

# Powered Braces With Myoelectric Controls\*

By WORDEN WARING, Ph.D., and VERNON L. NICKEL, M.D.\*\*

Patients who need orthotic devices vary greatly in the amount of function which has been lost. When the weakness in an extremity is quite marked, external power may be needed in addition to the brace. This power may be provided by compressed gas, or by electricity. The McKibben braided pneumatic actuator, using carbon dioxide for motive power, has worked well in many applications. More recently, miniature electric motors have been coming into use. In either case, the problem of how to control the external power is present.

In order to operate the device, some body site which is still under voluntary control must be found. The effects of poliomyelitis, muscular dystrophy, stroke, or a spinal cord injury may leave body areas greatly weakened but still useful for control purposes, or they may completely destroy voluntary control in some areas of the body. In any case, a body area with at least a minimum extent of voluntary control is needed, in order to express the patient's intention to the powered equipment. One of the most useful and promising techniques is that of the tongue switch control developed by Allen and Karchak<sup>1</sup> at this hospital. It is applicable to a wide variety of extremely disabled individuals; the tongue is almost always spared and controllable, even in quadriplegics, and is quite dexterous.

As an alternative to this, we are interested in another technique of control. When a person contracts, or attempts to contract, a muscle, the muscle generates a small amount of electricity. This "myoelectricity" can be picked up by suitable electrodes and used as a signal indicating the intent of the subject. Thus it may control the power used in the actual operation of the brace or splint, such as the powered hand splint reported recently in this *Journal*.<sup>2</sup>

In orthotic and prosthetic devices we desire "VPV" control: volitional, proportional, vectorial control. That is, the device should at all times obey the volition or intent of the user; the action or force should be proportional to the effort exerted by the user; and motions should not be limited to successive rotations about separate axes, but should be combined into single smooth motions in any direction desired (vectorial or directional addition of motions). Myoelectric control lends itself well to these requirements.

There are several possible advantages to myoelectric control. It is a more "natural" mode of control and should require less training for satisfactory use, since it uses the existing muscle signals of the subject. Also it should be less fatiguing because a task can be done without the continual

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\*\* W. Waring, Ph.D., Project Director; V. L. Nickel, M.D., Medical Director, Rancho Los Amigos Hospital, Downey, California.

division of attention between the task and the control system. For example, a person making a mosaic may concentrate on the choice of pieces and on placing them, without having to think about valves, switches, or foot motions for control. Also myoelectric controls should respond more promptly to the intent of the user, since the intent goes directly to the control mechanism instead of through a separate mechanically moved device. It will be very interesting to see how well these expectations are fulfilled in clinical experience.

Feasibility of this kind of control system with a prosthetic device has been established by the Russian and British hands, wherein pinch is controlled by myoelectric signals from the finger flexors and extensors. One advantage here, of course, is in the strength and the large signals from residual muscles of an amputee, in contrast with the weak muscles and reduced signals of a paralytic such as we are concerned with.

We feel the myoelectric technique may find two major applications with orthotic devices: one, the use with devices which the person uses consistently for his vocation, recreation, or other activities of daily living. It may either be used with a power boost for a weakened muscle still under voluntary control, or on a substitute muscle whose activity pattern is similar to the one with lost function or which can be trained for control purposes. The second area of application is in the retraining of muscles: aiding the patient to strengthen and to learn to control his muscles. There appears to be some clinical evidence that properly fitted braces help the person develop useful patterns of motion which carry on after brace removal, at least for some time. Here, too, myoelectric controls on training braces may accelerate the process of regaining strength and control, and will at least give the patient actual function and use of his extremity during the period of redevelopment.

In addition to the use of myoelectric control with external functional braces, particularly of the upper extremity, it can be used in connection with the electrical stimulation of muscles as a source of power for the actual motion. This may be considered an "internal orthosis," making use of the musculo-skeletal system present in the paralytic but which he is otherwise unable to control and use. This kind of system, with electrically stimulated muscles for power, has been shown to be feasible by Liberson<sup>3</sup> at Hines V.A. Hospital, and by Reswick, Long, and coworkers<sup>4</sup> in Cleveland.

Not all is simple and happy, however. If it were, doubtless the myoelectric technique would already be in wide use! One problem is that the patient must have some voluntary control of the muscle from which the myoelectric signals are to be taken. If the muscle is completely denervated, for example, it is useless as a control source. Visibly detectable motion is not needed, fortunately, and in fact signals can be obtained from muscles with very minimal residual activity. But if there is no voluntary control in a needed muscle, some other muscle must be selected as a substitute and more or less training is then required for it to function smoothly under the patient's volition.

Another problem is that electrodes placed on the skin over a particular muscle also pick up the electrical activity of nearby muscles. This can be very confusing to a control system, and such interference must be reduced in order to have satisfactory functioning of the controls. Further, the electrodes or electrode paste used may be irritating to the skin. One possible solution to both problems is to implant the electrodes surgically within the particular muscle, so signals can be picked up very specifically, and then broadcast with no skin contact.

