AREA

NORTH AMERICAN - CENTRAL

I. IOWA CITY, IOWA

ADDRESS
Orthopaedic Biomechanics
Children's Hospital
University of Iowa
Iowa City, Iowa 52240

Director: Richard Brand - Orthopaedic Surgeon
Roy Crowninshield - Engineer

I. EQUIPMENT

Biomechanical.

Walkway: Total length 10.0 m
Run-in 3.0 m Effective length 4.0 m Run-out 3.0 m
Force plate Foot switch Elgons Accelerometer
Strobe Cine

Physiological.

Dynamometer EMG surface and indwelling electrodes

II. PARAMETERS

Both simultaneously or singly
Motions: Linear: Stride length, cadence, swing and stance, velocity, gait width
Spatial Relations: Joints and body segments
Angular: In all three planes - all joints
Forces: Angular Moments: All joints in three planes
Ground Reaction: Vertical, AP and ML shear, center of pressure
Muscular Tension: Major groups and individual muscles

Physiological: EMG, nerve conduction

Processing: Sampling rates: 1.0 ms up
Time: 11-21 days

III. PHILOSOPHY

The philosophy of this laboratory centers around mechanical analyses associated with gait. A newly developing laboratory (see below) is concerned with the development of evaluation and treatment techniques for musculoskeletal, neuromuscular, and cardiopulmonary physical disabilities.

Physical Therapy Laboratory
University of Iowa
Iowa City
Iowa 52242

II. IOWA CITY, IOWA

ADDRESS

Multifaceted Physical Therapy Laboratory
120 Westlawn
University of Iowa
Iowa City, Iowa 52242

Director: Gary L. Smidt, L.P.T., Ph.D.

I. EQUIPMENT

Energy expenditure equipment
Treadmill
Cybex and other muscle tension equipment
Bicycle ergometer
Instrumented walkway
Video tape equipment
Electromyography
Computer
Electrogoniometers
Recorders, oscilloscopes, etc.
Accelerometers
L.E.D.'S

II. PARAMETERS

44 temporal and distance factors
Energy expenditure
EKG
Pulse rate
E.M.G.
Kinematics

Processing: Manual
On-line in development

III. HOUSTON, TEXAS

ADDRESS
Biomechanics Laboratory
Texas Institute for Rehabilitation and Research
1333 Moursund Avenue
Houston, Texas 77025

Director: Lewis A. Leavitt, M.D.
Deputy: Efrain N. Zuniga, M.D.

I. EQUIPMENT

Biomechanical.

Walkway: Total length 10.4 m
Run-in 1.0 m Effective length 8.4 m Run-out 1.0 m
Foot switch Elgons
Video

II. PARAMATERS

Both limbs simultaneously
Motions: Linear: Stride length, cadence, swing and stance, velocity
Angular: Knee only in sagittal plane
Forces: Angular Moments: Knee only

Processing: Manual, Computer

Time: 1/2 hour

IV. ROCHESTER, MINNESOTA

ADDRESS
Mayo Orthopaedic Biomechanics Laboratory Director: Edmund Y. Chao, Ph.D.
Medical Science Building
Mayo Clinic
Rochester, Minnesota 55901

I. EQUIPMENT

Biomechanical.

Walkway: Total length 12.0 m

Run-in	Effective length 10.0 m	Run-out
Force plate	Foot switch	Accelerometer
Cine		

Physiological.

Dynamometer for knee joint

II. PARAMETERS

Recording singly or simultaneously

Motions: Linear: Stride length, cadence, swing and stance, velocity, width
Spatial Relations: Joints and body segments
Angular: Hip and knee in three planes - ankle and foot sagittal only

Forces: Angular Moments: Sagittal only - ankle and subtalar joints
Ground Reaction: Vertical, AP and ML shear, center of pressure, vertical torque between foot and floor
Joints: Compression, tension, shear in ankle only
Bones: Compression, tension, shear in tibia and fibula
Musculature: Tension in individual muscles

Processing:

Experimental Error: less than 10 percent
Time: 2 hours

V. SASKATOON, CANADA

ADDRESS
Human Locomotor System
Department of Anatomy
University of Saskatchewan
Saskatoon, Saskatchewan
CANADA

Director: Bruce R. Brandell, Ph.D.

Deputy Director: Keth Williams, Ph.D.

Technical Advisors: George Dyck, Bill Woodward and A.E. Krause

I. EQUIPMENT

Biomechanical.

Treadmill: 0 - 5.0 mph

Walkway: Indoor rectangular - total length: 25.0 m
Run-in 2 m. Effective length 7.0 m
Outdoor - 1/4 mile hard packed cinder track
Cine Camera: Bolex, Motordrive, 50 fps

Physiological.

EMG surface and indwelling electrodes
Analog tape recorder - 7 channel
Oscilloscopes and 35 mm linegraph cameras
Integrator and digital counter
Functional electrical stimulator
4 isolated channels
Controlled parameters: strength - current regulated
cycle frequency - free oscillating
foot switch phase lock loop
cycle phasing by decade switching start and finish of cycle to nearest 1/100 cycle.
Stimulus isolator: Facilitates recording evoked EMG and quantitative measurement of isolated EMG

II. PARAMETERS

Both simultaneously but usually right limb only
Motions: Linear: Stride length, cadence, swing, stance, velocity
Spatial Relations: Body segments
Angular: Sagittal place only - hip, knee, ankle, foot
Forces: Nil

Physiological: EMG
The effects FES on EMG and motion

Processing: Manual (Encoding and digitizing equipment being designed)

Error: 5%
Days: several

III. PHILOSOPHY

The general approach to the study of gait in this laboratory is the analysis and definition of motion and muscle coordination in the normal human walking gait under a variety of stress conditions of speed and tilt and the application of established normal standards to the assessment of pathological gaits and the evaluation of surgical and rehabilitative treatments. Recently these evaluative objectives realized by means of synchronized cinematography and electromyography have been supplemented by experimental manipulation of muscle tensions in normal and activation of paralyzed muscles in patient subjects by means of Functional Electrical Stimulation.

IV. PROJECTS

A. Functional Electrical Stimulation

1. Basic research. This research is using cine, EMG and FES to establish the detailed functional relationships of lower limb motions and muscle contractions during normal walking gait. At the moment we are concentrating on interplay between heads of the triceps sural (med. and lat. heads of gastrocnemius and soleus) and the quadriceps in producing the heel rise and push-off of stance phase. Subjects walk on a treadmill while the output of up to four isolated stimulus channels to surface electrodes is held in synchrony with the gait cadence by means of a foot switch activated by Phase Lock Loop System. Decade switches regulate the timing of each channel to the nearest 100th of a gait cycle. The EMG is recorded from indwelling wire electrodes, either on a seven channel analogue tape recorder or directly on 35 mm film from the face of a 502A dual beam oscilloscope, and is processed by a uniform blanking technique to remove the stimulus artifact. Simultaneously, subjects are photographed at 50 fps with a motor driven Bolex camera and a LED in the picture is activated by a foot switch which also triggers a spike on a separate channel of the EMG recording. Quantitative EMG data is, at present, electrically integrated and digitized manually but computerization is being developed. The motion data at present are measured and recorded manually from a Vanguard Motion Analyzer, and the data plotted as curves of position, velocity and acceleration by an IBM 370.

2. Application to patients. At present, a belt-worn portable stimulator with simple foot contact switching is being used to correct foot drop in hemiplegic patients. In addition, a "universal" control which uses foot contact with time delays, is being built so that our four-channel stimulator can be applied to patients for the simultaneous FES of four muscle groups. It is planned to use the "universal" unit for researching the requirements of individual patients, for each of whom compact portable dedicated units may then be built.

Saskatoon cont.

B. Pre- and Post-Operative Evaluation of Patients

In cooperation with individual surgeons in the Department of Orthopaedic Surgery, we are making pre- and post-operative cinematographic plots and analyses of lower limb motions in patients who undergo plastic or replacement surgery for the toes, knee or hip.

VI. WINNIPEG, CANADA

ADDRESS
Gait Analysis Laboratory
Shriners Hospital for Crippled Children
633 Wellington Crescent
Winnipeg, Manitoba
R3M 0A8, CANADA

Director: A. O. Quanbury

I. EQUIPMENT

Biomechanical.

Walkway: Total length 10.0 m
Run-in 2.5 m Effective length 5.0 m Run-out 2.5 m
Footswitch via telemetry
Cine frontal and sagittal planes
Video sagittal plane

Physiological.

EMG surface and indwelling electrodes via telemetry

II. PARAMETERS

Both limbs simultaneously, EMG and footswitches only
Motions: Linear: Stride length, cadence, swing and stance velocity
Spatial Relations: Joints and body segments
Angular: In sagittal plane only - all joints. Absolute angle in space of thigh, leg, and foot
Forces: Angular Moments: Hip, knee and ankle in sagittal plane
Ground Reaction: Vertical and AP shear during single support
Joints: Compression, tension, and shear in all
Bones: Compression, tension shear in femur, tibia, and fibula
Energy Power Flow: Instantaneous energies of limb segments, power flows across joints

Physiological: EMG

Processing
Image Data: 60 TV fields/sec.
Experimental Error: Coordinate Data $\approx$ 1.5 mm
Time: EMG - 1.0 min.
Temporal - 1.0 min.
Kinematic - 3 days

III. PHILOSOPHY

Gait studies can provide important clinically useful information for the proper assessment of abnormal walking patterns. This gait laboratory has been set up to analyze walking patterns in children, both normal and abnormal, without causing undue encumberance to the patient. The current emphasis is

Winnipeg cont.

on the study of abnormal walking patterns rather than fundamental studies on normal gait although normal gait is studied when necessary to establish basic patterns for reference. Factors such as short turn around time for data retrieval, minimum encumberance to the subject and reliability of equipment have a somewhat higher priority than obtaining a few less percent of error in measurements below a permissible maximum.

IV. PROJECTS

1. Cerebral Palsy Gait. General EMG and slow motion cine studies on fifty cerebral palsy patients with various walking problems in an attempt to define some of the specific problem areas to study more closely. Two specific projects that are ongoing are the study of hip muscles in relation of femoral intoeing in CP patients and a comparison of the passive measurement of the ranges of joint motion in a spastic child and those measured while the child is actually walking. The first of these studies should provide detailed knowledge that will be of value in recommending various surgical procedures and the second will indicate the applicability of passive joint motion measurements in determining dynamic joint contractures. Both these projects should be completed in 1977.

2. Prosthesis Evaluation. An ongoing research project to obtain a complete biomechanical analysis of lower limb prosthesis. Studies to date have included an evaluation of recent knee joint design and a study of the accommodation and learning effect of wearing a new prosthesis. Kinematic information is obtained with a video system, processed by computer and made available for subsequent analysis.

3. Congenital Dislocated Hip. A study of abductor muscles of hip and paraspinal muscles in patients with congenital dislocated hip before and after treatment. Project is ongoing as patients become available.

4. Muscular Dystrophy. A study of the effect of this disease on gait and on the development of scoliosis in non-ambulatory patients. An ongoing project as patients become available.

5. Normal Children. A study to obtain both kinematic and EMG information on normal children for baseline references. An initial study is nearly complete on the gait kinematics of 25 children and the results should be available in a few months. More children will be added in each age group in the future.

6. Scoliosis. An investigation of paraspinal muscle activity during walking and various bending and flexing exercises in an attempt to learn more about the possible causes of idiopathic scoliosis. A series of normal subjects have been studied and analyzed and a study of a series of scoliotic patients has begun. This study should be complete in 1977.

VII. WOOD (MILWAUKEE), WISCONSIN

ADDRESS
Kinesiology Research Laboratory
Veterans Administration Center
5000 West National Avenue
Wood, Wisconsin 53193

Director: M. Patricia Murray, Ph.D.

I. EQUIPMENT

Biomechanical.

Treadmill: 0 - 7.0 mph

Walkway: 16.7 m long x 1.89 m wide, foot contact indication, strobe light, still camera, movie camera, instrumentated canes and crutches

Cybex II: System equipped with angular velocity and position indicators and modified torque sensor

Force platforms

Elgon for knee

Physiological.

EMG surface and indwelling electrodes

Data Handling.

2 Grass Model 7 polygraphs: 20 channels combined
Honeywell Model 5600 FM analog tape recorder: 7 channels available
Computer Automation Alpha LSI-2/10 mini-computer: 32 k core memory, assembler, BASIC, 16 channel analog acquisition dual floppy disc, Model 33 teletype, 2 channels analog output
Analog X-Y plotter
Vanguard Motion Analyzer
Recordak film reader
Calculators
Time sharing with Xerox Sigma IX at Marquette University Computing Center

II. PARAMETERS

Motions: Linear: Stride length, cadence, swing and stance, velocity, gait width, successive step length, foot angles, vertical and forward trajectories of any anatomical point, lateral trajectories of head, thorax, pelvis, etc.

Spatial relations: Multiple joints and body segments

Angular: Hip in two planes; knee, ankle, foot - sagittal only

Wood (Milwaukee) cont.

Forces: Moments: Bending moments and torque applied to instrumentated cane

Ground Reaction: Vertical force and center of pressure, axial force on recording canes and crutches

Muscular Tension: Major groups and individual muscles

Physiological: EMG

Processing: Experimental error: 1-3%
Time: variable

III. PHILOSOPHY

We are seeking quantitative information which will contribute to a deeper understanding of normal and abnormal human locomotion. The ultimate objective and significance is to obtain information which will provide a basis for early recognition and more effective treatment of patients with a wide variety of neuro-musculo-skeletal disorders.

IV. PROJECTS

1. We are utilizing our standards of normal locomotion as a basis for comparison and characterization of gait disorders in patients with selected neuromusculo-skeletal disabilities. We have developed a method to record the simultaneous displacement patterns of more than 20 anatomic points in two planes of space during locomotion and have used this method in seven studies to establish ranges of normal variability for the gaits of normal men and women in broad, yet specific, age and height groups, walking at free and fast speeds and with different types of foot gear. We have also developed force-recording canes and crutches which record the amount and nature of assistance the patients require during walking.

2. We are measuring and evaluating mechanisms which are operable in the causation of gait abnormalities. We have developed methods to obtain quantitative measurements of basic mechanisms and have begun to establish the reliability, reproducibility and ranges of normal variability for these mechanisms, which will serve as baselines for comparing the deficits in disabled patients. The mechanisms under study are: muscle weakness, muscle rigidity and spasticity, joint immobility, deficits in weight-supporting ability, postural unsteadiness and instability, and incoordination of muscular activity.

3. A multifaceted approach will be used to evaluate the effect of various therapeutic procedures on abnormal walking performance and on the deficits in mechanisms of motor performance which contribute to the gait abnormalities in patients with severe arthritis or with hemiparesis, spinal cord injury or Parkinson's disease. Therapeutic procedures may include major reconstructive orthopaedic surgery, drugs and surgical procedures directed at reducing spasticity, or use of assistive devices. The relative effectiveness of different treatment procedures directed toward improving functional performance of groups of patients with similar disabilities will be assessed.