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Symposium on Biolocomotion,
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ON
BIOLOCOMOTION:

A CENTURY OF RESEARCH USING MOVING PICTURES

Scuola Nazionale di Atletica Leggera
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April 14-17, 1989

SCIENTIFIC PROGRAMME

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SYMPOSIUM ON BIOLOCOMOTION: A CENTURY OF RESEARCH USING MOVING PICTURES

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Editorial

This newsletter is the abstract booklet of the symposium on Biolocomotion (Formia, April 15-17, 1989) and is therefore a special issue! At the same time it is a first trial to find out if this initiative can obtain your approaval. It is evident that the organizers and the participants of the symposium will be pleased with it because it helps to reduce the costs of the organization. We would appreciate if you could send us a note with your reactions. It will help us to accept or reject similar requests from smaller (ISB) conference organizers in the future.
Thank you in advance.

Jan Pieter Clarys

OPENING OF THE SYMPOSIUM

Sergio Cerquiglini

Istituto di Fisiologia Umana, Università degli Studi 'La Sapienza', Roma, Italy

It is useful to start this Symposium by stating that the needs of scientific research have given a crucial impulse to the invention of cinematography. In particular, this impulse came from those who wanted to get a closer insight into animal motion. In this historical review, special acknowledgement must be paid to the merits of three men who are universally recognized as the pioneers of motion picture recording: Janssen, Muybridge, and Marey. Biolocomotion must be regarded as a very complex phenomenon to be observed. This is due to not only to the peculiarity of the mechanical solutions adopted by nature, but also because of the simultaneity, multiplicity, and rapidity with which the action occurs. Proper scientific observation of biomovements is out of the reach of human unaided eye. The only way to achieve the dissection of this 'morphological object', as Bernstein terms biolocomotion, is through moving picture recording. This is the reason why the invention of photography has determined the renaissance of biomechanics. During the last century animal motion could then be analyzed in depth to the point that nowadays we are close to own sufficient knowledge which would allow us to realize the ultimate objective of science which in this case aims at the reconstruction of a biomotion starting from a few essential elements of it, that is its synthesis.

THE BORELLI'S HERITAGE

Aurelio Cappozzo and Marco Marchetti

Istituto di Fisiologia Umana, Università degli Studi 'La Sapienza', Roma, Italy

At the end of the XVII century, with no measurement instruments except for a ruler and a balance, G.A. Borelli produced the first exhaustive treatise on animal motion. Through the use of what we would call today mathematical models, he calculated muscular moments and forces associated with a number of motor activities. These ranged from simple postures to complex exercises such as walking, running, jumping, flying, and swimming. Through the attentive interpretation of the language used by Borelli, one has the opportunity of fully appreciating the scientific momentum carried by his results. In fact, the greater part of our effort addressed the interpretation of the physical quantities Borelli alludes to and to their translation into concepts familiar to us. Once this is done, a very exciting landscape opens up before the devoted Borelli's reader.

THE CALIFORNIAN CONTRIBUTION

John P. Paul

Bioengineering Unit, University of Strathclyde, Glasgow, U.K.

Following the end of second world war, the United States National Research Council Committee on Artificial Limbs commissioned work at the University of California with the aim of obtaining fundamental data on locomotion in the normal human subject and in the amputee in order to provide design information for the improvement of artificial limbs. The project was conducted at the Engineering Materials Laboratory in Berkeley by representatives of the College of Engineering and the Medical School of the University of California and the massive amount of work reported in the Contractor's Report submitted by Professor H.T. Eberhart was conducted in just under two years. The material presented in this paper corresponds largely to the Contractor's Report which covers four major sections: acquisition of information on the displacement and rotations of the limb in space during locomotion together with ranges of movement, velocities, accelerations, harmonics, internal and external forces: studies of the rotations of limb segments about their long axes during locomotion, range of rotations in three dimensions utilised at the ankle in walking, muscle activity as demonstrated by EMG of muscles in the pelvis, thigh and calf: the gait of a large number of normal and amputee subjects using stroboscopic lighting to determine the movements in the sagittal plans and studies of the rotation of the foot on the tibia. A major contribution of the whole study was the development of an effective force platform for three-dimensional six-component load measurement and also a pylon dynamometer for incorporation into the structure of the prosthesis. Other parts of the report relate to testing of prostheses, anthropometric surveys, pain in amputation stumps, and a number of other factors not relevant to this presentation.

CINEMATOGRAPHY IN THE STUDY OF ANIMAL LOCOMOTION

Richard MacNeil Alexander

Department of Pure and Applied Biology. University of Leeds, U.K.

Cinematographic studies of animal swimming began wit Marey's early films of fishes, shown to the Academy oı Sciences in 1890. Very similar films taken forty years later were the basis of Gray's (1933) explanation of mechanism of fish swimming. More recently, films have been used to discover the energy costs of swimming, by considering either the drag on body parts or the momentum of the wake: Nachtigall's (1960) study of water beetles and Webb's (1971) of fish are distinguished examples of these two approaches. The wing movements of flying birds were shown by some of Muybridge's sequences of still photographs and by pictures taken by Marey using his photographic gun. Hign framing rates have been needed for many later studies of flight, for example Stolpe and Zimmer's (1939) films that showed the wing action of hovering hummingbirds and Ellington's (1984) films of insects that supplied the data for his aerodynamic analysis of hovering, X-ray cine pictures of birds flying in a wind tunnel enabled Jenkins' group (1988) to show that the forcula bends during the wing beat cycle. However, the photographic investigation that has given the most profound insight into animal flight used multiple flash photography rather than cine: air movements behind flying birds and bats ware made visible by means of helium-filled soap bubbles. Muybridge's photographs showed how horses and other mammals move when they walk, trot or gallop, and much later films elucidated the gaits of many-legged arthropods. Films have been used in many studies of the dynamics an energetics of animal running, some using force plates an others depending entirely on kinematic analysis of the kind pioneered (in their study of human walking) by Braune and Fisher.

MAREY AND MUYBRIDGE: HOW MODERN BIOLOCOMOTION ANALYSIS STARTED

Virgilio Tosi

Associazione Italiana di Cinematografia Scientifica, Roma, Italy

Research work on the physiology of biolocomotion carried out more than a century ago was an important, probably the fundamental, stimulus to the invention of the new language of moving pictures and to the establishment of a new technique for scientific investigation, i.e. scientific cinematography. Marey and, through a different approach, Muybridge were in this respect both fathers and pioneers. They had the same dates of birth and death: 1830-1904. However they were totally different figures. Dadwaard J. Muybridge, more of an adventerous photographer than a scientist. Etienne J. Marey, physiologist, professor at the Collège de France, member the Academy of Science, president of the Academy oı Medicine, pioneer of aviation, inventor of the cinecamera. Through the interaction of the totally different experiences of these two men, modern biomechanics started. We shall see the original images taken by them and appreciate their scientific impact.

DYNAMIC PEDOGRAPHY A TOOL FOR THE EVALUATION OF THERAPEUTIC SUCCESS AFTER FRACTURE TREATMENT

Thomas Mittlmeier*, G. Lob*, W. Mutschler** and G. Bauer**

* Chirurgische Klinik und Poliklinik der Universitat Munchen, Klinikum Grosshadern, Munchen 70, W-Germany

** Abt. fur Unfallchirurgie, Hand-Plastische und Wiederherstellungschirurgie der Universitat Ulm, Ulm, W-Germany

Usually, the conclusions and clinical consequences to be drawn from gait analysis after therapy are only quite general and depend on the selection of relevant parameters which are capable of reflecting the basic gait disturbance. In a prospective study comprising 28 patients after conservative or surgical treatment of intraarticular calcaneal fracture the hindfoot function was evaluated employing both gait analysis and clinical and morphological assessment. For an analysis of the dynamic pressure distribution under the foot a calibrated 1344-element-capacitance met with a spatial resolution of 2 sensors per square centimeter and a resolution of force of 1 N at a sampling rate of 20 Hz was employed (EMED-F-system). On the basis of the standard parameters (area, time and pressure) a performance index was generated from a set of 5 parameters (contact time, normalized maximum pressure, normalized impulse, the local percentual distribution of the vertical impulse and the center of pressure line) comparing the formally injured and the intact controlateral foot in the same individual. Finally, the results were compared with the findings of a clinical and morphological assessment performed by a second independent research group. The results of the standard parameters proved sufficiently reliable at repetitive measurements (coefficient of variance ranging from 0.04 to 0.4 depending on the selected region of interest). There exists no discernible difference on the total area loaded more than 1 N/cm^2 after injury in contrast with the results of static podometry. Uniformly, in conservatively treated patients or in surgically treated patients with poor results a significantly decrease and delayed impulse is transferred to the forefoot region coinciding with a diminished maximum pressure in the forefoot area and a prolonged loading of the hindfoot. These phenomena may be related to a loss of normal impact absorbing varus to valgus roll of the heel in the early stance phase and the lack of supination in the push-off phase coinciding with avoidance of toe dorsiflexion which implies a hypomobility of the subtalar joint. This is supported by a shift of the center of pressure line which resembles to the gait behaviour after subtalar arthrodesis. Employing the contingence-table method and the chi^2-test reveals a close correlation of the results of gait analysis and the clinical evaluation score ($p < 0.005$). Thus, a parametric study of the foot to ground pressure distribution represents a valuable tool for the evaluation of gait function after calcaneal fracture treatment and permits a refined analysis which clinical analysis alone cannot offer.

ETIENNE JULES MAREY OR WHEN THE INTEREST FOR MOVEMENT BECAME A SCIENCE

Simon Bouisset

Laboratoire de Physiologie du Mouvement, Université Paris-Sud, Orsay, France

This lecture is devoted to E.-J. Marey (1830-1904), a French physiologist, and deals with the scientific impact of his work in the field of human movement. First, the basic ideas that underlie his work are reviewed, and they are placed within the context of the scientific theories in life sciences which were conflicting at that period. Then, the techniques invented by Marey are presented and their most important applications to human movement are reported. Finally, the role played by Marey in the development of human movement science is stressed, and compared to Muybridge and to Braune and Fisher. His influence on the painters at the turn of the XIXth century is also briefly evoked. The lecture is illustrated with reproductions from the Marey archive.

BIOLOCOMOTION: AN ITEM OF THE ENCYCLOPAEDIA CINEMATOGRAPHICA

Hans Karl Galle

Institut für den Wissenschaftlichen Film, Gottingen, W-Germany

The Encyclopaedia Cinematographica (EC), founded in 1952 at Gottingen, is an international collection of more than 3000 monographic film documents. Among these, numerous films deal with the locomotion of insects, fish, birds and mammals. A selection of these will be presented at the Symposium.

THE HUMAN GAIT BY BRAUNE AND FISCHER

Paul Maquet

Aiwaille, Belgium

Braune and Fischer's classic analysis of the human gait has never been equalled in its comprehensiveness and accuracy. The authors entered into a rectangular system of co-ordinates the centres of gravity of the body and of the different body segments, together with the centres of the different joints of their experimental subjects, for the successive phases of their gait. They calculated the external and internal forces involved in walking and described the kinematics and kinetics of the movement in detail.

THE PREHISTORY OF BIOLOCOMOTION STUDIES IN EASTERN EUROPE

Haralds Jansons

Latvian Research Institute for Orthopaedics and Traumatology, Riga, Latvia, U.S.S.R.

CLINICAL AND KINESIOLOGICAL ELECTROMYOGRAPHY BY 'LE DOCTEUR DUCHENNE (DE BOULOGNE)'

Jan Pieter Clarys* and Leon Lewillie**

* Vrije Universiteit Brussel; ** Université Libre de Bruxelles; Belgium

'Electromyography is the study of muscle function through the inquiry of the electrical signal the muscles emanate. Inherent movement is the prime sign of animal life. For this and many other reasons, man has shown a perpetual curiosity about the organs of locomotion in his own body and in those of other creatures. Indeed, some of the earliest scientific experiments known to us concerned muscle and its functions' (Basmajian, J.V. and De Luca, C.J. 1985).

The first logical deduction that human muscle generated electricity, was made by Francesco Redi in 1666. But we have to wait for more than one century to find a series of scientist in subsequent decenia that are exploring muscles' electricity.

1791: Luiggi Galvani observes the relationship between electricity and muscle contraction.

1795: A. Von Humboldt makes the first attempt to stimulate his own muscles.

1838: Carlo Matteucci proves that electric currents originate in muscles.

1849: Du Bois Reymond reports the detection of voluntary elicited electrical signals from human muscles.

1855; 1862; 1872: 1st-2nd and 3rd Editions of Duchenne (de Boulogne)'s Book 'De l'électrisation localisée'.

1857: N. Dally describes concentric and eccentric muscle action based on the findings of Du Bois Reymond.

1867: Duchenne (de Boulogne) publishes his 'Physiologie des mouvements' (the first scientific bestseller translated into English by E.B. Kaplan and into German by C. Wernicke). Duchenne (de Boulogne) applies electrical stimulation techniques and measures electrical signals of a dynamic muscle to investigate the functions of intact skeletal muscles.

1875; 1876: E.J. Marey makes graphical patterns of muscular fatigue after electrical stimulation. He calls them 'myographic patterns'.

1888: Fernand Lagrange describes the electrophysiology of muscular contraction.

1893: G. Trouvé introduces medical 'Electrology' or rehabilitation by electrostimulation.

1907: Piper uses metal surface electrodes.

1920: Forbes and Thacher are able to amplifie action potentials using Brauns' (1887) cathode ray (in conjunction with a string galvanometer).

1922: Gasser and Erlanger use a cathode ray oscilloscope to 'show' the signals from the muscles. Their interpretation of action potentials result in 1944 for Erlanger in a nobelprise.

1929: the introduction of the needle electrode by Adrian & Bronk.

The authors acknowledge Carlo De Luca, Peter Huying, Bengt Jonnson and Moche Solomonov for their help in locating 'older' research information.

ONE HUNDRED YEARS OF PHOTOGRAMMETRY IN BIOLOCOMOTION

Herman J. Woltring

Eindhoven, The Netherlands

Since Braune and Fisher's invention of Analytical, Close-Range Photogrammetry almost before its inception in Cartography and Surveying, analytical reconstruction of 3-D biolocomotion patterns from projective observations has made considerable progress. This paper provides a survey of the methodological work of the three major groups until the early fifties (Braune and Fisher, Bernstein, the Berkeley group), and proceeds to discuss current possibilities and limitations. It will be shown that 3-D reconstruction of gait data from complete observations on artificial landmarks by multiple camera's is rather simple, but that this condition is hardly realistic. Major problems are incurred by partial data availability, where combination of known (or assumed) rigid-body properties and time continuities with partially observed data allows optimal reconstruction of movement patterns, at the expense of rather complex computational procedures. Furthermore, the camera calibration problem is addressed, and some new results on complete camera calibration in the field from raw gait data are presented, thus obviating the need for a voluminous planar — or spatial calibration object — as advocated in earlier work.

THE PIONEERS OF SCIENTIFIC CINEMATOGRAPHY AT THE TURN OF THE CENTURY AND THEIR WORK IN BIOLOCOMOTION

Hans Karl Galle

Institut für den Wissenschaftlichen Film, Gottingen, W-Germany

After Marey and Muybridge a number of scientists with photographic knowledge continued to develop and use cinematographic techniques. From 1885 onwards, Anschuetz, Bull, Kohlrausch, Marinescu, Messter and Polimanti filmed locomotion in human beings and animals for the purpose of analysis. A selection of these films and animations obtained using original images will be presented.

AMBULATION, CULTURAL AND SOCIAL IDENTITY

Diego Carpitella

Istituto di Studi Glottoantropologici, Università degli Studi 'La Sapienza', Roma, Italy

'Tell me how you walk and I'll tell you who you are'. This means looking at human walking through the lenses of kinesis. As for sounds and gestures also for ambulation we can distinguish the subtle difference between the 'physics' and the 'culture' of the phenomenon. The task is not simple since these two aspects are very closely interwoven. Actors are experts in emphasizing the above mentioned difference. Bearing this in mind, we shall turn to actors for help and see some examples of ambulation played by Lawrence Olivier, Jacques Tati and Dario Fo.

ASSESSMENT OF MUSCULOSKELETAL DISORDERED BY LOCOMOTION ANALYSIS: A CRITICAL HISTORICAL REVIEW

Richard A. Brand

Department of Orthopaedic Surgery. The University of Iowa, Iowa City, U.S.A.

Attempts to assess musculoskeletal disorders by locomotion analysis began in the late 1800's, shortly after the introduction of techniques to record motion (e.g., time-lapse and motion photography, kymographs) and the forces associated with locomotion (i.e. force plates). The early efforts were purely descriptive, and offered little information to better understand the nature of disease, or to make a diagnosis, select among treatment options, or make a prognosis. While locomotion analysis offers the opportunity to answer well-formulated questions about injury and disease, it historically has contributed relatively little information needed by the clinician to make day to day decisions in individual patients. R. Plato Schwartz, working in the 1920's and 30's, was among the first clinicians to attempt assessment of the individual patient and stated three essential criteria for the usefulness of a clinical assessment technique. He developed various techniques to evaluate foot placement and temporal and distance factors of gait ; he reported collecting data from over 2500 normal subjects and patients. Nonetheless, a critical review of his work and that of most of his successors up through the 1980's reveals modest success at best in using locomotion analysis in clinical practice. One can cite, however, at least two important exceptions. To be useful to a clinician in treating individual patients, an assessment tool must provide critical information (i.e., information not otherwise available) selecting between competing diagnoses, selecting between various treatment options, or resulting in different prognoses. Few locomotion analyses can claim to provide such critical information. The likelihood of providing such critical information is enhanced if the locomotion tool meets the following criteria: 1) it is accurate and reproducible; 2) it does not alter the function it is assessing; 3) the measure exhibits stability over time; 4) the measure is not directly observable; 5) the measure is not dependent upon mood or motivation; 6) the measure clearly distinguishes between normal and abnormal; 7) it is cost-effective. Finally, any measure or tool must be validated, a minimum strategy for which includes; 1) well-designed cross-sectional and longitudinal clinical trials in statistically significant numbers of normals and patients; 2) appropriate statistics to separate confounding variables; 3) validation against independent measures.

WILD LIFE ON ONE: IN-FLIGHT MOVIE

Mike Kendall

BBC, Natural History Unit, Bristol, U.K.

Have you ever wanted to fly like a bird? By taking to the air ourselves, new filming techniques bring this experience to life. As we fly in the clouds with a flock of geese, look over the shoulder of a soaring buzzard or edge hop with a speeding starling, we reveal just how a bird's design is shaped to the life it leads — in-flight.

ANALYSIS OF RUNNING IN SOCCER PLAYERS

Raul Saggini and A. Calligaris

Scuola di Specializzazione in Medicina dello Sport, Università di Chieti, and Centro Studi della Federazione Giuoco Calcio Italiana, Italy

Some characteristic aspects of soccer player running have been investigated. This was done both while playing the ball and during free running. Films were taken while these exercises were executed in the field. Experiments were also made in the laboratory where foot-ground reactions were recorded as well as the kinematics of relevant body segments. To this latter purpose an optoelectronic system was used. A number of both kinematic and kinetic differences between usual running and running while playing soccer were observed and will be discussed during this presentation.

MOTION ANALYSIS IN CLINICAL ROUTINE

Fabio Catani and Sandro Giannini

Clinica Ortopedica II, Istituto Ortopedico Rizzoli, Università degli Studi, Bologna, Italy

One of the major tasks in the treatment of joint or neuromuscular patients is to correct joint deformity, to deal with the causes that have determined it and to give back to the patient joint functional ability. This is why any evident structural modification which occurred in the affected limb must be quantified using well defined clinical and biomechanical parameters. Based on this statement, the necessity arises to have and apply a non-invasive movement analysis technique which would yield data easy to interpret and, most importantly, repeatable and reproducible. Since 1986, we have been dealing with the study of gait abnormality in hip, knee, ankle joint arthrodesis, in total knee replacement and pronated or supinated foot patients. We have learned that quantitative assessment of orthopedic patients is becoming necessary to verify the quality and the accuracy of our diagnoses and surgical and non-surgical treatments. In the same way the biomechanical terminology and a more accurate knowledge of the causes and compensatory mechanisms associated with pathology. Despite the great amount of information gained by us through clinical and biomechanical evaluation, more research must be done both from the engineer (excessive cost and difficulty in the use of the equipment, difficulty in the management and interpretation of the collected data etc.) and physician (lackness of biomechanics background) point of view. More attention should be focused upon the following topics: 1) make the clinical and biomechanical evaluation easy to do and first of all well acceptable by the patients; 2) define a reproducible and anatomical experiment protocol to get the kinematic (6 DOF), foot-ground reaction and kinetic parameters (moments referred to anatomical axes of rotation); 3) choose the more significant clinical parameters to synthetize the 'normal' or 'pathological' neuro-muscular limb pattern; 4) present the biomechanical results (graphs, statistic etc.) in a way easy to read by the physician, physiotherapist and other medical personnel. We would also like to stress the necessity to have a closer relationship between laboratories, which may even use different kind of systems, trying to share important clinical and technical information which arises from the basic routine, and reach some kind of standardization of the experiment protocols and interpretative approach.

SYNTHESIS OF HUMAN GAIT

Necip Berme

Dept. of Mechanical Engineering, The Ohio State University, Columbus, Ohio, U.S.A.

A dynamic model for simulating lower limb movement and ground reaction forces during normal level human walking has been developed. The model consists of a seven degree-of-freedom, three-dimensional linkage, joined together with frictionless revolute joints. The corresponding dynamical equations of motion are generated numerically using the recursive Newton-Euler formulation. Muscle forces, via ideal force actuators and/or joint moments are recognized by the model as a set of pre-programmed inputs, controlling limb motion open loop. Choosing these inputs appropriately, and integrating the nonlinear differential equations forward in time, results in ground reaction forces and limb displacements that compare favorably with experimental gait data. The influence of individual gait determinants on ground reaction forces, as well as some gait deviations, were studied.

BERNSTEIN: THE MICROSCOPY OF MOVEMENT

Haralds Jansons

Latvian Research Institute for Orthopaedics and Traumatology, Riga, Latvia, U.S.S.R.

KINEMATIC ANALYSIS OF TRIPLE JUMP

Franco Merni*, Antonio Cicchella* and Albert Madella**

* Laboratorio di Biomeccanica, Cattedra di Anatomia Topografica, Università di Bologna, Italy
** Scuola dello Sport, Rome, Italy

The present study investigates various biomechanical parameters of the triple jump. All the variables usually investigated by researchers have been taken into account (e.g. distribution of the total distance achieved in three jumps, length of the last two strides, support times, trajectories of the center of gravity). Moreover some other data previously ignored by scientists have been analyzed: damping and driving time (separately) and flight times in the various phases of the jump. Kinematic and dynamic data, computed through the analysis of the trajectories of the center of gravity are also reported and discussed. Five jumps by four athletes of different qualification (3 junior international competitors and one of lower qualification) have been analyzed. The jumps have been filmed with three cameras simultaneously operated at 72 frames/sec. The data have been then digitized and filtered. It is possible to draw some interesting conclusions from the data now available that might be helpful to coaches and researchers. Significant differences of horizontal velocities and support times have been found in the different phases of the jump. In the two last strides the flight time is lower than the support time. Differences in speed are also evident in athletes of different qualification but for final jump. The velocity data recorded in the jump are not apparently influencing the performance of the athletes. Much more relevant differences may be found in the first two jumps and when dynamic data are compared.

TV/COMPUTER MOTION ANALYSIS SYSTEMS: THE FIRST TWO DECADES

Hans E. Furnee

Motion Studies Lab., Delft University of Technology, Delft, The Netherlands

The commemoration of October 1, 1888, when E.J. Marey surprised the scientific community with a strip of consecutive photographic records produced by his cronophotographic box at 20 exposures, marks not only the invention of an important measurement device for kinematic research, but also the origin of a consumer product which has expanded to the degree of becoming part of our lifestyle. When dealing with fast motion phenomena, there is still no substitute for ultra-speed cine cameras. As with Marey, the demand for a new recording method has arisen from the field of human and animal movement analysis. The most succesful of the newly emerging computer-coupled systems utilized existing sensor technology, such as the already well developed television camera or somewhat later the position-sensitive devices (Woltring, 1975). Motion analysis requirements fostered electronically shuttered CCD-cameras to improve the contrast of retroflective markers (Furnee, 1986). But the mainstream of these developments, such as initiated by Furnee (1967), and followed by, e.g., Paul et al. (1974) and commercialized by Oxford Instruments UK (1981), was the interfacing of available front-end imagers to an even more powerful range of mini and personal computers, ending up in portable systems to any indoor or outdoor location. These latter developments benefited from the incorporation of microprocessors within the video-coordinate converter interfaces, to provide real time data reduction and improved resolution and noise performance, e.g. by marker centroid processing (Furnee, 1984, 1988). This and other contributions, such as Winter's CINTEL and the TV based Honeywell Oculometer, will be put in perspective and reviewed against other optoelectronic systems. The continuity of multi-camera algorithms for 3-D kinematics, first calculated by hand and later through computer software, from cinefilm to optoelectronic records is a noteworthy subject in itself. A sobering thought might be that the sampling rate of TV-base systems (VICON, Expert Vision, ELITE, PRIMAS) has not gone beyond 10 times that used by Marey's primordial cinefilm one century ago.

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SOFT SATURATION, AN IDEA FOR LOAD SHARING BETWEEN MUSCLES APPLICATION TO THE STUDY OF HUMAN LOCOMOTION

Adam Siemienski

Biomechanics Laboratory, Academy of Physical Education, Wroclaw, Poland

Biomechanical systems are usually redundant in the sense that more muscles cross a joint than are necessary to produce a given moment. Thus the number of unknown muscle forces exceeds that of equilibrium equations and unique force distribution among muscles cannot be found. The solution of this general distribution problem (GDP) necessitates the formulation of a criterion reflecting the nervous system's strategy of recruiting the individual muscles. In all the approaches reported in the literature the natural limit on the muscle stress is introduced by means of an inequality constraint in the optimization scheme. This results in orderly recruitment of muscles (linear criteria), or piecewise linear synergism between muscles (non-linear criteria) (Dul J. et al., 1984a). None of the existing criteria, including the only one which gives non-linear synergism (Dul J. et al., 1984b), is thus able to predict a smooth relationship between muscle force and external moment throughout the whole range 0 F Fmax. The scope of the work is to present an alternative approach in which the limit of the muscle stress is imposed by the form of the objective function rather than by inequality constraints. With this soft saturation of muscles it is possible to model the changes in load sharing when approaching the limiting stress.

The new criterion is used to solve the GDP for the muscles of human lower limb during locomotion with the actuating moments obtained from film analysis of a marathon run and a sprint. An analysis of sensitivity of the results to the value of the muscle stress limit is also performed.

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FUNCTIONAL ANATOMY OF THE HIP

Giulio Cesare Todescan, Enzo Brizzi and Michelangelo De Faveri

Department of Human Anatomy and Histology, University of Florence, Italy

A film is shown which presents the movements of the coxofemural articulation. Individual movements are analysed both from the anatomical and functional point of view in relation with the muscles involved. Movements of flexion, extension, abduction, adduction and rotation are investigated. The action of articulating is shown using photographs and drawings and films of athletic exercises as well. Recordings made during autopsy dissections and motion pictures obtained using computerized graphic techniques are also shown. The audio-visual elaboration has educational aims in relation with the anatomical and functional aspects of this particular articulation as used in human locomotion.

POSTURE AND MOVEMENT ANALYSIS IN ERGONOMICS

Jan Dul

TNO Institute of Preventive Health Care, Musculoskeletal Research Group, Leiden, The Netherlands.

In most industrialized countries, musculoskeletal disorders are the major reason of sick leave and disability. In The Netherlands, one out of five sick leave days, and one out of three new cases of disability are caused by musculoskeletal disorders. It is generally accepted that musculoskeletal disorders at the work place can be prevented by reducing the mechanical load on muscles and joints during working postures and movements. However, no simple method is available to quantify the mechanical load during work, and to define acceptable load limits. At the TNO Institute of Preventive Health Care a two-phase approach is used to quantify the mechanical load on muscles and joints during work. The aim of the first phase is to get a general qualitative impression of the mechanical work load during the working day, and to select 'activities at risk'. Questionnaires are used to record the worker's musculoskeletal pain, and his perceived load during defined activities. An 'expert opinion' about the work load is given by the researcher, based on posture and movement observations in the field. In the second phase of the research, posture and movements during selected activities at risk are analyzed quantitatively. The aim of this phase is to quantify the mechanical load in specific body regions, and to formulate guidelines for ergonomics improvements of the work place or the work method. In an experimental set up in the laboratory or in the field, kinematic data of body segments are collected using the opto-electronic VICON system with four synchronized video cameras. Retro-reflective markers are put on the skin overlying selected body joints and bones. For further analysis of the data several existing biomechanical models (whole body models such as 2DSSPP, 3DSSPP, WATBAK, and single joint models such as the NIPG shoulder model) are used to quantify muscle and joint load. The following examples of this research approach will be discussed: a) improvement of working posture of female sewing machine; b) comparison of lifting techniques; c) postural changes during long term sitting at VDU terminal.

SIMULTANEOUS RECORDING OF BODY MOVEMENT AND FORCE DATA ON A COMMERCIAL RECORDING DURING IN VIVO MEASUREMENT OF HIP JOINT FORCE

Friedman Craichen and Georg Bergman

Free University, Department of Orthopaedics, Biomechanics Lab., Berlin, W.-Germany

A four channel telemetric transmitter inside a hermetically closed artificial hip joint permits in vivo measurement of the three-dimensional hip force and the temperature. After animal tests for several years two instrumented prostheses were implanted in the first patient in May and August 1988. The external equipment consists of an inductive power supply, a microcomputer with hardware extension for real time data processing and a VHS video system. During the measurement the movements of the patient are picked up by two video cameras transmitted by pulse- interval-modulation with a sampling rate of more than 200 Hz for each force component and a pulse duration of 50 s. This kind of modulation permits the simultaneous storage of the received pulse train on a separate audio track of a modified video tape recorder (VTR). In this way repeated plays and detailed analysis of the recorded force and movement at different speeds are possible without the patient needing to be present. During the on-line representation of the three force components in form of time diagrams the corresponding video-image of the patient's movement is shown on a monitor with a resolution of 25 frames per second. Joint force measurements have regularly been performed from the first postoperative day till now for various kind of activities.

KINESIS: A TOOL FOR ANALYSIS AND REPRESENTATION OF MOVEMENTS

P. Morasso, Massimo Solari and Gianni Vercelli

Dept. of Computer Science, University of Genova, Italy

The main idea of our work is that Representation of Movement, in particular anthropomorfic movement, could be exploited in a procedural way using an integrated system based on several open modules. Topics are reconstruction and extraction of relevant motoric information from the 3D structure of an actor moving inside a scene. For this purpose we developed a prototype tool, called KINESIS, that allows the reconstruction and animation of 3D postures, i.e. configurations of the structure of an actor, from multiple viewpoint. Sequences of images are acquired using multiple cameras and video recorder controlled by the system via software. Acquisition of key-points of such postures is performed semi-automatically or interactively; calibration of cameras is done only once for a session; both modules use a method of inverse perspective and are inside the window-based interface of the system. Reconstructed postures have an internal representation as trees of kinematic chains, using a geometric frame for each linkage. Animation of frames into a smooth simulated movement is performed by means of procedural motor algorithms written in NEM, a Movement Programming Language (Marino et al., IJCAI 1985). Final analysis of simulations is performed using post-processing routines. Simulation results of preliminary implementation of KINESIS are presented.

MEASUREMENT FACILITY OF FORCES AT THE KNEE JOINT DURING STAIR CLIMBING

François Pelisse, F. Marie, P. Richard and D. Geiriger

CERAVAL, Valenton, France

Climbing up and down stairs is especially stressful for the knee joint. It is well-known that patients with a femoro-tibial or femoro-patellar pathology fear climbing a few steps more than level walking even for a long time. A three step staircase was built. The top platform was one meter square. The intermediate step was a force plate which measured the reaction forces at its four corners. Three contactless displacement detectors were used. These were linear CCD's made of 2000 points. The knee coordinates in the saggittal plane were measured making reference to a micro lamp placed on the lateral side of the knee. The sampling frequency for all measurements was 100 Hz. The displacement accuracy was 1 mm and the vertical forces accuracy was + 2 daN. The moments at the knee joint were computed using the knee coordinates and the foot reaction forces. The contact forces between femur and tibia and between femur and patella were provided by a simple model of the knee joint. This model was based on the equilibrium between the computed forces and moments at the knee on one hand and the resultant forces of ligaments and muscles on the other. Results from normal subjects showed a maximum femoro-tibial reaction force of 2.5 times body weight for climbing upstairs and 4 times body weight for climbing downstairs. These values were about the same for subjects with pathological knee. It seems as if a person with painful knee cannot avoid loading his knee during stair climbing as he can during level walking.

GAIT ANALYSIS IN RACE WALKERS

Raul Saggini, A. Calligaris and A. Pezzatini
Scuola di Specializzazione in Medicina dello Sport
Università di Chieti, Italy

Our analysis concerns the fundamental characteristics of race walking at constant and defined velocity. Twelve race walkers have been studied. Body segment movement and ground-reactions were measured. The integrated analysis showed that during the phase of impact the hip exhibits a lateral displacement, and the ankle a pronounced dorsiflexion; in this way the best allignment between thigh and shank is achieved through a hyperextended knee. The ground reaction shows a high peak and it is inclined backwards. The centre of gravity exhibits a reduced vertical oscillation. The arms are flexed to 80 degrees and the trunk is flexed forwards by 10 degrees. The mid-stance phase is characterized by an increase of speed of progression as well as of the ground reaction value. The lower limb rotates externally, the trunk slightly extends. The propulsive phase shows an increase of speed of progression and a persistent external rotation of the lower limb. The arms invert their movement and the trunk flexes.

Calendar of world wide scientific events

June 5-9, 1989
Cincinnati, "Annual International Industrial Ergonomics and Safety Conference", Secretary: A. MITAL, Mechanical and Industrial Engineering Department, University of Cincinatti - Cincinnati, OH - 45221 0072 USA.

June 6-9, 1989
Paris, "Capteurs 89" (Conférences et Expositions), Secretary: CIAME - Université Paris XII, Pr. THUREAU, 9 rue Huymans, 75006 Paris, France.

June 9-10, 1989
Saint-Etienne, "Réunion Association des Physiologistes 'Exercice musculaire'", Secretary: Dr. N, MEI, CNRS, INP 1, 31 Chemin Joseph Aiguier, 13277 Marseille, Cedex 09 France.

June 15-17, 1989
Frankfurt am Main, "6th European Conference on Clinical Haemorheology", Secretary: Prof. Dr. A. EHRLY, J.W. GOETHE, University Hospital, Dept. of Internal Medicine, Theodor Stern Kai 7, D 6000 Frankfurt am Main 70, Germany.

June 18-23, 1989
Nancy, "7th International Congress of Biorheology", Secretary: Prof. J.F. STOLTZ, Centre Régional de Transfusion Sanguine, Brabois, 54500 Vandoeuvre les Nancy, France.

June 21-24, 1989
Berlin (West), FRG, "7th Intern. Symposium Adapted Physical Activity - an interdisciplinary approach" (c/o 7th ISAPA BERLIN '89, Secretary, Institut für Sportwissenschaft, Freie Universität Berlin, Rheinbabenallee 14, D-1000 Berlin 33) Tel.: (030)824.37.31.

June 24-25, 1989
Davis, California, USA, "Second International Symposium on Computer Simulation in Biomechanics", organized by the Department of Mechanical Engineering and the Human Performance Laboratory, University of California, Davis USA.

June 25-28, 1989
Munich, "2nd International Symposium Biofluid Mechanics and Biorheology in Large Blood Vessels, Secretary: Prof. Dr. D. LIEPSCH, Hal. B. Wallis Research Facility, Eisenhower Medical Center, 3900 Bob Hope Drive, Rancho Mirage, California - USA.

June 26-30, 1989
Los Angeles, "XII Congress of Biomechanics" (c/o XII Intern. Congress of Biomechanics, UCLA Deptm. of Kinesiology, 2854 Slichter Hall, Los Angeles, CA 90024-1568, USA. Tel.: (213)825-3910 of 825-5376.

June 29-July 3, 1989
Maccabiah-Wingate, International congress on sport sciences & coaching. International Congress Secretariat: Wingate Institute for Physical Education & Sport, Wingate Post 42902, Israel.

July 3-7, 1989
Brussels, Belgium, International Congress 'Dance and Research', Vrije Universiteit Brussel, Auditorium Q, Pleinlaan 2, Prof. Dr. Cl. Brack, International Congress 'Dance and Research', V.U.B.-H.I.L.O.K., Pleinlaan 2, B-1050 Brussel, Belgium.

July 3-7, 1989
Albena, Bulgaria, Sixth International Symposium on Motor Control, Union of the Medical Scientific Societies in Bulgaria, Bulgarian Society for Physiological Sciences, Institute of Physiology of the Bulgarian Academy of Sciences.

July 9-14, 1989
Helsinki, 31th International Congress of Physiological Sciences. (Secretariat: Pr. O. Hanninen - Travel Experts Ltd - P.O. Box 722 - SF - 00101 Helsinki - Finland).

July 16-19, 1989
Paris, Symposium 'Head Movement Control'. (Secretariat: A. Berthoz - CNRS - Laboratoire de Physiologie Neurosensorielle - 15 rue de l'Ecole de Médecine - 75270 Paris).

July 18-21, 1989
Birmingham, United Kingdom, 'International Sports Science Conference'. Theme 'Science in the service of sport' (c/o The Sports Council, 16 Upper Woburn Place, London WC1H OQP). Tel.: 01-3881277, Fax: 01-3835740, Telex: 27830 SPORTC G.

July 23-27, 1989
Denpasar, Indonesia, 'IX IAPESGW World Congress'. Theme: 'Better Family Life Through Physical Education and Sport' (c/o XI IAPESGW Congress, Gedung Koni, Jalan Gelora Pintu Satu, Jakarta 10270, Indonesia). Tel. (65021) 587492 - 5481890, Telex: 45214 koni ia.

Aug. 07-12, 1989
Singapore, '7th World Congress on Sport Psychology'. Theme: 'Sport Psychology and Human Performance' (c/o Dr. C. K. Giam, Singapore Sports Council, National Stadium, Kallang 1439, Singapore). Tel: (65) 3457111, Telex: rs 35467 natstad.

Aug. 23-25, 1989
University of Vermont at Burlington, Vermont, 13th Annual Meeting of the American Society of Biomechanics, UVM Conferences, 460 So. Prospect Street, Burlington, VT 05401 USA, (802) 656-2088.

Aug. 28-Sep. 01
Turku, Finland, '2nd Paavo Nurmi Congress and Advanced European Course on Sports Medicine'. (c/o Dr. Martti Kvist, M.D., Sports Medical Research Unit, Kiinamyllynk. 10, SF-20520 Turku, Finland). Tel.: 358-21-513355.

Aug. 29-Sep. 01, 1989
Saarbrücken, FRG, International Symposium on 'Research in Motor Learning and Movement Behavior' (c/o Prof. Dr. Reinhard Daugs, Sportwissenschaftliches Institut der Universität des Saarlandes, Im Stadtwald, 6600 Saarbrücken, FRG). Tel.: (0681)3024170.

Sep. 4-8, 1989
Tubingen, "6th International Symposium on Synthetic Membranes in Science and Industry", Secretary: Mrs. Birkenberg, Abt. Tagungen, P.O. Bos 97 01 46 - D-600 Frankfurt 97, Germany.

Sep. 05-08, 1989
Barcelona, Spain, 'XVI Congreso Grupo Latino y Mediterràneo de Medicina del Deporte' (c/o CEARE, Residència Blume, Av. Paisos Catalans, 12, 08950 Esplugues de Llobregat, Barcelona, Espana). Tel.: 254 07 78.

Sep. 6-8, 1989
Institut Méditerranéen de Technologie, Marseille, XIVème Congrès annuel de la Société de Biomécanique & Journée Protheses, Lasers, Instrumentation vasculaires, information: Mr. Régis Rieu, Institut de Mécanique des Fluides de Marseille, XIVème Congrès de Biomécanique, 1, rue Honnorat, 13003 Marseille, tél.: 91.08.16.90.

Sep. 11-15, 1989
At the London Hospital, London, England. VIIIth World fina Medical Congress on Aquatic Sports. Further Information: Conference Service Limited, Aldine House, 9-15 Aldine Street, London W12 8 AW. Tel.: 01-740 8121 (International 2 44-1-740 8121) Telex: 916024 Confer G.

Sep. 13-15, 1989
Brussels, "XVIth Congress ESAO - European society for artificial organs", Secretary: Mrs. I. VERSLYCKEN, Hopital Universitaire de Ghent, Division Rénale, De Pintelaan 186, B-9000 Ghent.

Sep. 18-22, 1989
Marseille, "57e Réunion Annuelle de l'Association des Physiologistes", Secretary: Prof. P. LAURENT, Lab. de Morphologie fonctionnelle et ultrastructurale des adaptations, NCRS, 23 rue du Loess, BP 20 CR, 67037 Strasbourg Cedex, France.

Sep. 22-24, 1989
Saumur, Médecine et Sports Equestres, 7e Congrès des pays francophones, Groupe d'étude de la médecine des sports équestres, secrétariat général: Dr. B. Auvinet, Centre Hospitalier de Laval, F 53024 Laval Cedex, Tél.: 43 66 50 00

Sep. 25-28, 1989
Lyon, "Réunion Association des Physiologistes 'Microgravité'", Secretary: Dr. C. BENSCH, Lab. de Biologie appliquée au sport, Université Bordeaux II, 146 rue Léo Saignat, 33076 Bordeaux, France.

Oct. 1-4, 1989
Sapporo, "VIIth World Congress of the International Society for artificial Organs", Secretary: c/o International Communications, Inc; Kaho Bldg; 2-14-9, NIHOMBASHI, CHUO-KU, TOKYO 103, Japan.

Oct. 4-6, 1989
Lyon, XXVe Congrès de la Société d'Ergonomie de Langue Française Self, Evolutions technologiques et ergonomie, Palais des Congrès de Lyon, Quai Achille Lignon, 69006 Lyon, Secrétariat: Congrès Self, Inrets Lesco 109, av. S. Allende, Case 24 - 69675 Bron Cédex-F, Tel.: 78.26.90.93

Oct. 9-13, 1989
Cargese, "Euromech 259. Biomechanical Transport processes", Nato, Workshop, Secretary: Prof. F. Mosora, Université de Liège, Institut de Physique, B, B-4000 Sart-Tilman, Belgique.

Oct. 29-Nov. 3, 1989
Colorado Springs, Colorado, U.S.A., World Congress o Sport Sciences. Promoted by the International Olympic Committee, Medical Commission. Organized by the United States Olympic Committee, c/o M.M. Newsom, U.S. Olympic Committee, 1750 East Boulder Street, Colorado Springs, CO 80909 U.S.A.

Jan. 28-Feb. 02, 1990
Auckland, New Zealand, IXth Commonwealth and International Conference (c/o Conference Convenor 1990, Ms. Rosalie King, Auckland College of Education, Private Bage, Symonds St., Auckland, New Zealand).

May 21-25, 1990
Brussels, Belgium, International Congress on 'Youth, Leisure and Physical Activity'. Vrije Universiteit Brussel, HILOK, P. De Knop, secretary general, Pleinlaan 2, B-1050 Brussels, Belgium.

May 21-25, 1990
Brussels, Belgium, International ISAK-congress 'Kinanthropometry IV) incorporated in the international congress on 'Youth, Leisure and Physical Activity' (c/o Dr. P. De Knop, Vrije Universiteit Brussel, HILOK, VTBP, Pleinlaan 2, 1050 Brussel, Belgium). Tel.: (02)641 27 44, Telex: 61.051 VUBCO-B, Fax: (02)641.22.82.

May 27-June 01, 1990
Amsterdam, The Netherlands, XXIV FIMS World Congress of Sports Medicine (c/o Organisatie Bureau Amsterdam b.v., Europaplein 12, 1078 GZ Amsterdam, The Netherlands, Tel.: 31/2044087. Telex: 13499 raico nl.).

July 9-14, 1990
St. Andrews, "International Scientific Congress of Golf", University of St. Andrews, Secretary: Dr. M.R. Farrally, Director of Physical Education, University of St. Andrews, Sports Centre, St. Leonarads Road, St. Andrews, Fife. KY16 9DY.

Aug. 26-31, 1990
La Jolla, "First World Congress of Biomechanics", Secretary: Prof. G.W. Schmid-Schönbein First World Congress Biom. AMES, Bioengineering M - 005 University of California, San Diego, La Jolla, CA 92093, USA.

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

Dec. 9-14, 1991
ISB XIII Congress
University of Perth - Western Australia organisation: Dr. Graeme Wood.