions

NeuroMuscular Research Center
Boston University

The Neuro Muscular Research Center is accepting applications for two postdoctoral positions to study:

1. The neural control and biomechanics of posture and locomotion.
2. The relationship between muscle fiber type and electromyography.

Qualifications:
Doctorate degree in biomechanics, biomedical engineering, neurophysiology or related area.

Application:
Please send a cover letter describing research interests, a curriculum vitae, and a list of three references to:

Professor Carlo De Luca
NeuroMuscular Research Center
Boston University, 44 Cummington Street
Boston, MA 02215, USA.

Conference news

Second International Symposium on 3-D Analysis of Human Movement

This is to inform you that the 2nd International Symposium on 3-D Analysis of Human Movement (one of the Satellite Symposia to next year's 14th International Congress of Biomechanics in Paris) has been advanced by one day, at the request of the ISB's executive Council. The meeting will start with a reception on the evening of June 30, 1993, and continue until approximately noon on July 3, 1993. In this way, Sunday July 4, 1993 can be kept open for the ISB's instructional courses prior to the start of ISB-14 on the evening of that day.

Author's Kits are currently being distributed; they can be applied for at the Symposium's standing secretariat:

Paul Allard
International Symposium on 3-D Analysis of Human Movement
Centre de recherche
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Submission deadline is February 1, 1993. Since the contributions are to be provided in camera-ready format, email submissions are not acceptable.
With kind regards, and hoping to see many of you at the, indeed, futuristic venue "Parc du Futuroscope" in Poitiers, France next year,

For the scientific committee,
Herman J. Woltring

The National Conference on Sports Medicine and Science in Tennis

Presented by The United States Tennis Association

Dates: April 28 - May 1, 1993

Location: Sonesta Beach Hotel, Key Biscayne, Florida

Directors: Jack Groppel, Ph.D., Robert Leach, M.D. and Paul Roetert, Ph.D.

Registration Fees:
$395 for physicians
$225 for all others

Keynote Speakers:
David Altchek, M.D., Howard Brody, Ph.D., Donald Chu, Ph.D., David Costill, Ph.D., Todd Ellenbecker, P.T., Jack Groppel, Ph.D., Brian Hainline, M.D., Richard Hawkins, M.D., Ben Kibler, M.D., William Kraemer, Ph.D., Robert Leach, M.D., James Loehr, Ed.D., Robert Nirschl, M.D., Per Renstrom, M.D., and Nancy Wellman, Ph.D.

Special Appearance by San Smith, Hall of Fame tennis great and USTA Director of Coaching.

List of Topics:
The conference will include a shoulder symposium, prevention and rehabilitation of joint areas, physiology, nutrition, biomechanics and psychology.

Format of Presentations: Abstracts and poster presentations.

Call for Papers:
Scientists and investigators are invited to submit abstracts for presentation in the areas of sports medicine and science in tennis. Abstracts are due October 15, and notification will follow after December 15. Registration fees will be waived for those attendees whose abstracts have been accepted for presentation.

For further information please contact:

USTA
Sport Science Department
201 S. Biscayne Boulevard
loth Floor
Miami FL 33131
(305) 530-4241

Institute Upgrade

In June of this year the Polytechnic of Huddersfield became the University of Huddersfield, and thus the address of the Spinal Research Unit becomes:

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Tel: +44 (0)484 422288, ext 2657;
Fax: +44(0)484 4355744

Kim Burton may also be contacted direct at the editorial office of Clinical Biomechanics on:
Tel: +44(0)484 424329; Fax: +44(0)484 435744

EDITOR'S NOTE

This Newsletter is published quarterly: February-March (Spring); May-June (Summer); August-September (Autumn), and November-December (Winter). Deadlines for material and articles are the first day of each first named month, and the Newsletter is mailed to members early in the second named month.

Members can submit *Letters, Special Articles, Affiliate Society News, Laboratory Features, Reports,* or *Announcements* of *Meetings, Conferences,* and *Jobs Available.* Also, *Short Abstracts* from biomechanics society meetings and *Thesis Abstracts* can be published. In special circumstances a complete edition of the Newsletter can be devoted to the publishing of a Society's "Proceedings".

Submitted material must be in letter-quality print and computer scannable, or on a computer disk as a text-only file, and in English. Graphics or complex equations must be in camera-ready art form, and photgraphs must be black and white

Society abstracts should not be more than 250 words in length. They should be submitted with full details of the conference, and accompanied by any conference or society logos which could be printed as well.

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.

Thesis abstracts should not be more than one Newsletter page in length.

Thesis abstract corner

Direct Measurement of In Vivo Forces in the Anterior Cruciate Ligament during Activity: Studies in a Quadruped Model

by

John P. Holden

Department of Aerospace Engineering and
Engineering Mechanics
Degree: Doctor of Philosophy
University of Cincinnati

Supervisor: Edward S. Grood, Ph.D.

In vivo forces in the anterior cruciate ligament (ACL) of three adult goats were measured during a variety of activities, including standing, walking, trotting, and passive flexion- extension. Direct measurements of ACL force were made using a modified pressure transducer (MPT) implanted within the anteromedial band of the ligament. Knee joint flexion angle, ground reaction forces (GRFs), and speed of locomotion were measured simultaneously. The MPT was calibrated using anteroposterior displacement tests at six flexion angles, and calibration data were fit to a polynomial function of transducer output and flexion angle. ACL forces were calculated for 10 trials of level walking or trotting by each animal. Multivariate regression analyses were used to calculate partial correlations, adjusted for the effects of animal subjects, between speed and peak ACL force, and between speed and the average ACL force during the stance phase of gait.

The ACL was primarily loaded during the stance phase, with maximum forces occurring within the first 40% of the contact duration. ACL loading during stance was characterized by two peaks in walking and a single peak in trotting. Magnitudes of the peak ACL force ranged from 63 Newtons (N) to 124 N during walking and from 102 N to 150 N during trotting. The average ACL force during stance ranged from 34 N to 68 N in walking and from 46 N to 69 N in trotting. Force in the ACL during quiet standing ranged from 30 N to 61 N.

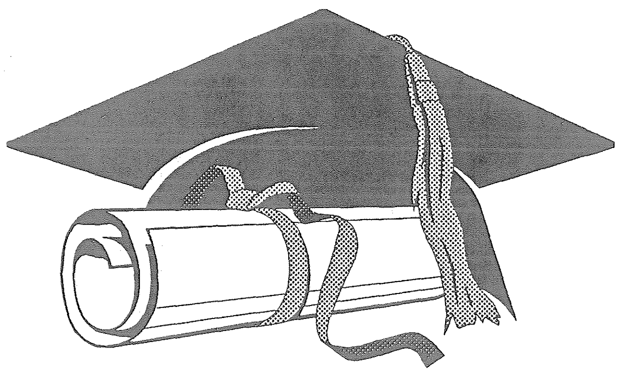
ACL force dropped to zero during the swing phase. In two animals, ACL forces remained small (< 15 N) throughout swing. In one animal, ACL loading occurred during late swing, near the time of maximum knee extension. This animal was also the only one that extended its knee to within 20 degrees of full extension during gait. During passive flexion tests on the anesthetized animal, ACL force rose sharply with knee extension beyond 40 deg (20 deg from full extension). During trotting by this animal, a linear correlation of -0.96 between the minimum flexion angle (i.e., extent of knee extension) and the peak ACL force in late swing was significantly different from zero ($p < .01$).

The partial correlation coefficient between speed and peak ACL force was .818. The partial correlation coefficient between speed and the average ACL force during stance was .539. Both coefficients were significantly different from zero ($p < .01$).

Both peak and average vertical GRFs (Fz) were greater in trotting than in walking. There was no similar increase with trotting, however, in either of the peaks (braking or propulsive) in the fore-aft GRF.

As a quantitative measure of the animals' use of the limb, Fz peaks on the instrumented limb were compared to the Fz peaks on the contralateral limb for trials at comparable speeds. On average, peak Fz forces on the instrumented limb were 89% of those on the unoperated limb.

Prior to the *in vivo* measurements, an *in vitro* calibration study was conducted in six left goat knees to examine the effects of flexion angle, tibial rotation, anteroposterior displacement rate, and tissue temperature on the MPT sensitivity to total ligament force. Changes in sensitivity with changes in flexion angle and tibial rotation varied from specimen to specimen. There were no significant differences in linear range sensitivity between any of four flexion angles from 0 to 70 degrees (measured from full extension). There was no significant change in sensitivity due to changes in displacement rate from 0.2 Hz to 2.0 Hz cycles. Differences in tissue temperature (22 C vs 37 C) produced a small positive offset in the output vs force curves, but had no significant effect on transducer sensitivity. The presence of the transducer within the ACL had no detectable effect on the force-length behavior of the ligament.



The shoulder mechanism: A dynamic approach

by

Frans C.T. van der Helm

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Degree: Doctor of Technical Sciences

Supervisor: Prof. dr.ir. Henk G. Stassen

The shoulder, consisting of collarbone (clavicula), shoulder-blade (scapula) and upperarm bone (humerus), is one of the most complex joints of the human body. It is a closed-chain mechanism due to the connection between chest (thorax) and shoulder-blade. This connection results in forced rotations and translations of the shoulder-blade. Motions of the shoulder are controlled by seventeen mostly poly-articular muscles with large attachment sites. Hence, parts of these muscles are functionally independent and muscle contractions result in simultaneous motions of several joints. Until recently, only qualitative knowledge of bony motions and muscle functions was available. This study has focussed on calculation of the forces and moments in several positions of the shoulder.

Extensive morphological measurements on both shoulders of seven human specimen has been performed. The segmental inertia, the three-dimensional positions of gross morphological structures, muscle architecture, muscle physiological cross-sectional area and muscle mass have been recorded. Using these data, model parameters for a detailed musculoskeletal model of the shoulder were estimated. In this model relevant morphological structures are represented by mechanical equivalents. Special attention has been given to the mechanical effect of muscles with large attachment sites and the sliding motion of the shoulder-blade over the chest. In this study the static positions of the shoulder bones have been recorded non-invasively using a specially developed spatial digitizer. Bony positions and external load on the arm are input variables of the model. In an inverse-dynamic simulation, muscle forces and joint reaction forces have been calculated using an optimization criterion. Calculated muscle forces are in reasonable agreement with recordings of the muscular electrical activity (EMG).

With this model muscle function during standardized arm elevations and during the push phase of manual wheelchair propulsion have been analysed. In addition, the effect of fusion angles between shoulder-blade and upperarm bone on the mobility area of the hand after a shoulder arthrodesis has been investigated. These simulations provide valuable insight in the function of morphological structures. The model is being used for improving diagnosis and treatment of shoulder complaints, and for ergonomic applications.

A Geometric Model of the Lumbar Spine in the Sagittal Plane

by

Claude Sicard

Département d'éducation physique
Université de Montréal
September 1991
Degree: Doctor of Philosophy

Supervisor: Micheline Gagnon

In the past, radiology has been the standard technique for obtaining the geometric configuration of the spine in different postures. It presents a high accuracy level but it involves high doses of radiation. The immediate goal of this research was to develop and validate a model for the reconstruction of the lumbar spine for any posture assumed in the sagittal plane.

The data were gathered on 27 subjects to study the relation between the geometric configuration of skin profile and lumbar spine. These subjects were randomly divided into two groups, the first group (20) for the development of the model, and the second group (7) for its validation. For each subject, anthropometric measurements and four lateral radiographs (standing, extension, half-flexion and flexion) were taken. For the detection of skin profile on radiographic images, thirteen radiopaque markers were placed over the skin in the middle of the back.

A descriptive analysis demonstrated than the indices of curvature of skin profile and those on the spine were significantly different and these differences varied as a function of the vertebral level and the posture. This analysis also revealed that the distance between the skin profile and the spine varied significantly as a function of posture. Finally, an interaction was noted between the orientation of skin profile and the orientation of the spine.

The model for the reconstruction of the lumbar spine involves three operations: deformation, rotation and translation of the skin profile. These operations were undertaken to take into consideration the differences in indices of curvature, orientation and distance between the skin profile and the lumbar spine. Ten regression

equations were developed with the first group (N= 20) and were used to predict these differences. The transformed skin profile was used for the reconstruction of the lumbar spine. A coordinate system was constructed on each segment. Subsequently, an anthropometric scaling technique was used to reconstruct each vertebra.

An error analysis of the model realized with the second group (N=7) has demonstrated an adequate level of accuracy for the absolute (1.68 to 1.82 cm) and relative (0.32 to 0.54 cm) linear positions of vertebrae as well as their absolute (2.6 to 6.7°) and relative (1.4 to 3.6°) angular positions except for T12; as for displacements, the validity of the model was limited to angular motions in flexion of the pelvis (12 $\pm$ 3 %), the entire lumbar spine (Ll/Sl) (14 $\pm$ 13 %) and the intervertebral motion of L4/L5 (13 $\pm$ 10 %).

The results of the present study have demonstrated that it was possible to reconstruct the lumbar spine with the skin profile for any posture assumed in the sagittal plane. The data are very useful, especially in models designed to evaluate loadings on the lumbar spine.

This thesis is available in French only. The complete reference is: Sicard, Claude (1991). Modélisation géométrique de la colonne Iombaire dans le plan sagittal. Thése de doctorat, Université de Montréal, 298 pp.

Calendar of scientific events

November 2-6, 1992
The Fifth International Conference on Environmental Ergonomics, Maastricht, The Netherlands. Contact: George Havenith/Wouter Lotens, Fifth Int. Conf. on Environmental Ergonomics, TNO-Institute for Perception, P.O.Box 23, 3769 ZG Soesterberg. Tel:+31-3463-56211; Fax:+31-3463-53977
E-mail: fifth-ee@izf.tno.nl

December 2-4, 1992
Seventh International Conference on Biomedical Engineering, National University of Singapore. Secretary: 7th ICBME 1992, Dept. Orthopaedic Surgery, National Hospital, Lower Kent Ridge Road, Singapore 0511. Tel: (65) 772 4424; Fax: (65) 778 0720.

April 1-2, 1993
International Seminar on Biomechanics and Joint Replacement in the Upper Limb, London. Contact: Conferences Services, IMechE Headquarters, 1 Birdcage Walk, London SW1H 9JJ, U.K.
Tel: +44 71 973 1318/1316; Fax: +44 71 222 9881; Telex: 917944.

June 14-18, 1993
IEA World Conference on Ergonomics of Materials Handling, Warsaw, Poland. Contact: EMH '93 Secretariat, Center for Industrial Ergonomics, University of Louisville, Louisville, KY 40292, USA. Tel: +1 (614) 292-6670; Fax: +1 (614) 292-7852; E-Mail: marras@CCL2.Ohio-state.edu

June 30 - July 3, 1993
Second International Symposium on 3-D Analysis of Human Movement, Poitiers, France. Contact: Paul Allard, PhD, International Symposium on 3-D Analysis of Human Movement, Centre de recherche Hôpital Sainte-Justine, 3175 Côte Ste-Catherine, Montréal, PQ, H3T 1C5, Canada.
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E-mail: aissaoui@ere.umontreal.ca

June 30 - July 2, 1993
IVth International Symposium on Computer Simulation in Biomechanics, Paris France. Contact: B. Landjerit, Laboratoire de Bioméchaniique, E.N.S.A.M., 151 Boulevard de l'Hôpital, 75013 Paris, France. Tel & Fax: 33.1.44.24.63.65.

July 4-8, 1993
XIVth Congress of the International Society of Biomechanics (ISB), Faculté de Médicine Pitié-Salpêtriè, Boulevard de l'Hôpital, Paris 13e, France. Congress Office: Convergences - I.S.B. '93, 120, avenue Gambetta, 75020 Paris, France. Fax: (33-1) 40.31.01.65; Telex: 216911 F.

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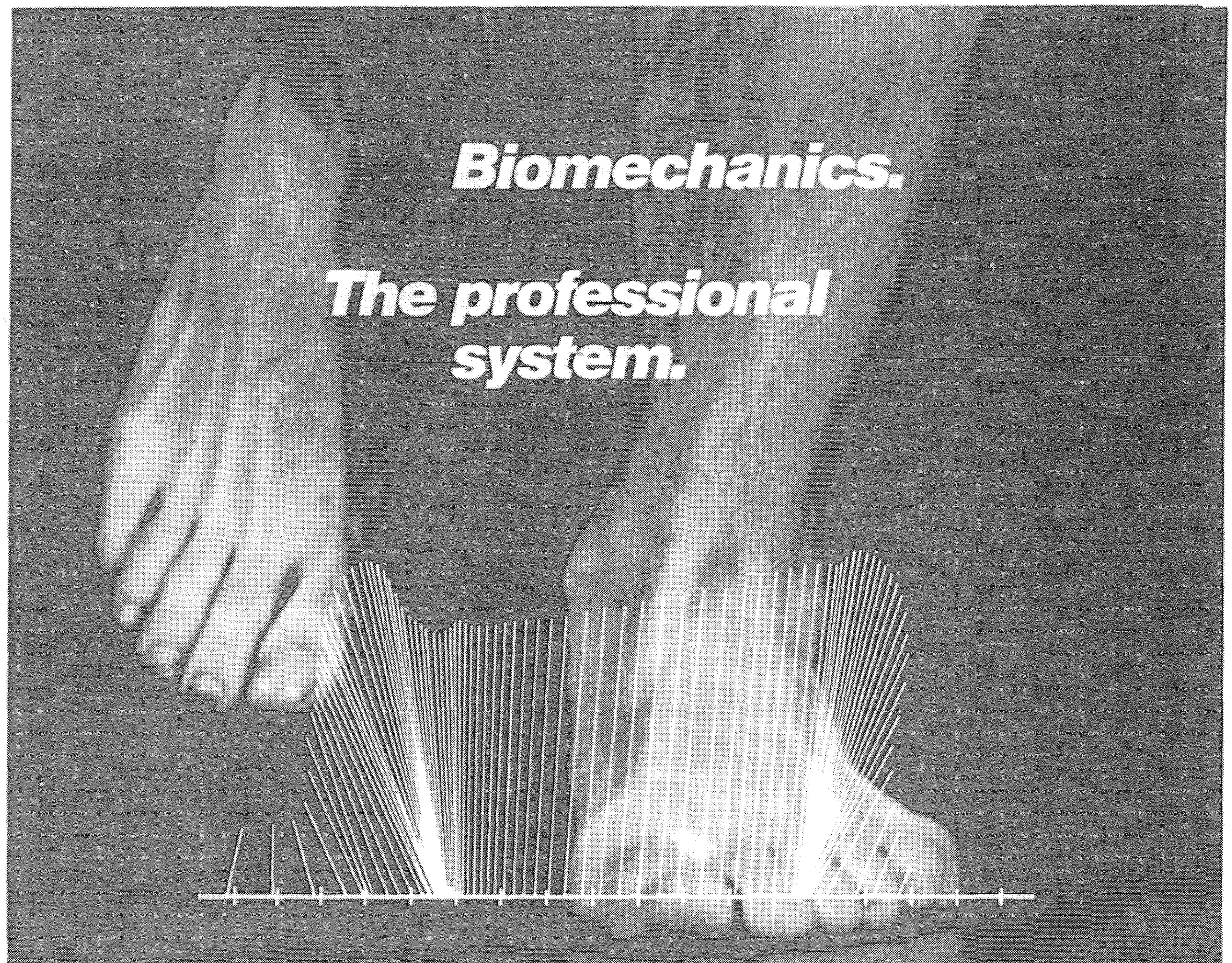

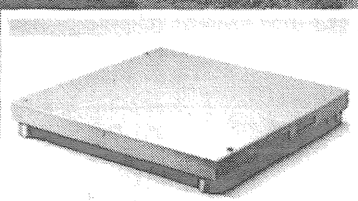

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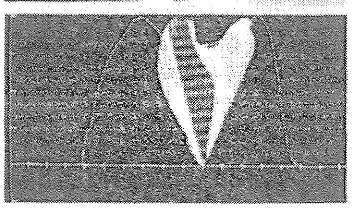

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