MYOELECTRIC TRAINING METHODS FOR THE PRESCHOOL CHILD WITH CONGENITAL BELOW-ELBOW AMPUTATION

A COMPARISON OF TWO TRAINING PROGRAMMES

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The Ontario Crippled Children's Centre has completed a two-year research project designed to develop effective strategies for training the preschool child to use a myoelectric prosthesis. Two programmes were developed: one home-based with the parent as primary trainer, and the other Centre-based with a therapist as trainer. Seventeen children were successfully trained and fitted with myoelectric prostheses. Both training programmes appear to be equally effective, proving that informed parents can assume responsibility for the training of their children. Economic implications are self-evident.

The functional assessment of the children's skill with the myoelectric prosthesis is very encouraging so far. However, long-term studies are indicated for adequate assessment of the cost-effectiveness of early myoelectric fitting. As a result of this study, effective training methods can now be used in routine clinical service; a manual is available to provide guidelines.

Recent advances in technology and fitting have led to the development and provision of myoelectric prostheses for below-elbow amputees. Initially, there was a belief that myoelectric prostheses should not be used until the early teens. However, studies from Sweden (Sörbye 1977, 1978, 1980) and England (Day 1980) have challenged this philosophy by demonstrating that myoelectric fittings are feasible for preschool children.

After a trial with three young children at the Ontario Crippled Children's Centre (OCCC) it was felt that small children could be fitted with these devices. However, a major problem was the lack of effective training techniques for the child of preschool age.

The Centre therefore decided to research and compare strategies for training. The aim of the project was to develop two training programmes, one home-based with the parent as primary trainer and the other Centre-based with the therapist as trainer; and also to determine the relative costs and effectiveness of each programme; to design and construct suitable aids for training young children and to interpret the findings to provide more effective training in routine clinical service. A comprehensive report (OCCC 1983) is available which describes in full the training regimes, technology and techniques deployed.

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MATERIAL AND METHODS

The criteria for selection were that all the children were aged two to five years, were below-elbow unilateral congenital amputees, had normal motor development, had an established prosthetic wearing pattern, and had a stump of adequate length.

Eighteen children were selected, 13 boys and 5 girls, and were divided equally between the two training programmes. Eight had right arm amputations and 10 left.

The age range at the time of training was 2 years 7 months to 5 years 1 month. In the therapist-trained group the mean age was 3 years 8 months (with a standard deviation of 11.0 months) and in the parent-trained group 3 years 6 months (standard deviation 10.6 months). The youngest child (2 years 7 months) was subsequently dropped from the home-based training programme due to lack of co-operation. The resultant total number of children trained and fitted was 17, the youngest of these being 2 years 9 months.

Procedures

The project was carried out in two phases. The initial phase was devoted to developing guidelines and equipment; this phase culminated in a four-subject pilot study in the spring of 1981. The second (formal) phase involved 14 children and was completed in October 1982.

The children were randomly assigned to the two training programmes and were trained in pairs, one child receiving home instruction while the other was trained at the Centre. Myoelectric training for the children was conducted in two distinct stages: (a) muscle control

training before prosthetic fitting and (b) functional training with the prosthesis.

Control training. The control training process involved three different steps: the identification of muscles suitable for prosthetic control, the selection of the appropriate control system, and training the selected muscles.

Muscle site identification. The therapist identified those muscles suitable for prosthetic control for *all* of the patients. This was done using visual feedback of the EMG signals on an Otto Bock Myoelectric Unit. One set of electrodes was placed on the appropriate muscle groups of the non-amputated arm. The subject was then asked to flex and extend his wrist. Once the child grasped the idea on the normal side, the same procedure was repeated on the stump side. Generally, it was found that the demonstration of normal wrist flexion and extension on the non-amputated side and encouragement to parallel that activity with the residual soft tissue at the end of the stump, resulted in successful muscle response for the amputated limb.

System selection. For both groups, control training was initiated with the Otto Bock two-muscle control system. The selection of a one or two-muscle control system was determined after assessment of the child's ability with the two-muscle system. If the two muscle groups were not independently controllable, then the muscle group which was easiest for the child to control was chosen and the University of New Brunswick one-muscle control system applied.

Voluntary muscle control training. Control training followed the identification process. Two sessions were carried out each day, five days a week with a maximum time of 30 minutes per session. Control training for children in the parent-trained group was provided by the therapist at the Centre for the first two days. During that time, explanations and instructions were given to the parents who participated in the training process so that they could become familiar with the equipment and procedures. The family was then provided with a complete training kit and manual and continued with the training at home.

The second group of children received all their control training at the Centre. Identical equipment was used for both groups; myoelectrically controlled toys and a myoelectric hand-training assembly—hand, elec-

trodes, battery and charger and a training log book for use by parent or therapist to document training activities.

A "control" test was done daily and training continued until the child achieved 80% accuracy or better on three consecutive tests.

A "relaxation" test was also given each day. This was a five-minute period when the child was asked to rest his stump muscles while engaged in a quiet activity such as reading a book. A record of inadvertent muscle activity was then compiled and used to determine the appropriate electrode sensitivity setting and to assess the child's ability to relax the controlling muscle groups.

Functional training. As soon as the prosthesis was delivered, purposeful activities were used to teach its use. In most cases, it served as an assisting or stabilising extremity, allowing the normal hand to manipulate held objects. In training the child, it was necessary to select activities within his interests, functional needs and capabilities.

The therapist-trained group had two 30-minute sessions daily for five days. The home-based group received one session by the therapist and then continued at home with the functional activities which were suggested. Subsequently, the two routines were identical and both groups of parents were asked to continue with informal training at home. During the first three months, the parents were required to provide 15-minute sessions, twice daily, five days per week; and for the next three months, one 15-minute session of training per day, five days per week.

Evaluation. A test was developed to assess objectively the prosthetic skill attained and to compare the functional levels achieved in each group. This test was carried out in standardised fashion and recorded on videotape, one, three, and six months after fitting the prosthesis. The tapes were reviewed by an outside evaluator who provided scores for each activity.

RESULTS

Seventeen preschool children were trained and fitted with myoelectric prostheses—four as pilot subjects and 13 as part of the formal study. Nine children were trained by a therapist at the Centre and eight by their parents at home. Sixteen were fitted with the Otto Bock control systems and one child required a UNB control system.

Table I. Training time (in hours): group means, standard deviations and ranges

	Therapist-trained		Parent-trained	
	Therapist	Parent	Therapist	Parent
Control training	11 ± 4.8 (range 3.5 to 19)	0	2.94 ± 0.77 (range 1.9 to 4.3)	11.2 ± 4.5 (range 2 to 15)
Functional training	4.7 ± 1.2 (range 2 to 6.1)	0	0.79 ± 0.40 (range 0.5 to 1.3)	4.6 ± 0.51 (range 3.5 to 5.0)
Combined times				
Control + function	15.7 ± 5.1	0	3.72 ± 0.85	15.8 ± 4.9
Therapist + parent	15.7 ± 5.1 (range 5.5 to 23)		19.5 ± 4.7 (range 10.3 to 24.5)	
Other therapy	4.61 ± 1.4 (range 2.2 to 6.2)		3.5 ± 1.7 (range 0.7 to 6)	

Wearing patterns. Adjustment to the myoelectric prosthesis varied considerably among the children. Some accepted the prosthesis immediately and quickly became full-time wearers. Others gradually built-up a wearing tolerance, as shown in Figure 1. The graphs also depict a more consistent wearing pattern for the therapist-trained group compared to a slower increase in wearing tolerance for the parent-trained group. Two children (Subjects 7 and 13) increased their wearing time after the addition of a simple harness which made the prosthesis less easy to remove. The daily wearing pattern at the end

number of children was too small to enable firm conclusions to be drawn. The child who trained quickest was one of the oldest (5 years 1 month) and he attained 100% on each of the three control tests he was required to take. However, the next-fastest-trained child was only 2 years 10 months and she required just five control-training sessions. The mean and standard deviation for the therapist-trained group was 12.2 ± 5.6 sessions and for the parent-trained group 13.3 ± 3.6 sessions. The mean number of training sessions for 12 of the 13 formal study subjects was 12.7 ± 4.5 . Figure 2 represents graphic-

Fig. 1

The daily wearing pattern of the myoelectric prosthesis showing the number of hours it was worn by each patient when reviewed at one, three and six months after fitting.

of six months ranged from 3.5 to 12.0 hours, the mean and standard deviation being 9.3 ± 2.3 hours for the therapist-trained group, 8.2 ± 3.2 hours for the parent-trained group, and 8.79 ± 2.7 hours for the total population of 17.

Cost-effectiveness. The parent-training (*P*) programme proved to be cost-effective when compared to the therapist-training (*T*) programme (Table I). Mean value for the therapist's time for the *P*-group was 3.72 ± 0.85 training hours versus 15.7 ± 5.1 hours for the *T*-group. Additional therapy time outside of the actual training procedures (orientation, parent instruction, socket and prosthetic check-outs) was also less for the *P*-group, being 3.5 ± 1.7 hours compared to 4.61 ± 1.4 hours.

Effect of age on training. Age did not appear to be a significant factor in the speed of training, although the

ally the amount of control training required for each subject. One of the children (Subject 12) still had not successfully met the control-training criteria (three consecutive tests of 80% or better) at the end of 25 sessions of training. Nevertheless, it was decided to allow him to proceed with fitting on an experimental basis but his results were excluded from the statistical analysis. His functional skill scores (Fig. 3, Subject 12) proved to be markedly lower than any of the other subjects.

Function tests. The total test score (Table II) for each subject was compared initially with the conventional prosthesis and then at one, three and six months after the fitting of the myoelectric prosthesis. Student's *t*-test (independent samples, equal size) was used to compare the results, and also to check for significant change between the test with the conventional prosthesis and the

Fig. 2

The number of control-training sessions required to reach the criteria for starting prosthetic fitting. The 13 children of the formal study are given in age order (the youngest having been withdrawn for non-cooperation).

Fig. 3

The total test scores in the function tests carried out initially with the conventional prosthesis and then with the myoelectric prosthesis at one, three and six months after fitting.

Table II. Total test scores during function tests, initially and at 1, 3 and 6 months

Subjects		Conventional prosthesis	Myoelectric prosthesis		
			1 m	3 m	6 m
<i>Therapist-trained</i>					
Pilot subjects	2			26.5	27.0
	4			30.5	31.0
Study subjects	6	34.0	31.5	30.5	28.0
	8	16.0	26.5	27.5	*30.7
	10	28.5	31.0	32.5	32.5
	12	18.0	16.0	16.0	15.0
	14	26.0	30.0	29.5	30.0
	16	21.5	29.5	32.5	32.5
	17	32.5	33.0	33.0	33.5
<i>Parent-trained</i>					
Pilot subjects	1			28.0	24.0
	3			30.5	33.5
Study subjects	5	22.5	26.0	26.5	29.0
	7	20.5	22.5	28.0	30.5
	9	22.0	25.5	24.5	31.5
	11	32.5	28.5	31.0	31.5
	13	17.0	26.5	29.0	29.0
	15	22.0	25.0	28.0	33.5

* Test results not available: average for the group used

Table III. Analysis of video tests

Comparison	t-test	d.f.	Significance
Test with conventional prosthesis T-group v. P-group	1.05	10	NS
Myoelectric prosthesis—1-month test T-group v. P-group	3.82	10	$P < 0.01$
Myoelectric prosthesis—3-month test T-group v. P-group	1.88	14	NS
Myoelectric prosthesis—6-month test T-group v. P-group	0.25	14	NS
T-group Conventional test v. 6-month myoelectric test	-1.65	10	NS
P-group Conventional test v. 6-month myoelectric test	-3.62	10	$P < 0.01$

d.f., degrees of freedom

six-month myoelectric test for each subject group. Degrees of freedom were incorporated and probabilities of $P < 0.05$ or of $P < 0.01$ (two-tailed) were considered to be significant. The results are shown in Table III.

The results in the therapist-trained group were significantly higher than those of the parent-trained group at the one-month review. However, no significant difference was found when the T-group was compared to the P-group at subsequent tests.

DISCUSSION

Seventeen preschool children have been successfully trained and fitted with myoelectric prostheses with a follow-up of 5 to 18 months. Both training programmes appear to be equally effective, proving that informed

parents can assume responsibility for the training of their children and achieve the same efficacy as the therapist in training these children. The economic implications are self-evident. The functional assessment of the children's abilities with their prostheses is quite encouraging. However, long-term studies are needed to assess the cost-effectiveness of early fitting of the myoelectric prosthesis.

As a result of this study, effective training strategies have been developed which can now be used in routine clinical service. In addition, a manual has been prepared and is available to provide training guidelines (OCCC 1982). The equipment devised for the project has proved useful and reliable for home use. A variety of training aids was found to be essential in order to capture and maintain the interest of the preschool child.

No particular difficulty has occurred in the fitting of the myoelectric prostheses. Repeated experience with this age group has enabled the prosthetists to become more facile with their casting and fitting techniques.

It has been found that age is not a determinant of the amount of time required for training. Some of the younger children became very facile very quickly while, in some other cases, an older child has required more time than anticipated.

Finally, in agreement with both the British and Swedish experience, we consider that it is feasible and promising to fit young children with the myoelectric prosthesis. We agree with Sörbye (1980) and Scotland and Galway (1983) that it is important to fit the child as young as possible to facilitate the acceptance of the prosthesis and its integration into the child's motor development, so that it is not merely an assistive device requiring conscious thought.

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