Spring 1964

Artificial Limbs

A Review of Current Developments

COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT

COMMITTEE ON PROSTHETIC-ORTHOTIC EDUCATION

National Academy of Sciences
National Research Council

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COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT
COMMITTEE ON PROSTHETIC-ORTHOTIC EDUCATION

The *Committee on Prosthetics Research and Development* and the *Committee on Prosthetic-Orthotic Education*, units of the Division of Engineering and Industrial Research and the Division of Medical Sciences, respectively, advise the Veterans Administration and the Department of Health, Education, and Welfare in the conduct of research and education activities in the fields of prosthetics and orthotics; they provide means for correlating Government- and privately sponsored research in those fields.

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Measurement and Evaluation

HERBERT R. LISSNER, M.S.[1]

> "I often say that when you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it in numbers your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge but you have scarcely in your thoughts advanced to the stage of science, whatever the matter may be."
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> —*Lord Kelvin*

MOST of us devote appreciable time in the course of daily activity to making evaluations and forming value judgments. Every time we make a purchase, watch television, eat a meal—the list is endless—we make evaluations. Factors considered may involve monetary costs, saving of labor and time, ethical principles, aesthetic enjoyment, and many other matters.

In order to reach a final decision, it is usually necessary to combine, or even to counterbalance, evaluations made in many subsidiary categories. Those subgroups to which numbers can be applied, such as initial monetary cost and maximum attainable speed, are the easiest to consider, while those to which numbers cannot be easily assigned are more difficult to evaluate.

The establishment of standards is a recognized aid in the making of evaluations. Standards may consist simply of a set of lower limits; any product which fails to meet them is automatically eliminated from consideration. Examples of this hurdle or barrier type are some of the standards of the Underwriters' Laboratories for electrical appliances. A variant of this kind of standard may involve an upper as well as a lower limit, such as the "go—no-go" type. Conversely, a standard may involve the expression of a ratio of the specific item to the ultimate attainable, so each evaluation is a rating indicating how closely the limit is approached. A standard of this type is involved in the grading of examinations. (Even then the relationship between the score and the practical application is not always clear; the "A" student is not always successful in later life.) An intermediate form of standard is a rank ordering of individual

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items, along some defined scale, thus allowing comparison of each item with the average and its fellows.

All these types of standards are clearly of value, so the establishment of standards, at least tentatively, should generally precede the process of evaluation. In the production of materials and the fabrication of products of all kinds, industry and Government depend on established standards in making purchases, compliance testing, and the design of more complex products. For many years the American Society for Testing and Materials, the American Standards Association, numerous trade associations, and various Government agencies have sponsored development of standards and specifications.

Now what has all this to do with artificial limbs and braces? Evaluation serves one primary purpose in this case—the improvement of the product, a special type of man-machine combination. If the artificial limb could duplicate exactly all the functions of the natural limb in spite of the limited resources of power, sensibility, and control remaining available to the amputee, presumably we would have an ideal prosthesis. Minimal standards can rule out gross malfunctions, frequent and hazardous physical breakdowns, and obvious discomfort. Reasonably accurate lower and upper boundaries of physical dimensions to match specific categories of amputees can be established from anthropometric data illuminated by the best experience of the industry. In another sense, the physical strengths and practical minimal wall thicknesses set lower limits to weights, while maximal tolerable weights and inertias can also be estimated. By specifying the functional capabilities of the human limb we can establish the maximum standards we would like to achieve with our replacement. (The frequent recent suggestions of servo systems or "man amplifiers," though, imply that merely human performance may not be an upper bound.)

These standards of several types should be specified in many categories. Any problem, no matter how complex, can be approached by breaking it down into small segments which can be analyzed. It is only as we define the significant categories, establish and progressively refine standards, and make objective evaluations that further appreciable advances in artificial limbs and braces will be made.

A Hemipelvectomy Prosthesis[1]

FRED HAMPTON, C.P.[2]

A HEMIPELVECTOMY amputation involves removal of the entire lower extremity and half of the pelvis, separation generally being effected at the sacroiliac and symphysis pubis joints. Whenever possible the gluteus maximus and oblique abdominal muscles are preserved and usually are sutured together along the lower anterior aspect of the abdominal cavity. Because of disease or trauma, it is often necessary to remove the gluteus maximus, in which case the "stump" consists simply of a skin-covered abdominal cavity. The operative procedure is described and pictured in detail in *An Atlas of Amputations* by Dr. Donald B. Slocum (*5*).

Because there is no longer a skeletal structure on the affected side to assume the forces required during ambulation with a prosthesis, many workers have attempted to design sockets that will transfer weight-bearing loads directly to existing bony structure. Some have tried to use the ischial tuberosity on the unaffected side to support body weight, but with limited success. Others have felt it necessary to extend the socket so that the rib cage can absorb most of the weight-bearing forces, but this arrangement greatly restricts body motion and heat dissipation.

However, it has been found that it is entirely feasible for the "stump" to carry the loads if the socket is designed so that the semisolid abdominal mass of the stump is upward and medially toward the somewhat firmer area of the lower rib cage. Sometimes it is possible to utilize the sacrum for some support but relief for the coccyx must be provided because pressure on this sensitive bone almost always results in pain. Some additional support can often be achieved by utilizing the area of the gluteus maximus on the unaffected side.

Such support may be achieved by means of a piece of 1-in. Dacron webbing anchored to the inner distal area of the socket so that the anchor point is anterior to the ischial tuberosity on the sound side. The Dacron tape is led from its anchor point in the socket, under the gluteus maximus on the sound side, passing just distal to the trochanter and then diagonally across the anterior of the socket to a buckle (Fig. 1). Because the strap passes across the sound side at the level of the trochanter, it acts as a counterforce to the shearing action of the stump slipping in the socket under weight-bearing.

This article describes a method for fitting the hemipelvectomy patient in such a manner that the major loads are carried through the stump. The hemipelvectomy prosthesis incorporates many of the features of the Canadian hip-disarticulation socket, which was fully discussed in the Autumn 1957 issue of *Artificial Limbs*. However, the opening used for donning the prosthesis has been moved from the anterior portion to the lateral side of the socket. Greater stability is achieved by this arrangement since both the anterior and the posterior sections of the socket can contribute more support.

The hip-disarticulation socket utilizes the ischial tuberosity on the amputated side to support the patient in the socket, and the crest of the ilium for suspension of the prosthesis. In the hemipelvectomy case, the skeletal structure is absent and support of the patient in the prosthesis depends upon oblique upward pressure on the stump with an equivalent opposing pressure on the sound

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