July 22, 1963

BIOMECHANICS LABORATORY
UNIVERSITY OF CALIFORNIA
San Francisco and Berkeley

REPORT: April, May, and June 1963

I. RESEARCH ACTIVITY

A. Basic and Applied

Below-Knee Prosthetics

End-Bearing (Total-Contact) Sockets

Comfortable distal contact is often difficult to achieve in below-knee fittings when the cut tibia is lightly covered with soft tissue. Lack of contact in this area will result in localized stump edema. Soft padding will often control the edema but seldom provides enough support to be termed "end-bearing." A new study is underway to investigate the use of supported flexible liners as a means of both controlling edema and achieving comfortable end-bearing sockets. Preliminary results with one amputee have been good.

BK Fitting Apparatus

Work on mechanical fitting aids for below-knee sockets continues.

Ischial-Bearing Prosthesis

Work on design and on model fabrication of ischial weight-bearing below-knee prostheses has been discontinued, since the demand for this type of prosthesis is limited and there is a shortage of patients suitable for research. This item will therefore not be reported on further.

Cuff Suspension

The cuff suspension system used with the patellar-tendon-bearing below-knee prosthesis continues to be a source of difficulty in some cases. A study to investigate new principles and designs for improvements in, or substitutes for, the present cuff suspension is being initiated.
Above-Knee Prosthetics

Total-Contact Socket

Investigations of fitting methods for total-contact sockets continue. A revised manual on the adjustable-brim fitting procedure is being distributed to all Veterans Administration contractors. It is available also in single copies from the Biomechanics Laboratory.

Methods for achieving an end-bearing (total-contact) socket which would permit partial support of body weight are currently under investigation. Use of "pumped-in" materials such as plaster of Paris as a means of achieving a weight-supporting distal fit has been studied earlier; results, however, were not satisfactory. Present studies are directed toward the use of a flexible liner supported by a mechanical attachment to the socket brim. This method shows promise of providing a comfortable and self-adjusting means for increasing end-bearing potential of an above-knee socket.

Variable Flexibility Sockets

A limited study of the feasibility of providing areas of differing flexibility in the brim and walls of an above-knee socket has been started.

Adjustable Sockets

Further studies with the adjustable above-knee sockets were made. The possibility of combining the adjustable socket and the supported flexible liner will receive particular attention in future investigations.

AK Alignment Studies

A study to evaluate and compare German and American principles for the alignment of above-knee prostheses is being undertaken as an extension of studies started during Professor Radcliffe's European trip.

Prosthetics Materials

A program of evaluation of new materials for possible application in the manufacturing of prostheses has been a major part of above-knee and below-knee prosthetics investigation. Studies are continuing and will be reported on under this separate heading.

Prosthetic Treatment (Geriatric Amputees)

A cooperative program involving the staff of the Biomechanics Laboratory, the San Francisco General Hospital, Laguna Honda Home, interested private physicians, and Bay Area prosthetics facilities is being organized. The study at present will be limited to a small number of patients. Treatment has been begun on two new geriatric patients, a male unilateral above-knee amputee, aged 64, and a male bilateral (above-knee and below-knee) amputee, aged 75. The Design and Development group is engaged in the design of special components for possible application in this study.
Prosthetic Treatment of Lower-Extremity Amputees

During the past quarter there were 72 patient visits—58 by unilateral above-knee and 13 by unilateral below-knee amputees and 1 by a bilateral above-knee amputee. Twenty visits of the total figure involved geriatric patients.

Skin Disorders

Clinical evaluation of cases is, in general, no longer being done. Only occasional follow-up visits by previous patients will be continued.

A fatal instance of verrucose hyperplasia of a below-knee stump has been documented. The patient, a 41-year-old physician, was a bilateral below-knee amputee. He first came to the Laboratory approximately two years ago. A massive verrucose hyperplasia without ulceration of the stump skin was noted. On revision, a squamous cell carcinoma was found which had metastasized from stump skin to bone. Metastases were later found in the lungs. It can be assumed from this occurrence that not all cases of verrucose hyperplasia are benign and reversible.

Along with preparation of the various chapters of the monograph on skin disorders of amputees, technical questions of publication are being investigated. The stump edema pamphlet is virtually complete, except for final layout. The financial aspects of publishing the material are now being studied.

Energy Expenditure

During the past quarter 37 runs were made in the Energy Laboratory.

<table>
<thead>
<tr>
<th>Description</th>
<th>No. of Runs</th>
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<tbody>
<tr>
<td>Normal subjects (EMG studies— intrinsic muscles of the foot)</td>
<td>35</td>
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<tr>
<td>Normal and hemiplegic subjects (energy expenditure during stair-climbing</td>
<td>45</td>
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<tr>
<td>exercises)</td>
<td></td>
</tr>
<tr>
<td>Normal subjects (energy expenditure during brace-wearing)</td>
<td>7</td>
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<tr>
<td>Total</td>
<td>87</td>
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Summarization of results obtained over the past four years was the primary endeavor of the Energy Laboratory during this quarter.

Energy Expenditure (Geriatrics)

This study has been terminated and will not be reported on further.
Horizontal Rotatory Displacements in the Human Body

1. Studies of the foot and ankle. Reduction of data has been completed. A paper on phasic activity of intrinsic muscles of the foot has been written and will soon appear as a Technical Report.

2. Motions of the thoracolumbar part of the spine. No report this quarter.

3. Factors affecting motion at the hip. Electromyographic studies of the adductor muscles of the thigh during normal motion have been completed. Evaluation of the data and a report on the findings are near completion.

4. Kinematics of the knee. The analysis of the series of instantaneous centers of rotation and other data reduction have been continued. Investigations are reported on under the heading Brace Research.

5. Determination of relative angles formed by coracoid, spine, and axillary border of the scapula of man and other vertebrates. This study has been postponed.

6. Hamstrings. A paper on the relation of the hamstrings in man to the general arrangement of muscles in vertebrates has been completed and is being prepared for limited distribution. This study has been completed and will not be reported on further.

7. Stress and strain in bone. A paper on bone as a natural two-phase material reports the ultimate breaking strength and modulus of elasticity under compression and tension of the individual mineral, protein, and mucopolysaccharide components of cortical bone. The paper is being prepared for limited distribution. This study has been completed and will not be reported on further.

Mechanisms of Pain

Studies on sensory input of the central nervous system continue. The effects of lidocaine, Nembutal, and inhalation anesthetics on the limbic system have been investigated in greater detail.

Preliminary testing of the perfusion pump resulted in the successful perfusion of a freshly amputated limb.

Basic Neurophysiology

As a new development, a microelectrode technique for recording from human muscle fibers in vivo has been successfully worked out.
Nerve Patterning

During April, May, and June, innervation studies were carried out on 12 dogs, 12 cats, and 8 lambs. The visceral sensory plexuses of the heart, pericardium, and some pulmonary structures were studied by methylene-blue immersion and perfusion techniques.

EMG Studies

These studies are being discontinued for the time being and will not be reported on until further notice.

Amputation Surgery

Pain problems of amputees continued to be studied on a reduced basis during this period.

There were 33 patient visits, and blocking procedures were performed 22 times.

The surgical studies of this project have been terminated and will not be reported on further. The studies of nerve blocking will henceforth be reported on under Mechanisms of Pain.

Brace Research

Results of tests done on cadaver knees during the previous quarter have been reduced and analyzed. While there is good reproducibility, the linearity has not been satisfactory. Instrumentation has been improved with the construction of a new control panel to make operation more convenient. Additional tests will be made early in the coming quarter.

No satisfactory method of determining the axes of rotation of the ankle-joint complex has been developed. Graduate students in engineering are devoting much of their time this summer to an attempt to solve this design problem.

Photographs of the casting and fabrication procedures for the UC Shoe Insert were made and most of the text for a report has been completed.

B. Design and Development

Prosthetics

UC-BL Ankle-Rotating Devices

Amputee tests are continuing at NYU and UC-BL.
UC-BL Molded SACH Foot

An investigation of possible polyurethane foam materials is under way.

UC-BL Knee-Bearing Joints, Wedge Friction

Because of manufacturing difficulties and lack of interest on the part of potential manufacturers, work on this device is being suspended and will not be reported on until new developments occur.

UC-BL Pylon-Type AK Prosthesis

Design and development of the first unit, the permanent prosthesis with flexion-extension adjustment at the knee, is under way. This device is to be used with the UC-BL Pneumatic Swing-Control Unit. It can also be adapted to the DuPaCo Hydraulic Swing-Control Unit with minor changes in machined dimensions. Twenty-five pylon castings have been ordered through the Veterans Administration central office.

UC-BL Knee-Disarticulation Prosthesis

The special knee unit for use with the standard pylon unit, discussed above, is being designed.

UC-BL Temporary Above-Knee Prosthesis

Work on this sub-project of the UC-BL pylon-type above-knee prosthesis study will be deferred until development of the permanent above-knee and knee-disarticulation units are well under way.

UC-BL Hip-Disarticulation Prosthesis

This study has been temporarily halted and will be reactivated when a suitable amputee becomes available for research.

C. Testing

UC-BL Polycentric Knee (Pneumatic)

Since testing at NYU has been hampered by a lack of test units, efforts are being made to supply an additional unit for this purpose.

UC-BL Pneumatic Swing-Control Unit

As noted in the preceding quarterly report, structural weaknesses in the laminated plastic shank have been the major problem delaying the completion of the program. In order to accelerate the development of
this device, a design with use of a wooden shank has been completed and
pilot models are under construction. The development of the cast aluminum
pylon is also being expedited.

**UC-BL Ankle Rotating Device**

Tests by amputees at NYU and UC-BL continue.

**II. PUBLICATIONS**

California. University. San Francisco and Berkeley. Biomechanics Laboratory:
Performance Characteristics of Fluid-Controlled Prosthetic Knee Mechanisms,
by C. W. Redcliffe and H. J. Ralston. Technical Report no. 49. San Fran-
cisco and Berkeley, The Laboratory, February 1963.

California. University. San Francisco and Berkeley. Biomechanics Laboratory:
Adjustable-Brim Fitting of the Total-Contact Above-Knee Socket, by J. Foort.
Technical Report no. 50. San Francisco and Berkeley, The Laboratory, March
1963.

Allende, M. F.; S. W. Levy; and G. H. Barnes: Epidermoid cysts in amputees.


Hirsch, C.; B. Ingelmark; and M. Miller: The anatomical basis for low back pain:
Studies on the presence of sensory nerve endings in ligamentous, capsular

Nachemson, A., and J. M. Morris: Lumbar discography: Lumbar intradiscal pressure

**III. RELATED ACTIVITIES**

**Intramural and Extramural Presentations, Attendance at Scientific Meetings,
and Visits to Associated Institutes**

On May 6 and 7, Dr. V. T. Inman attended a meeting of the American Associa-
tion of Orthodontists in Miami, where he presented a paper, "Response of Bone to
Mechanical Force." On May 10 and 11, Dr. Inman attended a CPhD meeting in Warm
Springs, Ge.

Professor C. W. Redcliffe and Mr. L. A. Wilson attended the VI Region AOPA
meeting in Rockton, Illinois, from June 13-16, 1963, where they gave a demonstra-
tion of the UC-BL adjustable-brim fitting technique.

**Visitors**

Names of visitors to the Biomechanics Laboratory will no longer be listed
in the Quarterly Report.