The V.A. Publishes a Study of the Hydra-Cadence Above-Knee Prosthesis

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CLINICAL APPLICATION STUDY: *A technical report issued by the Research and Development Division, Prosthetics and Sensory Aids Service of the U. S. Veterans Administration (TR-2).*

This 34-page report is being widely distributed by the U. S. Veterans Administration to prosthetic facilities. Since many readers of the *Journal* would not normally see it, we are giving below some of the important sections with our comments. Copies of the complete report may be received by writing the Research and Development Division, Prosthetic and Sensory Aids Service, U. S. Veterans Administration, 252 Seventh Avenue, New York, New York.

William M. Bernstock, who is Assistant Chief of the Research and Development Division, PSAS of the U. S. Veterans Administration, served as project director of this study and it reflects admirably his thoroughness and wide knowledge of prosthetic services.

Some 60 facilities, for the most part members of the American Orthotics and Prosthetics Association, cooperated in the study (see table one which follows for their addresses and the number of cases fitted).

Description of Unit—The Hydra-Cadence set-up offered to the public by Hydra-Cadence, Inc., a member of the Association, is composed of a single-axis knee with hydraulic resistance mechanisms, with piston rod pivoted behind the knee axis, hydraulically-controlled ankle, wooden foot, cosmetic cover and hardware necessary to attach the unit to any socket. Six sizes are available. Four models, A, B, C and D, are currently being worn by amputees. Information about the latest models may be obtained from Hydra-Cadence, Inc., 623 South Central Avenue, Glendale 4, California.

Design of Study—The basic intent of this study was to provide field participants with instructions, test forms, a fitting manual and other descriptive literature and then to receive and evaluate data submitted by the field on the experiences of amputees with the Hydra-Cadence prosthesis. An orientation visit was made to the Clinic Teams to familiarize them with the conduct of the study, test forms and the features of the hydraulic system.

A thorough study of the subject's performance on his conventional prosthesis was followed by five evaluations over a period of a year's wear of the Hydra-Cadence prosthesis. In the interest of economy and randomness of sample, selection was limited to the unilateral above-knee or hip disarticulation amputee veterans who would normally be eligible for a new prosthesis.

Table 1

COOPERATING STATIONS AND PROSTHETIC FACILITIES

STATION *	PROSTHETIC FACILITY	NO. OF CASES
VARO, Atlanta, Ga.	J. E. Hanger, Inc.	2
VAC, Boise, Idaho	Brownfield's Artificial Limb and Brace Shop	2
VAOPC, Boston, Mass.	Anthony and Williams, Inc.	1
	Boston Artificial Limb Co.	1
	J. E. Hanger, Inc.	1
	United Limb & Brace Co., Inc.	1
	Massachusetts Limb & Brace Co.	1
VAH, Buffalo, N. Y.	The Winkley Artificial Limb Co., Inc.	2
VAH, Chicago, Ill.	American Limb & Orthopedic Co., Inc.	1
	Bardach-Schoene Co.	1
	J. E. Hanger, Inc.	1
	Merrick-Hopkins Co., Inc.	2
	Scheck & Siress, Prosthetics	1
VAH, Cincinnati, Ohio	J. E. Hanger, Inc.	2
	Fidelity Orthopedic	2
VARO, Cleveland, Ohio	Paul Leimkuehler, Inc.	3
VAH, Dallas, Texas	J. E. Hanger, Inc.	1
	Hedgecock Artificial Limb & Brace Co.	1
	Rupley Artificial Limb Co.	1
VAH, Denver, Colo.	Gaines Orthopedic Appliances, Inc.	2
	Long's Limb Shop	1
	Scott Surgical, Inc.	2
VAC, Des Moines, Iowa	Winkley Artificial Limb Co.	2
VAH, Detroit, Mich.	D. R. Coon Co.	1
	E. H. Rowley Co.	1
	Wright-Filippis	1
VARO, Honolulu, Hawaii	C. R. Newton Co., Ltd.	1
VARO, Houston, Texas	Muilenburg Artificial Limb Co.	2
	The Texas Artificial Limb Co.	3
VAOPC, Los Angeles, Calif.	Adroit Prosthetic Manufacturing	1
	Alpha Orthopedic Appliance Co.	1
	Kolman Prosthetics	1
	Lanham Orthopedic Service	1
	Karg Prosthetics	1
	Peerless Prosthetics Co.	1
VAH, Memphis, Tenn.	Snell's Limbs & Braces, Inc.	3
	Tri-State Limb & Brace Co.	2
VARO, New Orleans, La.	J. E. Hanger, Inc.	2
	Snell's Limbs & Braces	1
VARO, Philadelphia, Pa.	J. E. Hanger of Philadelphia, Inc.	2
	Modern Limb & Brace Co.	1
	B. Peters Co.	1
VAH, Phoenix, Ariz.	Phoenix Limb Shop	3
VARO, Pittsburgh, Pa.	J. E. Hanger Co.	2
	Union Artificial Limb & Brace Co.	1

* VAC—Veterans Administration Center
VAH—Veterans Administration Hospital
VAOPC—Veterans Administration Outpatient Clinic
VARO—Veterans Administration Regional Office
VBO—Veterans Benefits Office

Table 1 (continued)

STATION	PROSTHETIC FACILITY	NO. OF CASES
VARO, Portland, Ore.	Artificial Limb & Truss Co.	1
	Coast Orthopedic Co.	1
	K. E. Karlson Co.	1
	Oregon Artificial Limb Co.	1
VARO, St. Louis, Mo.	J. E. Hanger, Inc. of Missouri	2
VAC, St. Paul, Minn.	George H. Botko Co.	2
	Ray Trautman & Son, Inc.	3
VAH, Salt Lake City, Utah	Fit-Well Artificial Limb Co.	2
	Intermountain Limb & Brace Co.	2
VARO, San Francisco, Calif.	Aunger Artificial Limb Co.	1
	C. H. Hittenberger, Inc.	2
	R. E. Huck Co., Inc.	1
	Miller & Sierakowski	1
VAH, Seattle, Wash.	Dodge & Lundquist Co.	2
	Lundberg's, Inc.	1
	Tacoma Brace & Limb Shop	2
VBO, Washington, D. C.	J. E. Hanger, Inc.	2
	Dankmeyer Prosthetic Appliances	1
	R&G Orthopedic Appliances	1
	Universal Artificial Limb Co.	1
VAH, Wilkes-Barre, Pa.	Modern Limb & Brace Co.	1
	Scranton Artificial Limb Co.	1
	James E. Sweeney Limb Co.	1
TOTALS:		
Cases		100
Clinic Teams		27
Prosthetic Facilities		68

Attitudes towards Conventional Prosthesis—The study found that the conventional prosthesis which had been worn by the amputees before the beginning of the study were in general serviceable. Eleven of the amputees rated their old prosthesis as excellent, 32 very good, 39 good, 13 fair and only one poor.

Amputee Reactions—Considered in this section are the significant responses of 92 reasonably continuous and long-term users: the 88 above-knee and three hip disarticulation subjects who completed the test period and the one subject who rejected the unit after six months of wear.

Probably the most significant response has to do with whether each of the test wearers decided to continue using the experimental device on a routine basis at the termination of the test period. Eighty-six elected to continue wearing the unit while six did not.

Eighty-two of the subjects, including the three H/Ds, were of the opinion that the unit improved their ability to vary length of steps. Regarding ability to vary over-all walking speed, 81 subjects, including the three H/Ds, considered this feature improved with Hydra-Cadence. The manufacturer's claim that the toe pick-up is beneficial to amputees appears to be confirmed, at least subjectively, by the test wearers' responses. Seventy-nine of the amputees, including three H/Ds, felt that the toe pick-up action helped. Each subject was asked which prosthesis required more effort to use. Sixty-seven, including two H/Ds, stated that the conventional limb required more effort, 15 that they were the same, and ten, including one H/D, that the experimental unit required more effort.

Fifty-nine of the wearers, including one H/D, stated that they experienced less fatigue with the new unit. Twenty-three, including two H/Ds, did not discern any difference while ten felt more fatigued using the new device.

Many (80 cases) of the wearers felt that the Hydra-Cadence device improved the way they walked at slow and fast speeds, on ramps (77 cases) and on various types of terrain (71 cases). A lesser number (24 cases) indicated that the device improved their performance on stairs.

Not all features of the Hydra-Cadence unit were well received. Negative feelings centered about foot slap and cosmesis. Fifty-six wearers who completed the one-year test period, and the one case who rejected the unit after six months wear, indicated that the toe slapped immediately after heel contact. It is significant to note that 50 of the 92 subjects felt that gait training had been helpful in reducing toe slap. The use of the newer style foot with neoprene crepe sole and toe appears to reduce the noise of foot slap by the additional cushioning action at "foot flat."

With respect to cosmesis, 56 of the subjects considered the prosthesis to be poorer cosmetically than their old leg, 13 did not think there was any difference, and 23 thought that cosmesis was improved.

Each subject was asked to comment on disadvantages of the experimental prosthesis. Thirty-seven subjects cited the following disadvantages:

Foot slap	17
Cosmesis	8
Mechanical breakdown	4
Foot size and shape	6
Weight	4
Difficulty on stairs	4
Stiffness in cold weather	4
Effort to use	3
Clothing wear	3

Clinic Team Reactions—The highly favorable opinions of most of the subjects toward the new prosthesis were shared by the Clinic Team members. In 81 cases the Clinic felt that the Hydra-Cadence prosthesis provided functional benefits to the amputee. Of the 11 subjects who, according to the Clinic Team, did not derive any functional benefits from the device, five subjects returned to the use of a conventional limb.

Table 29

FUNCTIONAL BENEFITS ATTRIBUTED BY CLINIC TEAM TO HYDRA-CADENCE

(N= 84—includes 3 H/D)

BENEFIT	REPORTED INSTANCES
Improved gait (including function and appearance)	*61
Stability	*52
Decreased fatigue or less effort	38
Improved shock absorption	17
Improved maneuverability	22
General improvement	*15
Able to walk faster (presumably for long distances)	3
TOTAL	208

* Includes 1 H/D.

In addition to the functional benefits cited in Table 29, for 82 subjects, the Clinic Team members indicated in responses to specific questions that they believed the Hydra-Cadence prosthesis improved the *appearance* of the gait. In 72 cases, they felt that the amputee was able to sustain, for 100 feet, a higher maximum speed (feet per minute) than was possible with the previous conventional prosthesis. For 13 subjects, they felt that there had been no change and in only seven cases did they feel that maximum speed had decreased. Six of these subjects had rejected the Hydra-Cadence unit.

Hydraulic Resistance—Knee mechanisms which are designed as fluid-controlled or hydraulic mechanisms are adjustable as to the amount of resistance to swing above a fixed minimum. This minimum resistance is made up of the mechanical resistance of the moving parts and the resistance which is present as the fluid flows through the passages even with the friction-adjusting valve fully open. In general this minimum value is higher than the resistance of a purely mechanical system designated as a "free knee." Because of these factors, it has often been suggested that long-term wearers of a "free knee" might not be able to wear successfully a hydraulic system. This hypothesis has *not* been substantiated by this study. Twenty-six of 84 test wearers, including three of the hip-disarticulation cases, who completed the study and for whom we have complete data, wore mechanical friction units using minimal resistance prior to being selected for this study. Twenty-three of these subjects were among those who elected to continue wearing the hydraulic device at the end of the study.

At the time of the selection interview, the Clinic Team was asked to estimate the amount of resistance being used on the conventional leg. They were then requested to estimate the resistance which would be needed with the hydraulic mechanism. As was expected, because of the marked differences between mechanical and hydraulic resistances, the estimates were in most instances inaccurate. In fact, it is surprising that accurate estimates were made in as many as 14% of the cases. Ratings of the hydraulic resistance used, based on evaluation of prosthetic function by the Clinic Team, were in most cases either "slight" or "moderate" and in only a few cases were there estimates of "none" (10 cases), "substantial" (10 cases), or "heavy" (1 case).

Design Changes—The study has already had an important result. As a result of the information obtained, the manufacturer has made a number of changes which are incorporated in the current production manual. The modifications are also made to all units returned to the manufacturer.

Summary—In the opinion of the reviewer, this study is a good example of a thorough going objective test of a device. One hundred male veterans with unilateral amputations above the knee were used. The opinions of the amputees, the findings of the survey and the comments of the Clinic Team as they arose during a one-year test period were used to help in determining whether or not this device should be used for routine issuance to veteran beneficiaries. It is noteworthy that only six subjects rejected the device and returned to the use of a "conventional type" prosthesis (since then one subject has requested and been issued a Hydra-Cadence prosthesis).

Conclusion—The Hydra-Cadence Above-Knee Prosthesis was well received by most of the subjects in the study as well as by the Orthopedic and Prosthetic Appliance Clinic Teams who supervised their progress. However, the system should be selectively prescribed and should not be considered as the prescription of choice for all amputees.

The most significant finding of this study reflects the superiority of fluid-controlled mechanisms as devices for controlling the swing of above-knee prostheses.