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STATUS REPORT

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Methodologies to Determine Forces on Bones and Muscles of Body Segments During Exercise, Employing Compact Sensors Suitable for Use in Crowded Space Vehicles

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(NASA-CR-196272) METHODOLOGIES TO DETERMINE FORCES ON BONES AND MUSCLES OF BODY SEGMENTS DURING EXERCISE, EMPLOYING COMPACT SENSORS SUITABLE FOR USE IN CROWDED SPACE VEHICLES Semiannual Status Report (Tulane Univ.) 6 p

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ACHIEVEMENTS

Work under this grant was carried out by the PI and by a graduate research assistant. The student, who was supported with funds from the grant, has completed his M. S. in Mechanical Engineering degree. The student's thesis is now a published record of the work done so far. A copy of the abstract and other relevant pages of the thesis are included with this report.

A complete description of an instrumented ergometer system, including the sensors, the data acquisition system, and the methodologies to calculate the kinematic parameters was initially developed at Tulane University. This work was continued by the PI at NASA Johnson Space Center, where a flight ergometer was instrumented and tested during a KC-135 Zero-Gravity flight. The sensors that form part of the system include EMG probes and accelerometers mounted on the subject using the ergometer, load cells to measure pedal forces, and encoders to measure position and orientation of the pedal (foot). Currently, data from the flight test is being analyzed and processed to calculate the kinematic parameters of the individual. The formulation developed during the initial months of the grant will be used for this purpose.

The system's components are compact (all sensors are very small). A salient feature of the system and associated methodology to determine the kinematics is that although it uses accelerometers, position is not determined by integration. Position is determined by determining the angle of two frames of reference for which acceleration at one point is known in coordinates of both frames.

FURTHER WORK

The PI will finish processing the flight experiment data to determine the kinematic parameters of the foot, shank, and thigh. These results, along with the methodologies for the kinematic solution, will be submitted for publication. Subsequently, the PI will develop a formulation to determine forces exerted by particular muscles on the bones, and use the previous kinematic solution along with pedal forces and EMG data from the flight experiment to test the methods developed. A second paper will be submitted to publish these results.

To determine muscle and bone forces during exercise, optimization methods will be used. This is necessary, because the system of equations that result form the equations of motion of the body segments is indeterminate. The PI will develop at least one solution that optimizes one criterium.

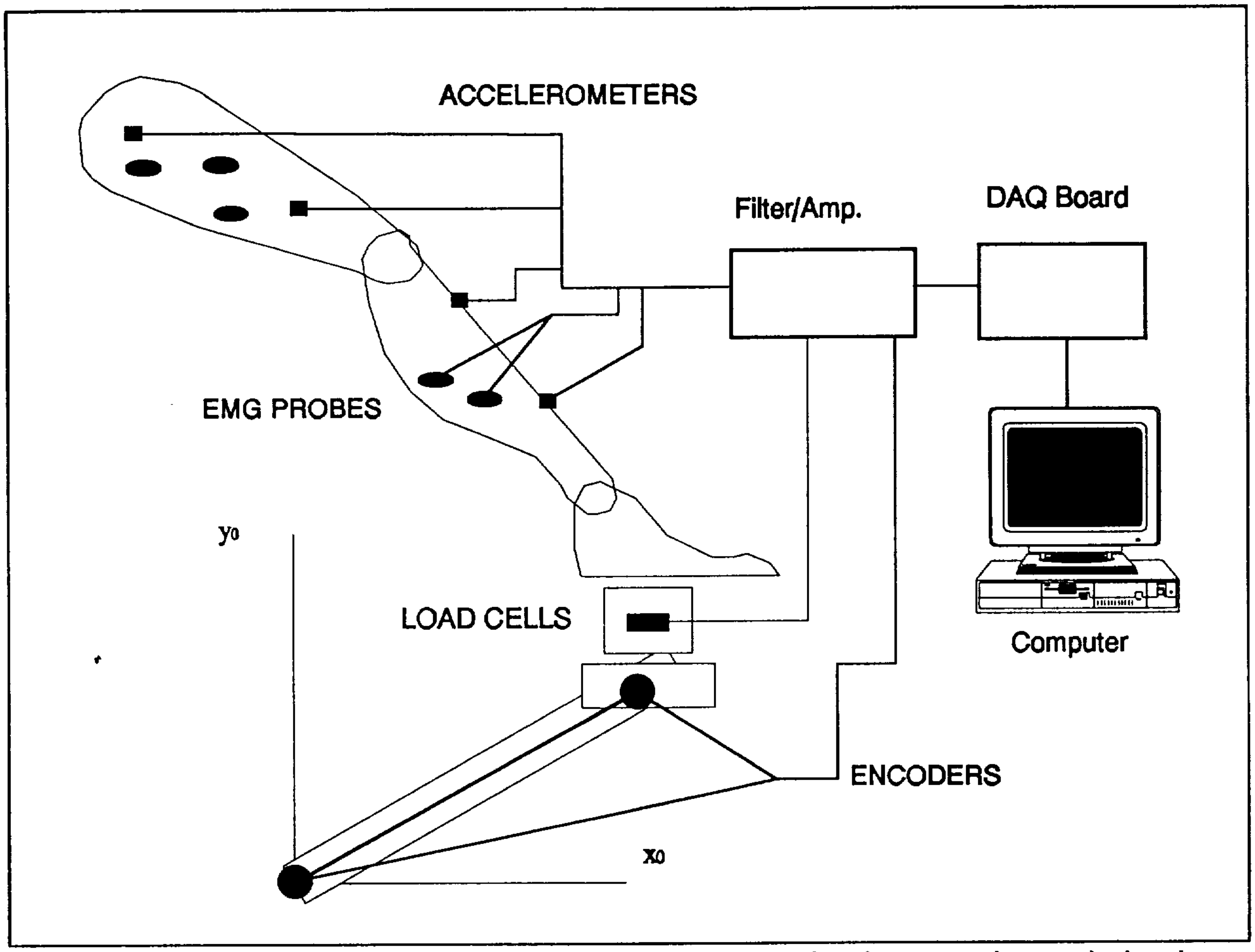

Figure 1 Instrumented Ergometer System to determine bone and muscle loads

A METHOD TO DETERMINE THE KINEMATICS OF THE LOWER LIMBS OF A SUBJECT PEDALING A BICYCLE USING ENCODERS AND ACCELEROMETERS

A THESIS

SUBMITTED ON THE TWENTY FIRST DAY OF APRIL, 1994

TO THE DEPARTMENT OF MECHANICAL ENGINEERING OF TULANE

UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SCIENCE IN ENGINEERING

BY

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ABSTRACT

The goal of this research was to determine kinematic parameters of the lower limbs of a subject pedaling a bicycle. An existing measurement system was used as the basis to develop the model to determine position and acceleration of the limbs. The system consists of an ergometer instrumented to provide position of the pedal (foot), accelerometers to be attached to the lower limbs to measure accelerations, a recorder used for filtering, and a computer instrumented with an A/D board and a decoder board. The system is designed to read and record data from accelerometers and encoders. Software has been developed for data collection, analysis and presentation. Based on the measurement system, a two dimensional analytical model has been developed to determine configuration (position, orientation) and kinematics (velocities, accelerations).

The model has been implemented in software and verified by simulation. An error analysis to determine the system's accuracy shows that the expected error is well within the specifications of practical applications. When the physical hardware is completed, NASA researchers hope to use the system developed to determine forces exerted by muscles and forces at articulations. This data will be useful in the development of countermeasures to minimize bone loss experienced by astronauts in micro gravity conditions.

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