ISB

International Society of Biomechanics Newsletter

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ISB Officers

PRESIDENT
Dr. Ronald Zernicke
University of Calgary
Department of Surgery
3330 Hospital Drive N.W.
Calgary, Alberta T2N 4N1
CANADA
Tel: + 1 403 220-8666
Fax: + 1 403 283-5666
E-Mail: zernicke@acs.ucalgary.ca

PRESIDENT-ELECT
Dr. Peter R. Cavanagh
The Centre for Locomotion Studies
Room 10, I.M. Building
Pennsylvania State University
University Park, Pennsylvania
U.S.A. 16802
Tel: + 1 814 865-1972
Fax: + 1 814 863-4755
E-Mail: prc@ecl.psu.edu

PAST PRESIDENT
Dr. Aurelio Cappozzo
Istituto Di Fisiologia Umana
Universtà Degli Studi 'La Sapienza'
Piazzale Aldo Moro, 5
Roma
ITALY I-00185
Tel: + 39 6 490673
Fax: + 39 6 4452303
E-Mail: cappozzo@itcaspur.bitnet

SECRETARY-GENERAL
Dr. Christopher L. (Kit) Vaughan
University of Virginia
Motion Analysis Laboratory
2270 Ivy Road
Charlottesville, Virginia
U.S.A. 22903
Tel: +1 804 982-0893
Fax: +1 804 982-1727
E-Mail: kvaughan@virginia.edu

TREASURER and
NEWSLETTER EDITOR
Dr. Graeme A. Wood
Department of Human Movement
The University of Western Australia
Nedlands, WA 6009
AUSTRALIA
Tel: + 61 9 380-2361
Fax: + 61 9 380-1039
E-Mail: gwood@uniwa.uwa.edu.au

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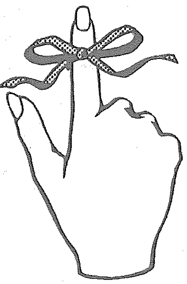
AFFILIATE SOCIETIES OF ISB:
American Society of Biomechanics; British Association of Sports Science; Bulgarian Society of Biomechanics; Canadian Society of Biomechanics; China Sports Biomechanics Association; Czechoslovak Committee on Biomechanics; French Société de Biomécanique; Japanese Society of Biomechanics; Korean Society of Biomechanics; Polish Society of Biomechanics; Romanian Comisia de Biomecanica, Inginerie Si Informatica.

FROM THE TREASURER - Graeme A. Wood

From time to time the Society receives a request for its 'Membership list'. Our policy is that if the organisation is an Affiliate Society, a Biomechanics Conference Organiser or appropriate non-profit group then we readily obligue and in doing so ask for a return copy of their 'list'. We are equally cooperative with our official Sponsors and Supporters but other commercial bodies are politely refused, and in no instance do we release a computer diskette containing the list in case it gets passed along to others. If, however, you do not wish to have your name and address distributed to those indicated could you please so advise the Treasurer and your name will be 'hidden' during such print-outs.

Fogotten Something ?

Are you one of the members who has not yet paid 1994 dues?



Unfortunately your Society can't operate on good intentions alone!

Mail or Fax your Renewal Form back to the Treasurer Today
(If it's hopelessly buried on your desk then ask for a new copy)

Are you one of the 'silent majority' who have yet to renew their ISB Membership? If the address label on the envelope that contained this newsletter had an 'X' at the top right-hand corner then the answer is "Yes", and I hope to be hearing from you very soon !

XVth CONGRESS UPDATE

XVTH Congress of ISB July 2.-6. 1995 at the University of Jyväskylä, Finland

The preparations for the ISB XV are active at the moment. The Second Announcement will be delivered to the members of ISB no later than August 15th, 1994. We wish to remind the Biomechanists that ISB XV is expecting two page abstracts to be submitted no later than December 15th, 1994. Notification to authors about acceptance or rejection will be given no later than March 15th, 1995. Deadline for preferential fee is April 15th, 1995. Deadline for registration by mail is June 15th, 1995. On-site registration will start with the start of the congress itselft on July the 2nd, 1995.

Some representatives of the ISB XV congress organisation will be present at the Biomechanics congress in the Netherlands this summer and 2nd Announcement brochures will also be available at the time of that Congress.

The ISB XVth Scientific Programme is planned to include 5 parallel two-hour podium sessions in the morning and similarly in the afternoon, totalling 2*5*8 papers=80/day. Poster presentations independent from the podium presentations will be given in two parallel sessions (50+30) twice a day, totalling 2*50+30 papers=160/day. Key-Note lectures (six) will start at 8.30am and 1.30pm each day except Wednesday (5th). The Muybridge address will be on Wednesday at 8.30am. The Wartenweiler memorial lecture will be on Sunday (July 2nd) just after the opening ceremonies. While there will be one day for partly leisure activities (Wednesday, July 5th) the convenient maximum of papers during the Congress would be around 280 oral presentations and 480 poster presentations, totalling 760 papers. The amount of papers can be increased, if necessary.

All abstracts submitted for the Congress will be blind reviewed before acceptance. Maybe this means that it is somewhat more difficult to have a paper presented at ISB XV than was the case in ISB XIV.

Contact Address by Mail:
XVth ISB Congress
Jyväskylä Congresses[6]
P.O. Box 35
FIN-40351 Jyväskylä
FINLAND

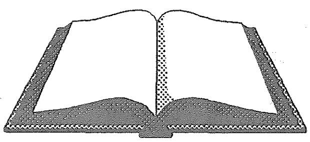
Contacts by Telephone:
Secretariat (Ms. Multasuo) +358 41 603664
Secretary General (Dr. Keskinen +358 41 602056

Contacts by Fax:
Secretariat (Ms. Multasuo) +358 41 603621
Secretary General (Dr. Keskinen) +358 41 602031

Contacts by Email:
Congress Secretariat MULTASUO@tkserver.jyu.fi
(Congress Secretariat TVANTTIN@jyu.fi)
Secretary General KESKINEN@pallo.jyu.fi

JYVÄSKYLÄ CONGRESSES

ISB PUBLICATIONS



The following Society publications can be obtained at the special rates shown by writing to the person concerned with sales and distribution.

BOOK OF ABSTRACTS, XIVth Congress of the International Society of Biomechanics.
Price: 550 FF plus postage
Supplier: Professor S. Metral
Explorations Fonctionnelles du Systeme Nervuux
C.H. Bicetre
78 Avenue du General Leclerc
94275 Kremin Bicetre, FRANCE
Fax: (33.1) 45.21.27.14

BOOKS OF ABSTRACTS, XIIth and XIIIth Congresses of the International Society of Biomechanics.
Price: $AUS 40 plus postage ($AUS40 airmail) ea.
Supplier: Graeme A. Wood
Department of Human Movement
The University of Western Australia
Nedlands, WA 6009, AUSTRALIA
Fax: +61 9 380-1039

BIOMECHANICS XI-A and XI-B, Proceedings of the XIth Congress of the International Society of Biomechanics.
Price: 200 Dfl (includes both volumes and postage - please send cashier cheque)
Supplier: Peter Hollander
Faculty of Human Movement Sciences
Vrije Universiteit
van de Boechorststraat 9
1081 BT Amsterdam
THE NETHERLANDS
Fax: +31-20-6442043

BIOLOCOMOTION: A CENTURY OF RESEARCH USING MOVING PICTURES, edited by A.Cappozzo, M.Marchetti and V.Tosi (ISB Book Series-Volume 1; Hard-bound, 356 pages, 180 b&w and 7 colour figures).
Price: $AUS 65 plus postage ($AUD 20 airmail)
Supplier: Graeme A. Wood
(address as above)

BIOMECHANICS IN SKIING

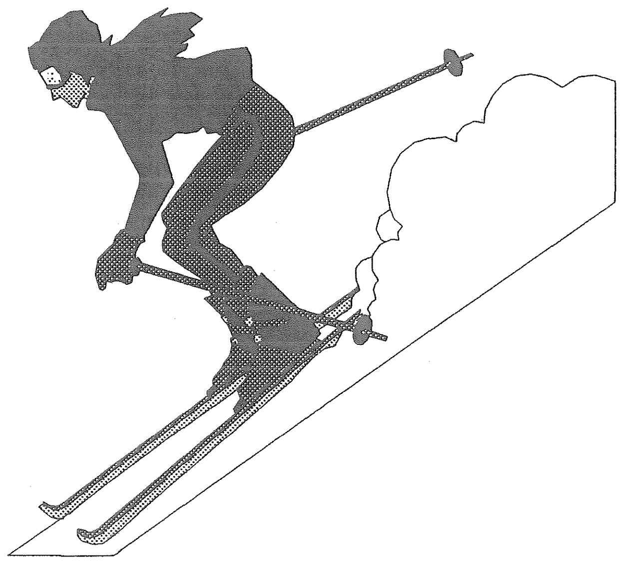
Reort on a Workshop in St. Christoph, Austria
March 2-6, 1994

A new group, which was founded during the ISB Conference in Paris, met for the first time for a workshop in Austria. The group comprised 17 researchers from the USA, Spain, Germany and Austria who were interested in biomechanical research in skiing.

The goal of the meeting was to exchange experiences with measurement methods applied to the investigation of skiing and to discuss results of prior research. Four topics were addressed: (1) movement analysis and related problems (kinematics, kinetics, EMG), (2) calculation of joint loading (i.e. knee), (3) use of biomechanics in training (identification of performance-determining factors, development of performance-enhancing exercises), (4) testing procedures for equipment (i.e. skis and boots).

Since the feedback of the participants was very positive, it was decided to have such a meeting on a regular basis (once a year). If anybody is interested in participating in further activities of this group, please contact:

Dr Erich Mueller
Institut für Sportwissenschaften
Universitaet Salzburg
Academiestrasse 26
A-5020 Salzburg
Tel: +43-662-8044-4852
Fax: +43-662-8044-614



THE PROFILE OF THE ISB AFFILIATED SOCIETIES

by Micheline Gagnon, ISB Affiliated Societies Officer

The ISB now includes 11 Affiliated Societies, 3 of these having recently joined our ranks and coming from Bulgaria, Japan and Romania. The geographical distribution is as follows: in Asia, 3 societies representing China, Japan and Korea with over 1200 members (data from Korea not available); in America, 2 societies from Canada and the United States with 751 members; in Eastern Europe, 4 societies representing 5 countries, Bulgaria, the Czech and Slovak republics, Poland and Romania, with 321 members; in the European Economic Community, 2 societies from France and Great Britain with 350 members. The Affiliated Societies have very diverse interests: a large number of the societies are devoted to sport biomechanics, others to engineering and informatics; certain societies do assume a particular vocation in specialized areas, for instance human locomotion; other societies do cope with biomechanics in its broadest sense.

I have requested the information about all our societies (history, membership, structure) in the past years and I received a large response. This could be in the interest of the reader-ship to share this information. I have organized this information according to geographic areas and countries, in alphabetical order. In some cases, the information may not be updated and I apologize for it.

ASIA

. The Chinese Society of Sports Biomechanics

It is comprised as one branch of the Chinese Society of Sports Science. Its objectives are the improvement of research in biomechanics, of the educational level in sports biomechanics and of the performance of sports and skill; the strengthening of health; the development of International Sports Biomechanics. Its 425 members are researchers, teachers or coaches. There are 29 Council members from diverse areas of the country. The president is Mr. Huang Zongcheng.

. The Japanese Society of Biomeehanics

This Society was established in 1978 on the basis of a 20-year history of the Kinesiology Research Society. It functions as the Biomeehanies section of the Japanese Society of Physical Education. Its objectives consist of promoting scientific research on human move-ment and of fostering the growth of biomechanics. The Society has hosted the 8th ISB Congress at Nagoya in 1981; it holds a biennial national meeting and publishes the Japanese Journal of Sports Sciences. There is an Executive Committee of 10 members; there are 769 members. The chairman is: Dr. Masahiro Kaneko.

. The Korean Society of Sports Biomechanics
(No information provided)

NORTH AMERICA

The Canadian Society for Biomechanics

The Society was formed in 1973. Its objective is to foster research and the interchange of ideas in the study of the biomeehanics of human movement. The Society has 190 members, 40% of them being student members, and they represent diverse backgrounds including therapists, physicians, engineers, sport researchers and ergonomists. The main activity is the organization of the biennial conference altogether with the symposium on Human Locomotion. It biennially awards one Open and one Masters New Investigator Award. On two occasions, in 1987 and 1993, the meeting has been held in eonjunetion with the Congress of the American Society of Biomechanies under the name of NACOB (North American Congress on Biomechanics). The Executive is comprised of five officers plus a student representative. The president is: Dr. Mario Lafortune.

See ISB Newsletter, Issue no 40, nov./dec. 1990, p. 3 for more information on this society.

. The American Society of Biomeehanics

The Society was rounded in 1977. Its objectives consist of providing a forum for the exchange of information and ideas among researchers in biomechanics working in different fields of application. The principal activity of the Society is an annual scientific meeting addressing a wide range of topics in biomeehanies. It is also affiliated with the Journal of Biomechanies. It annually awards the Giovani Boreiii Award, a Post-doctoral and a Pre-doctoral Young Scientist Award and a Travel Fellowship. The Society has 561 members which includes regular, student and corporate categories; they come from 5 different discipli-nary categories including biological sciences, engineering and applied physics, ergonomics and human factors, exercise and sport sciences, or health sciences. The Executive Board is made of 9 officers. The president is Dr. Thomas Brown; the past-president is Ron Zernicke.

EASTERN EUROPE

. The Bulgarian Society of Biomechanics

The Society was rounded in 1991 and includes 42 members. Its objectives consist of helping scientific and applied investigations in biomechanics, helping the biomechanics specialists in their teaching and qualification and supporting contacts with specialists in other countries. The members come from several fields of interest in biomechanics, orthopaedics, traumatology, sports, robotics, etc. They organize national and international scientific events, annually award the best

Bulgarian publication, support fellowships. More specifically, the Society has helped in the creation of a department of biomechanics at the South-West University in Blagoevgrad; it is also involved in an international joint research project titled "Science to help the disabled people in Bulgaria". The Society is an associate member of the European Society of Biomechanics. The board of managers comprised the president Dr. Yuli Toshev, the vice-president and the secretary.

See ISB Newsletter Issue, no 45, Feb./March 1992, p. 10.

. <u>The Czech and Slovak Society of Biomechanics</u>

From January 1993 there should have been a separated Czech Society but I have not been notified of any change yet. The Society has been formed in 1991 and the president is profes-sor Vladimir Karas. There is an Executive Board of 5 officers. The objective of the Society is to support the development of individual fields of science with a coherence to biomecha-nics, to assert biomechanics as a branch of science, to favour the exchange of findings and opinions and to cooperate with foreign organizations of similar focus. Some of its main activities are the organization of lectures, conferences, seminars and the facilitation of publications in editing non periodical publications. The Society has 153 members.

Within its structures the Society has a liaison Committee for international relations in general and in charge of the contacts with ISB, in particular. One of the main activities of the Committee is the biennial organization of international conferences on the theme "Biomechanics of Man". It includes 20 members and its chairman is Dr. Vratislav Kafka who is also the vice-president of the Czech and Slovak Society of Biomechanics.

. <u>The Polish Society of Biomechanics</u>

Its objectives consist of promulgating and promoting the development of biomechanics as well as aiding its propagation in technology, medicine and sports and it is affiliated with the Polish Academy of Sciences. It was rounded in 1987. It includes 106 members representing all major university centers and also biomechanics practitioners mainly in sport, rehabilitation and ergonomy. Every year it organizes a scientific-educational event called School of Biomechanics and every four years this event is replaced by another scientific event, the Polish Conference of Biomechanics. It also stimulates and aids scientific publications; for instance, it is the co-publisher of the scientific quarterly "Biology of Sport". The structure of the Society is made of the Executive Council, the Supervisory Commission and the Arbitration Board. Its president is Professor Kazimierz Fidelus.

See ISB Newsletter Issue no 45, Feb../March 1992, p. 9.

. <u>The Commission for Biomechanics, Engineering and Informatics of Romania</u>

It is a national organization devoted to the promotion and stimulation of the development of biomechanics in relation to engineering and informatics. It includes 20 members who are specialists from different fields of activity including biology, medicine, engineering, informatics, sports methodology and who have a mutual interest for physical activities and sports. Among its activities, the commission works at the creation of a data bank on problems of biomechanics, modelling and simulation; it supports or organizes scientific events. The activities are conducted in accordance with the Statute of the Council for Sport Science of Romania. There is a Board of 5 persons and the president is Mr. Vladimir Schor.

THE EUROPEAN ECONOMIC COMMUNITY

. <u>The British Association of Sport and Exercise Sciences (BASS)</u>

The BASS was formed in 1984 when three existing bodies, the Sports Sciences Society, the Sports Biomechanics Study Group, and the British Society of Sports Psychology, united. Its alms are the promotion of the scientific study of sport, the facilitation of communication amongst the researchers involved in the theoretical and practical aspects of sport, and the dissemination and application of information. The Executive Committee is comprised of seven officers: the chairperson, Dr. Roger Bartlett; the secretary; the treasurer and one chair-person for each of the four sections represented by Sports Biomechanics, Sports Physiology, Sports Psychology and Open.

Only the section Sports Biomechanics is afffliated to ISB. Its main objective is to promote interest in and understanding of the inter-relationships between mechanical principles and sports activity and to develop biomechanical techniques in evaluating performance. There are 378 members of BASS, 150 of whom with biomechanics as an area of interest.

The main activities of BASS include the organization of an Annual Conference, the contribution to student development by organizing student conferences among other activi-ties, the organization of multidisciplinary meetings, the publication of the Journal of Sports Sciences. The Biomechanics chairperson is Dr. James Watkins.

. <u>La societe de biomecanique (France)</u>
(No information was provided)

See ISB Newsletter Issue no 36, Autumn 1989, p. 5.

Special feature article

PROPOSALS FOR DEFINITION OF JOINT COORDINATE SYSTEM OF VARIOUS JOINTS

Coordinated by Ge Wu

March 21, 1994

The ISB Standardization and Terminology Committee has distributed a draft Recommendation for Standardization of Reporting of Kinematics data (ISB Newsletter #47, August/ September, 1992). The standard involves a basic set of definitions for joint coordinate systems (JCS).

I have been asked by Dr. Peter Cavanagh, Chair of the Committee, to communicate with people who wish to be involved in the definition of JCS. Since November 1993, about seven groups have been established. They included: spine, shoulder, wrist and hand, ankle, TMJ, whole body, and animal. Some of those groups have forwarded the proposals to me and I am grateful to them (see below).

Due to the page limitation, following are the proposals for the spine, wrist and hand, shoulder, and whole body. The proposals for other joints will appear in the next issue of the ISB Newsletter. In addition, anyone who is interested in working on other joints besides the ones as listed above please contact me at (814)865-1972, or via e-mail at gxw9@psuvm.psu.edu.

1. Proposal for definition of a joint coordinate system for the wrist and hand

by Frederick W. Werner and Bryan Buchholz

SCOPE: This document defines a joint coordinate system for three dimensional rotational and translational motions in the hand and wrist. It is only one component of an overall standard being developed by the ISB on how to report kinematic data.

SIGNIFICANCE: In the study of joint kinematics, it is important to have common terminology that can be used by different investigators. Measurements by one research group, perhaps using a new methodology, can thus be compared to those by other groups.

RATIONALE: This document is based upon the ISB Standardization and Terminology Committee's recommendations for standardization in the reporting of kinematic data (draft version 4.1, 4/3/92). This document addresses only parts 2 and 5 of the ISB proposed standard. Part two requires a definition of the segmental local center of mass reference frames, and part five requires a definition of a method for expressing the relative attitudes of the body segments with respect to each other. The other parts of the proposed standard cover a definition of the global reference frame (part 1), global displacements (part 3), global attitudes (part 4), and joint moments (part 6).

Separate coordinate systems have been developed for each bone that is distal to the elbow, so that relative motion between any two adjacent segments may be described. These systems are then also applicable to global wrist motion as well as to motion of the individual components that cause the global motion. Global wrist motion is typically considered as the motion of the second and/or third metacarpal with respect to the radius and is achieved by movement of the carpal bones with respect to the radius as well as the numerous articulations of the eight carpal bones with respect to each other. Some researchers who only examine global wrist motion and have no need to examine carpal motion, can still use the definitions given for the radius and the metacarpal bones to describe wrist motion.

The ISB committee proposal recommends that orthogonal triads be fixed at the segmental center of mass. In the hand and wrist, the center of mass is simply not known for most of the segments or bones. Data from cadaver studies do exist that describe the center of mass location for the forearm and hand as a proportion of the entire length of each of these segments. These center of mass definitions may be fine for global wrist motions, but can not be used to describe the kinematics of the component parts. The phalanges can not be ignored and many researchers are examining individual movement of the carpal bones or movement of the radius with respect to the ulna. Therefore for this joint coordinate system application, the location of the orthogonal triad on each bone is primarily based on bony landmarks and is usually located at the axial center for long bones or the volumetric centroid for the carpal bones. (CT scans might be used to define the volumetric centroid, however this method may not be available or necessary for all applications.) If the center of mass location is necessary and defined, the origin may be translated from the bone center to the center of mass.

DEFINITION OF SEGMENTAL LOCAL CENTER OF MASS REFERENCE FRAME

For each bone, a coordinate system is given, assuming that the forearm is initially in the standard anatomical position, with the palm forward (anterior), and the thumb lateral. The dorsum of the hand and forearm face posteriorly. In general, the positive Yi axis is directed proximally, and the positive Zi axis is directed to the right.

ULNA: The origin of the coordinate system is located midway between the distal ulna, at the level of the dome of the ulnar head; and the proximal ulna, at the level of the coronoid process. In the transverse plane it is at the approximate center of the tubular bone (at its moment of inertia). Since the Yi axis is directed proximally, the negative Yi axis is directed along the long shaft of the ulna from the specified origin to intersect with the center of the dome of the ulnar head. The positive Xi axis is directed anteriorly, oriented in the direction of the tuberosity of the ulna. The positive Zi axis is mutually perpendicular to the other two as defined by the right hand rule.

RADIUS: The origin of the coordinate system is located midway between the distal radius, at the level of the ridge between the radioscaphoid fossa and the radiolunate fossa; and the proximal radius, at the level of the depression in the proximal radial head. In the transverse plane it will be at the approximate center of the tubular bone (at its moment of inertia). Since the Yi axis is directed proximally, the negative Yi axis is directed along the long shaft of the radius from the specified origin to intersect with the ridge of bone between the radioscaphoid fossa and the radiolunate fossa (midway dorsally and palmarly along the ridge). The positive Zi axis is directed perpendicular to the Yi axis, to the right, in a plane defined by the tip of the radial styloid, the base of the concavity of the sigmoid notch and the specified origin. The positive Xi axis is mutually perpendicular to the other two as defined by the right hand rule.

CARPAL BONES: The eight carpal bones, scaphoid, lunate, triquetrum, pisiform, trapezium, trapezoid, capitate, and hamate, will be considered simultaneously. Most researchers only report angular changes in carpal bone motion and use the neutral wrist position as a neutral reference position. The neutral wrist position is when the wrist is in neutral flexion/extension and neutral radial/ulnar deviation such that the third metacarpal long axis is parallel with the Yi axis in the radius. These researchers define the motion relative to the radius and typically not the ulna. Therefore the orientation of the coordinate systems for each carpal bone should be parallel with the radius coordinate system when the wrist in the neutral position, using the previously defined convention for Xi, Yi, and Zi. At present, most researchers who need to define a coordinate system origin in a carpal bone use the volumetric centroid of the bone. Therefore it is proposed that, when necessary, the origin of a coordinate system in a carpal bone be located at the volumetric centroid of the bone.

METACARPALS: The five coordinate systems for the five metacarpals are described in the same manner. The major differences in the metacarpals are in the shape of their bases where "contact" with the carpals is made and their relative movement capabilities. In this regard, the first metacarpal has a very large range of motion. The third metacarpal has special significance because of its use in the definition of global wrist motion. Most researchers consider either the second or third metacarpal as representative of hand motion.

The origin for each of these coordinate systems is located midway between the base and head of each metacarpal. In the transverse plane, it will be at the approximate center of the tubular bone (at its moment of inertia). The positive Yi axis will be directed proximally, parallel to a line from the center of the distal head of the metacarpal to the midpoint of the base of the metacarpal. The positive Xi axis will be directed palmarly. The Xi and Yi axes will form a sagittal plane that splits the metacarpal into mirror images. The positive Zi axis will be directed laterally, perpendicular to the Xi and Yi axes.

PHALANGES: The fourteen coordinate systems for the phalanges of the five digits can be described in a manner that is analogous to the description used for the metacarpal systems. The proximal and middle phalanges for the five digits are similar in shape as are the five distal phalanges.

<u>Proximal Phalanges</u>: The origin for each of these coordinate systems is located midway between the base and head of each phalanx. In the transverse plane, it will be at the approximate center of the tubular bone (at its moment of inertia). The positive Yi axis will be directed proximally, parallel to a line from the center of the distal head of the proximal phalanx to the center of the distal head of the metacarpal. The positive Xi axis will be directed palmarly. The Xi and Yi axes will form a sagittal plane that splits the phalanx into mirror images. The positive Zi axis will be directed laterally, perpendicular to both the Xi and Yi axes.

<u>Middle Phalanges</u>: The origin for each of these coordinate systems is located midway between the base and head of each phalanx. In the transverse plane, it will be at the approximate center of the tubular bone (at its moment of inertia). The positive Yi axis will be directed proximally, parallel to a line from the center of the distal head of the middle phalanx to the center of the distal head of the proximal phalanx. The positive Xi axis will be directed palmarly. The Xi and Yi axes will form a sagittal plane that splits the phalanx into mirror images. The positive Zi axis will be directed laterally, perpendicular to both the Xi and Yi axes.

Distal Phalanges: The origin for each of these coordinate systems is located midway between the base and head of each phalanx. In the transverse plane, it will be at the approximate center of the tubular bone (at its moment of inertia). The positive Yi axis will be directed proximally, parallel to a line from the center of the unguis of the distal phalanx to the center of the distal head of the middle phalanx. The positive Xi axis will be directed palmarly. The Xi and Yi axes will form a sagittal plane that splits the phalanx into mirror images. The positive Zi axis will be directed laterally, perpendicular to both the Xi and Yi axes.

DEFINITION OF METHOD FOR EXPRESSING RELATIVE ATTITUDES OF TWO SEGMENTAL COORDINATE SYSTEMS

The methods of Grood and Suntay (1983) will be used to express the relative attitudes of two coordinate systems whenever possible. Applying these methods to the global wrist, interphalangeal, metacarpophalangeal, intercarpal, and radiocarpal joints is straight forward. A neutral posture can be defined as the position where the orientations of the proximal and distal segmental systems are identical. Flexion-extension will occur about the Zi-axis (proximal), rotation (pronation-supination) will occur about the Yj-axis (distal) and abduction-adduction (radio-ulnar deviation) will occur about the floating axis. This method allows for a relative attitude description that corresponds to clinical terminology.

Different methods will be needed for the five carpometacarpal joints and the radioulnar joint. The problem that arises with these joints is that the clinically neutral posture does not correspond to a position where the orientations of the proximal and distal segmental systems are identical for some of these joints. This problem can be overcome by stating the neutral posture using Grood and Suntay's method via an intermediate coordinate system, e.g. Cooney et al. (1981) described the neutral position of the trapeziometacarpal joint as being flexed 48 degrees, abducted 38 degrees and pronated 80 degrees with respect to the third metacarpal. In the case of the radioulnar joint, the Yi axes of the radius and ulna are not parallel. However, they only diverge by a few degrees depending upon the subject. Also, neither the radius or ulna can be considered proximal to the other. Therefore we are defining the motion between the radius and ulna as motion of the radius with respect to the ulna. The neutral position for the radius and ulna is clinically called neutral forearm rotation. With the elbow flexed to 90 degrees, this position can be visualized as when the thumb is pointing to the shoulder. In the standard anatomical position, the radius is supinated about the ulna. For the radioulnar joint, we propose an intermediate coordinate system whose origin is identical with the radial coordinate system origin. The orientation of this intermediate coordinate system will be identical to the ulnar coordinate system when the forearm is in neutral forearm rotation. The motion of the radius with respect to the ulna will then be described using the flexion/extension, radioulnar deviation, and pronation/supination definitions given above but using the intermediate coordinate system of the radius and the ulnar coordinate system. The user of this standard should define the orientation of the intermediate coordinate system relative to the anatomically based radial coordinate system.

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Grood and Suntay (1983) A joint coordinate system for the clinical description of three-dimensional motions: Application to the knee, *J Biomech Eng* 105A, 136-144.

2. Proposal for definition of a joint coordinate system for the spine

by Ian Stokes, Wafa Skalli, and André Plamondon

This proposal is based on recommendations made in a report presented to the Scoliosis Research Society by THE SCOLIOSIS RESEARCH SOCIETY WORKING GROUP ON 3-D TERMINOLOGY OF SPINAL DEFORMITY (Ian A.F. Stokes, Chair) (to be published in Spine)

These recommendations deal with some special cases of axis definition for use in biomechanics relevant to the axial skeleton. Biomechanics of the spine sometimes deals with the individual vertebrae (for which a local axis system is defined) and sometimes with the entire trunk (for which a spinal axis system is defined).

These recommendations for axis system definition are based on those made previously to the Scoliosis Research Society. The axis system uses the principle of ISO 2631 in which X is forward, Y left and Z up. A right-hand convention is used. (Note that in the axial skeleton there is no possibility of using different systems for the two sides of the body). This is different from the draft ISB system, which has X forwards, Y up and Z right. However. if the draft system is confirmed, the system presented here could readily be adapted to the ISB system, using the same landmarks, but altered conventions for axis names and directions.

The choice of points to define axis systems is based on a compromise between using bony landmarks (which are often inaccessible), and using surface markers (which are often imprecise).

Local axis systems (Vertebra axis system x_v,y_v,z_v) (Figure 1a).

This axis system aligns with the assumed plane of symmetry of a vertebra. In deformed or asymmetric vertebrae it is aligned with identifiable landmarks on the vertebral endplates and pedicles.

Definition: The origin is at the centroid of the vertebral body (half way between the centers of the two endplates), the local 'z' axis passes through the centers of the upper and lower endplates, the 'y' axis is parallel to a line joining similar landmarks on the bases of the right and left pedicles.

Spinal axis system (spinal x_s,y_s,z_s) (Figure 1b)

The spinal axis system has the origin and sagittal plane defined by the pelvis, with a line parallel to the plane containing the anterior superior iliac spines (ASIS) defining the transverse global (Y) direction. (For static x-ray studies, alignment would be achieved by positioning the ASIS parallel to the film plane.) The apparently more logical approach of aligning the axes with the sacrum or hip joint was not accepted for practical reasons.

Definition: The origin is at the center of the upper endplate of S1, the 'z' axis passes through the center of a specified vertebral body (usually C7 or TI), and the 'y' axis is parallel to the vertical plane containing the ASIS.

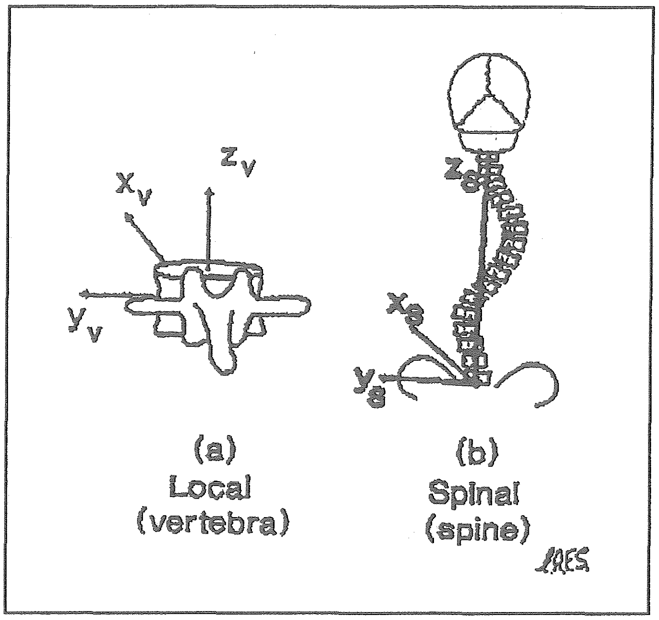

Figure 1: The two coordinate systems defining spinal geometry; (a) Local coordinates based on a vertebra. (b) Spinal coordinates, defined by the Z_s axis passing through the centers of the most caudal and cephalad vertebrae of the entire spine with its origin at the base of the spine (SI), and the Z_s axis directed towards a chosen vertebra at the top of the spine.

Submitted by:

Ian Stokes - stokes@med.uvm.edu;
stokes@ensam-paris.fr
Wafa Skalli - skalli@ensam-paris.fr
André Plamondon - aplamondon@nickel.laurentian.ca

3. Proposal for definition of joint coordinate system for the whole body
by Fred Yeadon

Whole body orientation may be defined by successive rotations about lateral, frontal and longitudinal axes. For aerial movement the terms somersault and twist are already in use and correspond to rotations about an axis fixed in space for somersault and a longitudinal body axis for twist. In the Cardan system described, the lateral axis is considered to be initially aligned with the somersault axis. Angles may be determined from film data as described in:

Yeadon, M.R. 1990. The simulation of aerial movement - I. The determination of orientation angles from film data. *Journal of Biomechanics*, 23, 59-66.

There are advantages to defining the longitudinal axis in such a way that changes in body configuration have minimal effect on the body axes. This may be done as described in Appendix 2 of:

Yeadon, M.R. 1990. The simulation of aerial movement - III. The determination of the angular momentum of the human body. *Journal of Biomechanics*, 23, 75-83.

This choice of longitudinal axis corresponds approximately to the axis of minimum moment of inertia which is used in a theoretical analysis of whole body aerial movement in:

Yeadon, M.R. 1993. The biomechanics of twisting somersaults. Part I: Rigid body motions. *Journal of Sports Sciences*, 11, 187-198.

As a consequence it is better to define the twist or longitudinal axis as the axis of minimum moment of inertia for aerial movement as in:

Yeadon, M.R. 1993. The biomechanics of twisting somersaults. Part IV: Partitioning performances using the tilt angle. *Journal of Sports Sciences*, 11, 187-198.

For whole body movements in other activities the minimum axis of inertia is unlikely to be as important and so the scheme of Appendix 2 may be more appropriate or even a system of axes fixed in a single segment. I would recommend that to give some consistency, a Cardan system of successive rotations about lateral, frontal and longitudinal axes be employed where these axes are defined relative to the body segments in such a way that they are mutually orthogonal. It will be necessary to have some flexibility to cater for different situations but it would be helpful if researchers could adopt the same general system as proposed.

4. Proposal for definition of a joint coordinate system for shoulder joint

Drs. Frans C.T. van der Helm and Jesus Dapena have been working on the proposal for the shoulder JCS. Each of them submitted a proposal. They are similar to a great extent. However, there are some differences in content, format and wording. Due to the page limit, portions of the proposal (part 2 and part 5) by Dr. Frans C.T. van der Helm will be published in this issue of the Newsletter. Nevertheless, a list of the differences between the two proposals is presented by Dr. van der Helm for your convenience.

PART 2: DEFINITION OF LOCAL COORDINATE SYSTEMS OF THE SEGMENTS

Each local coordinate system should be defined as much as possible by palpable bony landmarks. When the body is in the anatomical position, the orientation of the X-, Y- and Z-axes of each local coordinate system should approximate the left-right, forward and upward directions, respectively. The following segmental coordinate systems are recommended:

THORAX: Local coordinate system $\mathbb{T}$

- ${}^G\underline{Z}_t$: $\{({}^G\underline{IJ} + {}^G\underline{C7})/2 - ({}^G\underline{PX} + {}^G\underline{T8})/2\} / \|({}^G\underline{IJ} + {}^G\underline{C7})/2 - ({}^G\underline{PX} + {}^G\underline{T8})/2\|$
- ${}^G\underline{X}_t$: Perpendicular to the plane fitted to the points ${}^G\underline{IJ}$, ${}^G\underline{C7}$ and $({}^G\underline{PX} + {}^G\underline{T8})/2$, pointing to the right.
- ${}^G\underline{Y}_t$: Perpendicular to ${}^G\underline{Z}_t$ and ${}^G\underline{X}_t$
- Origin: ${}^G\underline{IJ}$

where ${}^G\underline{IJ}$ is the position vector of bony landmark Incisura Jugularis (or suprasternal notch), ${}^G\underline{PX}$ is the position of the Processus Xiphoideus (bottom of the sternum), ${}^G\underline{C7}$ is the position of the Processus Spinosus of the 7th cervical vertebra and ${}^G\underline{T8}$ is the position of the Processus Spinosus of the 8th thoracic vertebra.

Notes:

2.1) The purpose of this somewhat complicated definition is to approximate the anatomical planes (frontal plane, sagittal plane and transversal plane) and anatomical axes (see fig.1). This 'Anatomical' coordinate system is implicitly used in most medical-oriented definitions of the shoulder, although the exact position of these axes w.r.t. the thorax have never been defined. ${}^G\underline{Z}_t$ approximates the longitudinal axis of the thorax.

2.2) When high accuracy is desired, the thoracic coordinate system should be defined in the exhaled position.

2.3) In case of severe distortions of the thorax, it is up to the researcher to define a close approximation to the present definition. This also holds for the other local coordinate systems.

CLAVICLE: Local coordinate system $\mathbb{C}_A$ (projects of category A).

- ${}^G\underline{X}_c$: $({}^G AC - {}^G SC) / \|({}^G AC - {}^G SC)\|$
- ${}^G\underline{Y}_c$: Perpendicular to ${}^G\underline{Z}_t$, (!!) and ${}^G\underline{Xc}$, pointing forward.
- ${}^G\underline{Z}_c$: Perpendicular to ${}^G\underline{X}_c$ and ${}^G\underline{Y}_c$
- Origin: ${}^G\underline{SC}$

CLAVICLE: Local coordinate system $\mathbb{C}_B$ (projects of category B).

- ${}^G\underline{X}_c$: $({}^G\underline{AC} - {}^G\underline{SC}) / \|({}^G\underline{AC} - {}^G\underline{SC})\|$
- ${}^G\underline{Z}_c$: Perpendicular to the plane of the S-curve of the clavicle, pointing upward.
- ${}^G\underline{Y}_c$: Perpendicular to ${}^G\underline{Z}_c$ and ${}^G\underline{X}_c$
- Origin: ${}^G\underline{SC}$

where ${}^G\underline{AC}$ is the most dorsal point of the AC-joint that is retrievable by palpation during the whole range of humeral elevation, and ${}^G\underline{SC}$ is the most anterior point of the SC-joint, approximately half-way between upper and lower border of the joint.

Notes:

2.4) The S-curve of the clavicle is not visible in projects of category A. Therefore, in those projects the orientation of the local reference frame of the clavicle is defined with the help of axis ${}^G\underline{Z}_t$ of the thorax. The relation of coordinate systems $\mathbb{C}_A$ and $\mathbb{C}\underline{B}$ will have to be determined experimentally, to enable communication between projects of categories A and B.

2.5) Definition of ${}^G\underline{Y}_c$ and ${}^G\underline{Z}_c$ is important in order to determine the axial rotation of the clavicle in definition $\mathbb{C}_A$. If the axial rotation of the clavicle is not known, the rotations in the AC-joint can not be assessed, and only the pro/retraction and elevation/depression of the clavicle in the SC-joint can be determined. If for each position ${}^G\underline{Y}_c$ and ${}^G\underline{Z}_c$ would be determined with help of ${}^G\underline{Z}_t$, the notion of axial rotation of the clavicle would be without significance. Therefore, these axes are defined in the initial (resting) position. Subsequently, the axial rotation of the clavicle should be estimated e.g. by minimization of the rotations in the AC-joint.

2.6) Bony landmarks at the joints are used to define the coordinate system, <u>not</u> the joint centers, since the latter can not be recorded or palpated. This distinction is important to enable definition of joint centers w.r.t. bony landmarks, and a more precise calculation of joint torques, etc. For input in musculoskeletal models, the rotations of the rigid bodies can be used, or the positions of the bony landmarks.

SCAPULA: Local coordinate system $\mathbb{S}$.

- ${}^G\underline{X}_s$: $({}^G\underline{AC} - {}^G\underline{TS}) / \| ({}^G\underline{AC} - {}^G\underline{TS}) \|$
- ${}^G\underline{Y}_s$: Perpendicular to $({}^G\underline{AC} - {}^G\underline{AI})$ and ${}^G\underline{X}_s$, i.e. perpendicular to the scapular plane, pointing forward.
- ${}^G\underline{Z}_s$: Perpendicular to ${}^G\underline{X}_s$, and ${}^G\underline{Y}_s$
- Origin: ${}^G\underline{AC}$

where ${}^G\underline{TS}$ is the Trigonum Spinae and ${}^G\underline{AI}$ is the Angulus Inferior.

Notes:

2.7) In this definition of the local coordinate system of the scapula no axis points from the proximal joint (AC) toward the distal joint (GH). Also, given the shape of the scapula, none of the three axes can be called the longitudinal axis.

2.8) Many studies refer to the scapular plane, as initiated by Johnson (1937). The present definition would define the scapular plane by <u>AC</u>, <u>TS</u> and <u>AI</u>. However, in *in vivo* studies the orientation of the scapular plane changes during humeral elevation (Van der Helm & Pronk, 1993). When cadaver specimens are used for experiments (category $\mathbb{B}$), the scapular plane is often the only plane of reference.

HUMERUS: Local coordinate system $\mathbb{H}$

- ${}^G\underline{Z}_h$: $({}^G\underline{GH} - {}^G\underline{E}) / \| ({}^G\underline{GH} - {}^G\underline{E}) \|$, or the longitudinal axis operationalized in another way, e.g. by a cuff mounted at the upper arm.
- ${}^G\underline{Y}_h$: Perpendicular to ${}^G\underline{Z}_h$, and $({}^G\underline{EL} - {}^G\underline{EM})$, pointing forward.
- ${}^G\underline{X}_h$: Perpendicular to ${}^G\underline{Y}_h$ and ${}^G\underline{Z}_h$
- Origin: ${}^G\underline{GH}$

where ${}^G\underline{GH}$ is the rotation center of the glenohumeral joint, ${}^G\underline{EM}$ is the medial epicondyle and ${}^G\underline{EL}$ is the lateral epicondyle. ${}^G\underline{E}$ is the midpoint between ${}^G\underline{EM}$ and ${}^G\underline{EL}$.

Notes:

2.9) ${}^G\underline{GH}$ is not a true bony landmark. However, it is an useful landmark, because it lets ${}^G\underline{Z}_h$ approximate the longitudinal axis of the humerus. Since ${}^G\underline{GH}$ often can not be recorded, the longitudinal axis can be operationalized by a cylindrical cuff mounted to the upper arm, or by a similar method.

2.10) ${}^G\underline{X}_h$ is <u>not</u> the flexion-extension axis of the elbow. Sometimes, ${}^G\underline{X}_h$. has been defined as the normal vector to the plane formed by the longitudinal axes of the upper arm and of the forearm. However, such a definition would assume that the flexion-extension axis is perpendicular to the longitudinal axis of the humerus, which is not necessarily the case. The advantage of the present definition is that ${}^G\underline{EM}$ and ${}^G\underline{EL}$ can always be retrieved without recording the elbow motions. This could be especially important when the forearm is not included in the study, for instance in a cadaver experiment (projects of category $\mathbb{B}$).

PART 5: RELATIVE ORIENTATIONS

Relative orientation is the orientation of one bone w.r.t. another. In most biomechanical analyses, this is given as the orientation of a bone w.r.t. the bone immediately proximal to it, and constitute the angle of the joint between them. However, such an approach is hard to interpret when the orientations of the proximal bone are difficult to imagine, as is often the case for the clavicle and the scapula. Therefore, a second option is necessary. For the second option, we defined the relative orientation of a bone w.r.t. the thorax. For instance, the orientation of the scapula w.r.t. the thorax is often more informative than the orientation of the scapula w.r.t. the clavicle. And when the orientation of both clavicle and scapula cannot be recorded, often the orientation of the humerus w.r.t. the thorax is presented. Therefore, two definitions are given:

5A: Rotations relative to the immediately proximal segment

Sternoclavicular joint:

$$ {}^{T}_{C}\mathbf{R} = [{}^{G}\underline{\mathbf{X}}_{c}\ \ {}^{G}\underline{\mathbf{Y}}_{c}\ \ {}^{G}\underline{\mathbf{Z}}_{c}]\bullet[{}^{G}\underline{\mathbf{X}}_{t}\ \ {}^{G}\underline{\mathbf{Y}}_{t}\ \ {}^{G}\underline{\mathbf{Z}}_{t}]^{T} \tag{8} $$

Acromioclavicular joint:

$$ {}^{C}_{S}\mathbf{R} = [{}^{G}\underline{\mathbf{X}}_{s}\ \ {}^{G}\underline{\mathbf{Y}}_{s}\ \ {}^{G}\underline{\mathbf{Z}}_{s}]\bullet[{}^{G}\underline{\mathbf{X}}_{c}\ \ {}^{G}\underline{\mathbf{Y}}_{c}\ \ {}^{G}\underline{\mathbf{Z}}_{c}]^{T} \tag{9} $$

Glenohumeral joint:

$$ {}^{S}_{H}\mathbf{R} = [{}^{G}\underline{\mathbf{X}}_{h}\ \ {}^{G}\underline{\mathbf{Y}}_{h}\ \ {}^{G}\underline{\mathbf{Z}}_{h}]\bullet[{}^{G}\underline{\mathbf{X}}_{s}\ \ {}^{G}\underline{\mathbf{Y}}_{s}\ \ {}^{G}\underline{\mathbf{Z}}_{s}]^{T} \tag{10} $$

Implicitly, we chose to define the zero-zero-zero rotation of each joint as the rotation in which the axes of the distal segment are aligned with the proximal segment. Since no two consecutive local coordinate systems of the shoulder (thorax-clavicle-scapula-humerus) are aligned when a subject is in the 'resting' position, this implies that none of the joints of the shoulder is at zero-zero-zero rotation when the subject is in the resting position. In fact, in the SC- and AC-joint it will be impossible to attain the zero-zero-zero rotation. But this is not a significant problem: We will soon become familiar with typical angular values for the motion range of these joints.

Rotations are expressed with Euler/Cardan angles, representing three successive rotations about axes embedded in the distal segment, starting from a position in which the proximal and distal coordinate system are aligned. These rotations produce the actual orientation of the distal segment w.r.t. the proximal segment. The second and third rotations are about axes that have been displaced by one or two previous rotations, respectively, and they are designated by single and double quotes in the rotation sequences shown below. We propose to use the following rotation sequences:

Sternoclavicular joint:

Z-Y'-X": pro/retraction about the Z-axis, elevation/depression about the Y-axis, axial rotation about the X-axis

Acromioclavicular joint:

Z-Y'-X": No anatomical terminology has yet been defined for rotations in the AC-joint.

Glenohumeral joint:

Z-Y'-Z": Pole angle w.r.t. the scapular plane, humeral elevation, and axial rotation about the longitudinal axis of the humerus.

Notes:

5.1) For the SC-, AC- and GH-joint no flexion/extension, abduction/adduction and internal/external rotation axes have been defined. In the literature, rotations in the SC- and AC- have never been defined, and rotations in the GH-joint have been defined w.r.t. the scapular plane.

5.2) A general pitfall for interpreting rotation angles is that a non-linear system of equations is parameterized. Therefore, the results are only indicative when all three rotation angles are considered. It is erroneous to compare e.g. the last rotation angle when the first two are different: The axis of rotation of the last rotation angle is different.

5.3) Gimbal lock position will not occur for the SC- and AC-joint (Van der Helm & Pronk, 1994). For the GH-joint gimbal lock will occur only at zero degrees elevation.

5.4) These definitions are suitable for projects of category B, and can be used to compare the results with projects of category A. They are not applicable for projects of category C.

5B: Rotations relative to the thorax.

The orientation of the clavicle, scapula and humerus can also be defined in the local coordinate system of the thorax. For the clavicle this definition coincides with the definition under 5A. For the other bones it would mean:

Scapula.

$$ {}^{T}_{S}\mathbf{R} = [{}^{G}\underline{\mathbf{X}}_{s}\ \ {}^{G}\underline{\mathbf{Y}}_{s}\ \ {}^{G}\underline{\mathbf{Z}}_{s}]\bullet[{}^{G}\underline{\mathbf{X}}_{t}\ \ {}^{G}\underline{\mathbf{Y}}_{t}\ \ {}^{G}\underline{\mathbf{Z}}_{t}]^{T} \tag{11} $$

Humerus:

$$ {}^{T}_{H}\mathbf{R} = [{}^{G}\underline{\mathbf{X}}_{h}\ \ {}^{G}\underline{\mathbf{Y}}_{h}\ \ {}^{G}\underline{\mathbf{Z}}_{h}]\bullet[{}^{G}\underline{\mathbf{X}}_{t}\ \ {}^{G}\underline{\mathbf{Y}}_{t}\ \ {}^{G}\underline{\mathbf{Z}}_{t}]^{T} \tag{12} $$

These rotation matrices can be decomposed into Euler angles:

Scapula:

Z-Y'-X": pro/retraction about the Z-axis, lateral/medial rotation in the scapular plane about the Y'-axis, and tipping forward/backward about the scapular spine (X"-axis)

Humerus:

Z-Y'-Z": plane of elevation w.r.t. the frontal plane, elevation angle about the Y'-axis, and axial rotation about the longitudinal axis of the humerus.

Notes:

5.5) The purpose of the naming convention after anatomical terminology in 5A) and 5B) is to make rotations easier to interpreted. Though, one should keep in mind that these rotations may not correspond perfectly with the traditional anatomical terminology, since that is only defined starting from the anatomical position. In Euler angle conventions, rotations can take place about axes skewed by previous rotations. Hence, they are not 'anatomical' rotations.

5.6) The Z-Y'-Z" rotation order for humeral rotations does not agree with current terminology as forward flexion, abduction/adduction and external/internal rotation. On the other hand, it is a well interpretable, unambiguous definition as is earlier proposed by An et al. (1991) and Pearl et al. (1992). Definition of the rotations about three consecutive anatomical axes has the problem that the second and third rotation are about rotated axes anyway. Advantage of the present definition is that the rotation about the Y'-axis represents the true elevation angle.

5.7) Gimbal lock will not occur for the rotations of the scapula. The gimbal lock position for the humerus is 0° elevation and 180° elevation. 0° elevation is blocked by the thorax, and 180° elevation cannot be achieved by most people (Van der Helm & Pronk, 1994).

5.8) Zero-zero-zero orientation of the scapula would mean an orientation in which the scapular plane is parallel with the frontal plane of the thorax, and the scapular spine is along the $^{G}\underline{X}_{t}$ axis. However, as was noted in definition 5A, this is not a significant problem, because we will soon become familiar with typical values for the motion range of the scapula.

5.9) The orientation of the humerus w.r.t. the thorax is widely used, e.g. using video/film recording equipment. Then, the scapula and clavicle cannot be recorded, and the humerus is moving w.r.t. the thorax in a kind of 'lumped' joint. Hence, this definition is useful for communication between projects of categories A and C, and particularly among projects of category C.

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Van der Helm FCT, Pronk GM (1994). Three-dimensional recording and description of motions of the shoulder mechanism. *ASME J. Biomechanical Engineering* (in press).

Differences between the proposals of F.C.T. Van der Helm and J. Dapena

- Flexibility: In the proposal of Dapena flexibility in the definition of standards is advocated, especially for the order of rotations to avoid gimbal lock. In the proposal of Van der Helm a strict standardization is proposed.

- Notation: In the proposal of Van der Helm a system of notation for vectors and rotation matrices is proposed.

- Local Coordinate system Thorax: Dapena proposes to use (IJ + C7)/2. Van der Helm proposes to use IJ.

- Clavicle: Dapena uses Ca and Cb, in order of preference. This is Cb and Ca, respectively in Van der Helm's proposal, who has named them after the research categories A and B, identified in the proposal.

- Van der Helm recommends using the longitudinal axis of the humerus for operationalizing the local coordinate system of the humerus. Dapena only allows for the rotation center of the humerus.

- Van der Helm explicitly describes what is meant by global and local positions and displacements. In addition, he identifies a need for standardization of the joint rotation center for power calculations, in order to distinguish between translational and rotational power.

- Dapena recommends flexible standards to describe global orientations, to avoid gimbal lock. Van der Helm proposes one standardized rotation order.

- Dapena recommends the second option for relative orientations to describe the orientation w.r.t. the thorax. Van der Helm has no particular preference.

- Van der Helm identifies potential gimbal lock positions for relative orientations, and recommends one standardized rotation order. Dapena recommends one rotation order, but allows different rotation orders to avoid gimbal lock positions.

- Van der Helm presents equations to explicitly identify what is meant by particular global and relative orientations, using the preferred notation.

- Dapena recommends several suboptions for humeral rotations.

Announcements

CONFERENCE/COURSE ANNOUNCEMENT

Surface Electromyography: Theory and Practice

NeuroMuscular Research Center
Boston, MA
June 17 & 18, 1994

This course is designed to provide additional information to individuals who have attended prior courses on surface EMG presented by our staff during previous ISEK meetings in Florence and Baltimore. If you did not have the opportunity to attend these prior courses, don't worry -- the material will be presented in such a way that it will be instructive to new participants as wellI

TOPICS TO BE ADDRESSED:

- Theory of Electromyography
- Practical Aspects of How to Detect and Record the EMG Signal
- Use of EMG Signal as a Fatigue Index
- Use of EMG Signal for Timing of Muscle Activation
- EMG Signal and Force
- Clinical Application of Surface EMG for Diagnosis and Monitoring Treatment

COURSE FORMAT:

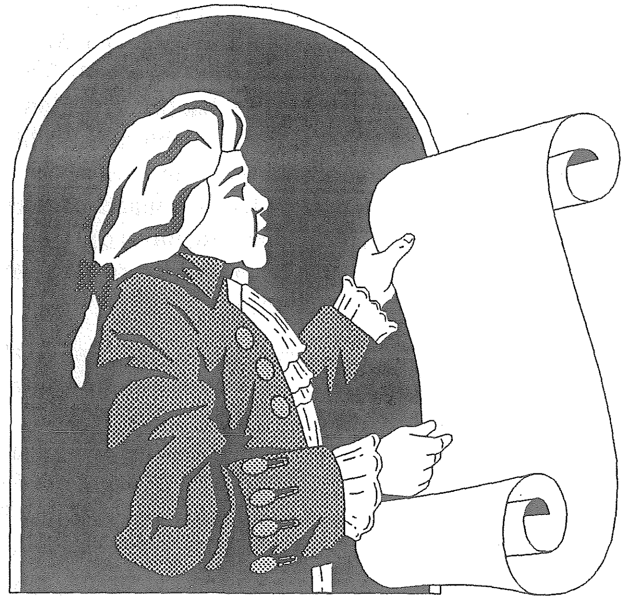
- Morning Session: Didactic presentation
- Afternoon Session: Demonstration and hands-on practice

REGISTRATION INFORMATION:

- The cost for the two-day course is $350.00 (U.S. $) per person which includes two continental breakfasts, beverages, and course handouts.
- Lodging is available in student housing from $35.00 per day or in nearby hotels from $100.00-$150.00 per day.
- Continuing education credits are pending.

For additional information, please write to:

Carlo J. De Luca
NeuroMuscular Research Center
Boston University
44 Cummington Street
Boston, MA 02215
Tel: (617) 353-9757; Fax: (617) 353-5737
E-mail: DAVIS@bunmrg.bu.edu



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 photographs 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.

Biomechanics positions available

FACULTY POSITIONS AVAILABLE

Biomechanics - Upper Extremity
Biomechanics - Soft Tissues

University of Pittsburgh Medical Center
Department of Orthopaedic Surgery
Musculoskeletal Research Center

The Musculoskeletal Research Center (MSRC) of the Department of Orthopaedic Surgery at the University of Pittsburgh is currently recruiting two faculty members specializing in **Upper Extremity Biomechanics and Soft Tissue Biomechanics** at the Assistant/Associate Professor levels. These are tenure track, full-time faculty positions. Candidates will be expected to merit secondary appointments in the School of Engineering.

Successful applicants at the junior level will be expected to pursue independent research as well as collaborating with other investigators in the MSRC of the Department of Orthopaedic Surgery. Senior-level candidates should have a track record of original research. It is also expected that successful candidates will participate in classroom teaching as well as supervision of undergraduate and graduate engineering students. Each candidate must have a Ph.D. or equivalent degree.

Qualified applicants should forward a comprehensive curriculum vitae and three letters of recommendation to:

Savio L-Y. Woo
Ferguson Professor and Vice Chairman for Research
Department of Orthopaedic Surgery
University of Pittsburgh
Suite 1010 Liliane Kaufmann Bldg.
3471 Fifth Avenue
Pittsburgh, PA 15213, USA

The University of Pittsburgh School of Medicine is an equal opportunity and affirmative action employer. Women and minorities are encouraged to apply.

BIOMECHANICS AND KINESIOLOGY LECTURER

The University of Southern California
Department of Exercise Sciences

Applications and nominations are invited for a lecturer position in the Department of Exercise Sciences, one of seven departments in the Division of Natural Sciences and Mathematics. Applicants should have an earned doctorate in biomechanics and/or kinesiology. The responsibilities of this position include teaching upper level undergraduate courses in biomechanics and kinesiology.

Applicants should forward, by May 15, 1994, a statement of interest, a current curriculum vitae, names of three references to:

Jill L. McNitt-Gray, Ph.D.
Chair, Search Committee
Department of Exercise Sciences
University of Southern California
Los Angeles, CA 90089-0652, USA.
Fax: 213-740-7909
Tel: 213-740-2492

The University of Southern California is an Equal Opportunity, Affirmative Action Employer.

BIOMEDICAL POSTDOCTORAL RESEARCH POSITION

Description:

The Hand Biomechanics Laboratory in Sacramento, California is pleased to announce a research training position. The duties will include the engineering aspects of the development of instrumentation and associated software on the Etiology of Carpal Tunnel Syndrome project. As a component of this project, the trainee will be exposed to the broad range of problems of a clinical hand practice both within the clinic and in surgery. This will include a specific emphasis and training on the biomechanics of carpal tunnel syndrome.

Duration of Training:

One year with the possibility of a second year extension.

Eligibility:

The applicants should be active scientists with a committment to research and continued training in biomechanics. The applicants must posses a PhD in an engineering field with training and practical knowledge in instrumentation, computer software development, and biomechanics. Experience with MacIntosh computers is desired as well as the ability to assist in experimental work on cadavers. The applicant must be a US citizen. Smoking is not permitted in the laboratory or associated clinical area.

Resources:

The Hand Biomechanics Laboratory is a privately funded research and development laboratory. The activities of the Laboratory include the study of the biomechanics of the wrist and hand joints and the design of improved devices for hand function as well as the evaluation and proof of these devices. The laboratory's success derives from its active involvement in the patient care arena which results in an appreciation of the clinical problems and the inadequacies of current medical technology. The environment combines patient care, research, and development, as well as the design, manufacture, and marketing of medical devices. The in-house machine shop and prototype labs combine to facilitate the rapid development of prototypes and related upper extremity instrumentation.

Contact:

Dr. John M. Agee, MD
77 Scripps Drive - Suite 104
Sacramento, CA 95825
Tel: (916)923-5073; Fax: (916)923-2215

ASSOCIATE DEAN FOR RESEARCH

School of Engineering and Technology
Indiana University - Purdue University Indianapolis (IUPUI)

Applications and nominations are invited for the position of Associate Dean for Research at the Purdue School of Engineering and Technology at IUPUI, available January 1, 1995. The Dean will be responsible for facilitating both individual and collaborative faculty research.

Applicants must have a Ph.D. in electrical, mechanical or biomedical engineering or related discipline and meet the standards for a tenure appointment at the rank of associate or full professor. Candidates must have a strong commitment to teaching and excellence in research. They should have demonstrated the ability to provide leadership for academic programs and to conduct innovative and collaborative research, as well as have excellent interpersonal and communication skills. Consideration will be given to candidates with a record for attracting external support and building collaboration among a diverse community of academic, industrial, and government groups. Experience in some aspect of biomedical engineering is particularly desirable.

Applicants should submit a resume with a list of five references and an accompanying cover letter with a statement of academic accomplishments and career objectives to:

Dr. Larry A. Abel
Chair, Associate Dean for Research Search and Screen Committee Indiana University Purdue University Indianapolis
ET 1219
799 West Michigan Street
Indianapolis, IN 46202, USA

Screening of applications will begin July 15, 1994, and continue until the position is filled.

With 2,300 students, the School of Engineering and Technology is one of the largest of 18 academic units at IUPUI. IUPUI is a comprehensive urban campus that enrolls more than 27,000 students, offers 174 academic programs, and includes an internationally known medical center. On the IUPUI campus, the Indiana University Schools of Medicine and Dentistry and the Purdue University School of Science offer the opportunity for collaborative, multidisciplinary research activities in areas such as biomechanics, biomaterials, medical imaging, and cardiovascular science, environmental engineering and electronics manufacturing. IUPUI resources include the Biomechanics and Biomaterials Research Center; the Medical Imaging Research Group, in association with the Department of Radiology and the Indianapolis Center for Advanced Research (ICFAR); the Krannert Institute of Cardiology and the Electronics Manufacturing Productivity Facility.

More than 1.2 million people live in metropolitan Indianapolis, which is not only the capital city but also the business and technical center of the state. Indianapolis has become a center for recreational activities, amateur sports and culture. It is the site of world class athletics with many held in IUPUI's Olympic and professional caliber aquatic, track, and tennis facilities.

IUPUI is an Equal Opportunity, Affirmative Action employer. Women and minority candidates are encouraged to apply.

ORTHOPAEDIC RESEARCHER

The Division of Orthopedic Research Mayo Clinic/Mayo Foundation, Department of Orthopedic Surgery is seeking a Scientist or Bioengineer (Ph.D. or equivalent) for a tenure track position (open rank) in orthopedic research with an emphasis on one or more of the following: Joint kinematics, Computer Modeling, Material Testing, or Biophysiology. Responsibilities will include close interaction with clinicians engaged in research, training and supervision of postdoctoral fellows, and development of independent research programs. Candidates should be capable of gaining national recognition and funding, and be recognized as a career scientist within the research community.

Please provide Curriculum Vitae and one page of research interests. Mail all correspondence to the following address. Please do not reply by electronic mail.

William P. Cooney, M.D.
Vice Chair for Research
Department of Orthopedics
Mayo Clinic
200 First Street, S.W.
Rochester, MN 55905 USA

BIOMECHANICAL ENGINEER

Cardiac Pacemakers, Inc., a leader in implantible defibrillators and pacemakers is looking to hire an engineer for its Leads Technology Development group.

Description of duties:

Perform biomechanical analyses using both research and analytical techniques to determine in vivo forces and ranges of motion for current and future pacemaker/defibrillator lead models.

Requirements:

PhD in Mechanical or Biomedical engineering. Prefer biomechanics experience related to cardiovascular or upper thoracic applications. Strong background in anatomy and physiology required.

Email response can be sent to:
hum@lilly.com

Written response should be sent to:
Cardiac Pacemakers, Inc.
Attention: Steve Haik
Mail Stop A270
4100 Hamline Ave. N.
St. Paul, MN 55112-5798, USA

BIOMECHANICAL SOFTWARE ENGINEER

MusculoGraphics, Inc. is seeking to hire a biomechanical software engineer to develop computer graphics software to represent tne human musculoskeletal system. Applicants should have extensive experience (4+ years) programming in C/Unix on computer graphics workstations. Experience on Silicon Graphics workstations is particularly relevant. Experience in musculoskeletal biomechanics, deformation modeling, and medical imaging is needed. Project planning and excellent communication skills are essential.

MusculoGraphics is a start-up software development company specializing in biomechanics. The company is engaged in several projects aimed at creating visually compelling models that accurately represent the human musculoskeletal system for use in various research and commercial applications. We are seeking an exceptionally talented engineer to join the team.

MusculoGraphics is located in the Technology Innovation Center, which is part of the Northwestern University Research Park. It is located in Evanston, Illinois, the first city north of Chicago on Lake Michigan. The proximity to Northwestern University and Chicago offers a wide range of opportunities.

To apply, please send a resume and cover letter to:

Mail: MusculoGraphics
1840 Oak Avenue
Evanston, IL 60201
Fax: 708-866-1808

BIOLOGICAL ENGINEERING FACULTY POSITION (Tenure-Track)

Mississippi State University

Assistant Professor of Agricultural and Biological Engineering, College of Agriculture and Home Economics and the Mississippi Agricultural and Forestry Experiment Station, Mississippi State University.

Position Description:

The individual will be expected to participate in the departmental research and academic programs in one or more of the following areas: biomaterials, bioprocessing of and physical properties evaluation of biological materials, biotechnology, animal health or animal model development, biosystems simulation, machine vision or imaging, or other appropriate biological/biomedical area. The person will be expected to develop and obtain extramural funding for a comprehensive research program in one of the above-listed areas. The position will be approximately 50% teaching and 50% research with a tenure-track, 12-month appointment.

Application deadline May 31, 1994.

Location:

Mississippi State University, Mississippi State, MS. The university is located adjacent to Starkville, MS, a town of 18,000 in northeast Mississippi.

Educational Qualifications:

A Ph.D. in Agricultural Engineering, Biological Engineering, Biomedical Engineering, or related field.

Personal Qualifications:

The applicant should possess extraordinary personal initiative and must have the ability and willingness to participate in interdisciplinary, collaborative research. The individual should be innovative and flexible in terms of willingness to adapt research skills to varied and different applications.

Opportunities for Advancement:

Opportunities for advancement are potentially excellent, depending upon individual performance. The opportunity to provide leadership for interdisciplinary research and academic innovation will occur immediately.

Salary: Dependent upon qualifications.

Duration:

Renewable tenure track, twelve-month appointment beginning September 1, 1994.

Contact:

Dr. R. Kenneth Matthes
Dept. of Agricultural and Biological Engineering
Mississippi State University
Box 9632, Mississippi State, MS 39762, USA
Tel: (601) 325-3282

Mississippi State University is an Equal Opportunity Employer.

INTERNSHIP

The Human Performance Engineering Lab at Reebok International Ltd. has an immediate opening for an intern. This is a one year position, with a salary of $25,000 and does not include benefits. The duties include data collection for studies of footwear design using both material tests and human subject tests, as well as general lab maintenance. There will be opportunities for exposure to the various stages of the footwear design and development process. Experience in human subject research, computerized data collection, and proven organizational and communication skills required. Masters preferred.

Send resumes to:

Bob Rich
Reebok International Ltd.
100 Technology Center Drive
Stoughton, MA 02072, USA
Tel: (617)341-7635
Fax: (617)297-4800

ONE YEAR RESEARCH CONTRACT IN ITALY

Laboratorio di Tecnologia dei Materiali
(Biomaterials Technology lab)
Istituti Ortopedici Rizzoli - Bologna, Italia

A position is available for a one year contract in our Laboratorio di Tecnologia dei Materiali (LTM). The position are open to young researchers, imediately after PhD in biomechanics. The contracts will last one year, with the potential opportunity of one more year.
The LTM is a brand new lab with about one milion US$ of equipment not older than three years. It is part of an institution (ISTITUTI ORTOPEDICI RIZZOLI) formed by a research center, which is hosting other four labs (Biocompatibility, Cellular biology, etc.) and one of the largest orthopaedic hospital of the country. All the labs are completely devoted to research on Orthopaedic related fields.

The LTM is completely focused on orthopaedic bioengineering, orthopaedic biomechanics and related mechanics of biological tissue of hip joint and total hip replacement. Active researches are on bone remodeling, prosthesis biomechanics (stability, stress shielding) and prosthetic implants evaluation. The resident team is formed by Engineers, MD, Biologists and Physicists. The main object of the research contract will be the application of supercomputer to the prediction of bone remodelling with particular interest to the integration of data from different diagnostic devices as tools of pre and post processing.

The selected researcher will be the coordinator of the research project, which will involve also graduate students. Most of the work will be done on SGI machines, Cray C-90 and the new Cray T3D parallel machine. Cray itself will be a partner of the international project.

Applicants should have an engineering background and a strong commitment to applied research; english will be the working language. A specific experience on the proposed topic and an additional knowledge of the italian language are welcome.

Gross annual salary is 30,000,000 (thirty millions) italian lire. As benefit, a room in the research center guest house could be rented for 270,000 italian lire per month. Canditates should send (possibly by e-mail) a complete Curriculum vitae and a list of pubblications to:

Prof. Armando Giunti
Laboratorio di Tecnologia dei Materialitel.
Istituti Ortopedici Rizzoli
via di barbiano 1/10, 40136
Bologna, Italy
Tel: 0039-51-6366864
Fax. 0039-51-6366863
Internet: ita0940@AppleLink.Apple.com

BIOMECHANICAL ENGINEERING RESEARCH

Ariel Dynamics Inc., a pioneer and industry leader in Movement Analysis Systems and Computerized Exercise Systems was contracted by NASA, Johnson Space Center's Exercise Countermeasures Project to develop the Space Station Exercise System and Movement Analysis System. We are seeking an individual with a B.S. / M.S. degree in Engineering or Biomechanics or combination of the two. Individuals with Exercise Science with the proper coursework are to be considered. The successful applicant should have experience with: 1. Force plates, 2. Strain gauges, 3. Video Motion Analysis, 4. Electromyography and 5. Dynamometry. Applicants experienced in operation of the Ariel Performance Analysis System are preferred.

Contact:

Scott Smith
Exercise Countermeasures Project
c/o June Richmond
Human Resources / Suite 120
Krug Life Sciences
1290 Hercules
Houston, TX 77058, USA

or

Gideon Ariel:
Tel: 714-858-4216; Fax: 714-858-0377
E-Mail: GBARIEL@uci.edu

BIOENGINEER

Brown University is recruiting a Bioengineer for the Department of Orthopaedics at Rhode Island Hospital and the Division of Engineering. The successful candidate must qualify for a full-time medical faculty position at the rank of Assistant/Associate/Full Professor. Minimum requirements include: post-doctoral experience in bioengineering with demonstrated research productivity as evidenced by peer-reviewed publications with emphasis on connective tissue research. Must have a PhD in related field and be a capable teacher. Associate/Full Professor appointments must have a national reputation and proven success in obtaining extramural funding. Applications are expected by 15 April 1994.

Contact:

Michael G. Erlich, MD
Surgeon-in-Chief
Departmnent of Orthopaedics
Rhode Island Hospital
593 Eddy Street
Providence, RI 02903
Tel: (401) 444 5895; Fax: (401) 444 6243

MECHANICAL SYSTEMS SCIENTIST

Cornell University
Sibley School of Mechanical and Aerospace Engineering
Upson Hall, Hoy Road
Ithaca, New York 14853, USA

The Sibley School of Mechanical and Aerospace Engineering at Cornell University is seeking an individual to fill a tenure-track faculty position in the general area of mechanical systems. Applicants must have demonstrated potential for building a vigorous, independent program in teaching and research. Salary and rank will be commensurate with qualifications. In order to complement existing strengths within the School, preference will be given to individuals with research interests related to musculo-skeletal biomechanics. Priority will be given to candidates who are interested in developing laboratories. Teaching responsibilities will include core undergraduate courses in mechanical systems and graduate offerings of general interest and of specialized interest to the applicant. Women and minority candidates are particularly encouraged to apply.

Applications will be accepted until the position is filled. Each applicant should send a resume and the names of three references to:

Professor David A. Caughey, Director
Mechanical and Aerospace Engineering
105 Upson Hall, Cornell University
Ithaca, New York 14853, USA

Cornell University is an equal opportunity/affirmative action employer.

BIOMECHANICS RESEARCHER

Biomechanical/Human Factors Engineering
Univeristy of Michigan

The Biosciences Division of The University of Michigan Transportation Research Institute (UMTRI) is seeking a versatile and capable individual to conduct basic and applied research in biomechanics related to motor-vehicle transportation. Potential areas of research include: laboratory experimentation and testing with regard to the biomechanics of human impact response, injury criteria, and tolerance; in-depth accident and injury investigations relative to the mechanisms of traumatic injuries and the secondary effects of trauma on the human system; anthropometric and ergonomic studies with regard to vehicle seat and interior design; development of crash test dummies; and mathematical modeling of the interaction of motor-vehicle occupants with the vehicle interior and occupant restraint systems.

Applicants must have completed a doctoral program in engineering or related field and have one to five years experience conducting research in biomechanics. The successful candidate must demonstrate an ability to identify problems and develop proposals for new research activities and will be expected to conduct high-quality, independent research involving the development of research hypotheses, the design and performance of experiments, analysis and interpretation of results, and communication of research and presentations. As a member of multidisciplinary organization, the successful applicant will be expected to work effectively with other research staff and to function as a member of the Biosciences research team.

UMTRI was established in 1966 and conducts and interdisciplinary program of research in the areas of vehicle dynamics, biomechanics, human factors, highway safety studies, marine systems, and the automotive industry.

Forward responses to:

Head, Biosciences Division, UMTRI
2901 Baxter Road
Ann Arbor, Michigan 48109-2150, USA
Tel: (313) 763 3582
Fax: (313) 747 3330

The University of Michigan is an equal opportunity/affirmative action employer and encourages women and minorities to apply.

Thesis abstract

DEVELOPMENT AND EVALUATION OF A STATIC HAND FORCE EXERTION CAPABILITY MODEL USING STRENGTH, STABILITY AND COEFFICIENT OF FRICTION

by

Carter Jay Kerk

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy
(Industrial and Operations Engineering)
The University of Michigan 1992

Chair: Don B. Chaffin

A comprehensive biomechanical model is developed to estimate feasible hand force exertion capability (HFEC) under static conditions. A two-dimensional sagitally-symmetric version (2DHFEC) uses fifteen linear constraints from three classes: strength, stability (or balance), and coefficient of friction (COF). These constraints define a feasible solution space for combinations of horizontal and vertical reaction force vectors at the hands. Example lifting and pushing exertions demonstrate features and advantages. Graphical output provides important insight for evaluation and design. Plotting an L5/S1 disc compression safety limit illustrates how strength can exceed the limit.

Laboratory evaluation of 2DHFEC used eight selected subjects of varying characteristics performing maximum exertions in novel tasks (posture/exertion direction combinations) to demonstrate relative importance of stability, COF, and strength capability. Model prediction of HFEC was compared to observed force exertion vectors.

Results clearly demonstrate tasks in which the hand force magnitude is constrained solely by strength, stability, or COF. The identity of theoretically limiting constraints was well predicted by the model. There was significant difference between requested and observed exertion direction. Human perception of exertion direction is questionable. Analysts must carefully define exertion directions. Results suggest stability limits be placed approximately 40% of the distance from the ankle joint center to the posterior-most point of the barefoot and 130% of the distance to the ball. This information will adjust assumptions in current models.

Use of novel tasks established evidence of specific constraints, but the novel nature combined with limited training may restrict exertion magnitudes. Future research could study the learning effect and should include conventional tasks. Future COF studies should consider one-legged exertions to better identify slips.

A three-dimensional biomechanical model (3DHFEC) is formulated to estimate feasible HFEC under asymmetry. The foundation for forty-seven convex constraint equations is formulated in the three constraint classifications. These define a feasible solution space for three-dimensional orthogonal combinations of reaction forces at the hands. Though not yet operational, it describes important physical interpretations for each constraint type. With asymmetric potential, the new model offers important advances over existing models, because it provides a more comprehensive method of evaluating multiple factors affecting HFEC.

Calendar of scientific events

June 21-24, 1994
Tenth Congress of International Society for Electrophysiology and Kinesiology (ISEK), Charleston, South Carolina, USA. Contact: Richard Shiavi, Biomedical Engineering, Vanderbilt University, Nashville, Tennessee 37235, USA; Tel: (615) 322-3598; Fax: (615) 343-7919; E-mail: rgs@use.vanderbilt.edu.

July 5-8, 1994
Third International Symposium on 3-D Analysis of Human Movement, Stockholm, Sweden. Contact: Dr. Arne Lunberg, Dept. of Orhtopeadics, Karolinska Institute, Huddinge University Hospital, Sweden. Tel: +46-8-7462420; Fax: +46-8-6497177; E-mail: arne_lundberg_okh@kicom.ki.se.

July 5-8, 1994
International Conference on Clinical Gait Analysis, University of Dundee, Scotland. Contact: Mrs Jean Whyte, Dundee Limb Fitting Centre, 133 Queen Street, Broughty Ferry, Dundee DD5 1AG, Scotland, U.K. Tel: +44 (0)382 730104; Fax: +44 (0)382 480194.

July 10-15, 1994
Second World Congress of Biomechanics, Amsterdam, The Netherlands. Congress Office: Biomechanics Section, Institute of Orthopaedics, University of Nijmegen, PO Box 9101, 6500 HB Nijmegen, The Netherlands. Tel: +31-80-613366; Fax: +31-80-540555; E-mail: ortho_sec@mc01.azn.kun.nl.

July 16-19, 1994
Third International Symposium on Biofluid Mechanics, Institut für Biotechnik, e.V. München, Munich, Germany. Contact: Prof. Dr. Dieter Liepsch, FB05, Fachhochscule München, Lothstr. 34, 80335 München, Germany. Tel: 0049-89-1265-1533; Fax: 0049-89-1265-1502.

July 31 - August 4, 1994
4th International Congress of Vertebrate Morphology, Chicago, IL, USA. Contact: Dr. Susan W. Herring, Dept. of Orthodontics, SM-46, University of Washington, Seattle, WA 98195, USA. Tel: (206) 543-3203; Fax: (206) 685-8163; E-mail: herring@ u.washington.edu.

August 9-11, 1994
International Congress on Applied Research in Sports, Helsinki, Finland. Contact: The Finnish Society for Research in Sport and Physical Education, Stadion, torniporras, SF-00250 Helsinki, FINLAND.

August 18-20, 1994
VIIIth Biennial Conference of the Canadian Society of Biomechanics, The University of Calgary, Calgary, Alberta, Canada. Contact: Conference and Special Event Services, The University of Calgary, 1833 Crowchild Trail, NW, Calgary, Alberta, Canada, T2M 4S7. Tel: (403) 220-6229; Fax: (403) 284-4184.

August 21-26, 1994
World Congress on Medical Physics and Biomedical Engineering. Rio de Janeiro, Brazil. Secretariat: Congrex do Brasil S/A, 20040-030 Rio de Janeiro RJ, Brazil. Tel: +55-21-224-6080; Fax: +55-21-231-1492.

September 21-24, 1994
Second International Symposium on Computer Methods in Biomechanics & Biomedical Engineering, Marriott Hotel Swansea, U.K. Contact: John Middleton, Biomechanics & Biomedical Eng. Cntr., Engineering Building, University College of Swansea, Singleton Park, Swansea SA2 8PP, Wales, UK. Tel: (0792) 295517; Fax: (0792) 295514.

September 26-29, 1994
2nd International Symposium on Three-Dimensional Scoliotic Deformities, Pescara, Italy. Contacts: Drs. M. D'Amico & A. Merolli, CERBITEB, Fond. Paolo VI, L.re Giovanni XXIII, I-65126 Pescara, Italy. Fax: 39-85-4213969.

October 3-7, 1994
Twelfth International Symposium on Posture and Gait, Matsumoto, Japan. Symposium Secretariat: World Meeting Corporation, 1-29-16-201 Shinjuku, Shinjuku-ku, Tokyo 160, Japan. Tel: 81-3-3350-0363; Fax: 81-3-3341-1830.

October 13-15, 1994
Annual meeting of the American Society of Biomechanics (ASB), Ohio State University, Columbus, Ohio. Contact: Alan S. Litsky, M.D., Sc.D. Meeting Chairperson, American Society of Biomechanics, Orthopaedic Biomeaterials Laboratory, The Ohio State University, 834 Northbridge, Worthington, Ohio, 43235.

November 22-25, 1994
Second Russian Conference on Biomechanics (in memory of N.A.Bernstein), Nijnii Novgorod, Russia. Secretariat: 603005, Russia, Nijnii Novgorod, Minin place, 10/1, Medical Institute. Tel: +7 (8312) 39 00 91; Fax: +7 (8312)365745; E-mail: bimech@hydro.nnov.su.

July 2-6, 1995
XVth Congress of the International Society of Biomechanics. Jyväskylä, Finland. Contact: XVth ISB Congress, Jyväskylä Congresses, P.O. Box 35, FIN-40351 Jyväskylä, FINLAND. Tel: +358 41 603621; Fax: +358 41 603 664.

November 9-12, 1995
2nd Interdisciplinary World Congress on Low Back Pain: The Integrated Function of the Lumbar Spine and Sacroiliac Joints, La Jolla, USA. Contact: UCSD, Office of Continuing Medical Education, UC San Diego School of Medicine, La Jolla, CA 92093-0617, USA.

ISB membership news

NEW MEMBERS

HINTERMEISTER, Robert (#1578)
Steadman Hawkins Sports Med. Foundation
181 W. Meadow Drive, Suite 1000
Vail, CO 81657
USA

GIL, F. X. (#1579)
Dept. C. Materiales e Ing. Metallurgica
ETSEIB-Universidad Politecnica Catalunya
Av. Diagonal, 647
08028 Barcelona
SPAIN

ROMAGNOLI, Guido (#1580)
4 Atias Crt.
Richmond Hill, ONT L4S-1G1
CANADA

JORDAN, Caroline (#1582)
Crewe & Alsager Faculty
Manchester Metropolitan University
Alsager
ST 7 2HL
ENGLAND

HOUSHEER, Aart-Frederick (#1583)
Oudenoord 135
3513 EM Utrecht
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GHEORGHE, Dragoi S. (#1584)
Dept. of Anatomy, Embryol. & Biomecanics
University of Craiova
Grivita Rosie nr. 2, bloc. 2, ap. 3
Craiova, 1100, Dolj
ROMANIA

ALKILANI, Maher (#1585)
Department of Sport Instruction
Faculty of Physical Education
Yarmouk University
P.O. Box 4696
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OATIS, Carol A. (#1586)
Department of Physical Therapy
Beaver College
Glenside, PA 19038
USA

GIBSON, Barry John (#1587)
38 Leon Road
Dalkeith, WA 6009
AUSTRALIA

HORTOBAGYI, Tibor (#1588)
Department of Biomechanics
East Carolina University
251 Sports Medicine Bldg.
Greenville, NC 27858
USA

GRASSMANN, Florian (#1589)
AB-Biomechanik
University of Hamburg-Harburg
Denikestr. 15
Hamburg, 21073
GERMANY

MACUKOW, Bohdan (#1590)
Institute of Mathematics
Warsaw University of Technology
Pl. Politechniki 1
00-661 Warsaw
POLAND

GALLOWAY, Margaret Anne (#1591)
Elite Sport Unit
NSW Academy of Sport
P.O. Box 57
Narrabeen, NSW 2101
AUSTRALIA

NUSSBAUM, Maury (#1592)
Center for Ergonomics
The University of Michigan
1205 Beal Aveneue
Ann Arbor, MI 48109-2117
USA

LOCKWOOD, Kelly (#1593)
Department of Phys. Ed.
University of Alberta
Edmonton, Alberta T6G 2H9
CANADA

PAPADOPULOS, Christos (#1594)
Dept. of Phys. Ed. and Sport Science
Aristoteles University of Thessaloniki
Agios Ioannis
Serres 62100
GREECE

PEN, Lorette J. (#1595)
Department of Health Sciences
Griffith University - Gold Coast
PMB 50 Gold Coast Mail Centre
Southport, QLD 4217
AUSTRALIA

KOGLER, Geza F. (#1596)
Department of Surgery
Southern Illinois University
School of Medicine
P.O. Box 19230
Springfield, Illinois 62794-9230
USA

CRIPTON, Peter A. (#1597)
Muller Institute for Biomechanics
Murtenstrasse 35, P.O. Box 30
Bern, CH-3010
SWITZERLAND

STEADMAN, Richard (#1598)
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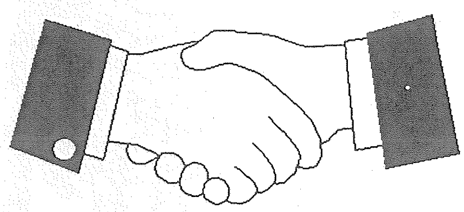

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