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A field evaluation of arm prostheses for unilateral amputees

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Abstract

A post-clinical investigation has been carried out among 42 unilateral amputees who lost their hand due to an accident. The investigation was directed at two main topics of interest. Firstly the amputee, the problems he has to cope with, and the role the prosthesis plays in his life; and secondly the prosthesis, its use and its potential benefits and burdens. The group of amputees consisted of above-elbow and below-elbow amputees. Body powered as well as myoelectric prostheses were represented in the group. Most of the information was obtained during a two-day home visit where a semi-structured interview was conducted, and where a number of daily life activities were observed. The information thus obtained has led to a number of conclusions and recommendations with respect to the rehabilitation of this category of amputees, and with respect to the design criteria of protheses for unilateral amputees.

Introduction

In the Laboratory for Measurement and Control of the Delft University of Technology a research group is working on the design of prostheses and orthoses for the upper limb. Besides this design group another unit, the Man-Machine Systems Group, is involved, among other things, in evaluation studies and in the generation of design criteria in this field of rehabilitation. Both groups work in close co-operation with a number of rehabilitation centres.

In order to arrive at adequate design criteria, information should be available on the role the prothesis plays in the life of the amputee. Here it should be mentioned that the design activities in the laboratory are directed at provisions for unilaterally handicapped, because this is the largest group. Although much information about this category was obtained directly from the rehabilitation centres which co-operated in the design projects, the impression existed that the assumptions on which the choice of prostheses and the corresponding training programmes were based might not always reflect the actual role of the prosthesis in practice. A number of field studies on the use of myoelectric prostheses are known, such as those of Soerjanto (1971) and Pieper (1977). A comparative study between myoelectric and body powered prostheses with respect to their intensity of use was conducted by Becker (1979). Each of these studies, however, has a rather limited scope. A more extensive evaluation study has been conducted by Kay and Peizer (1958), who also took into account the psychological and social aspects in a comparative study between two different body powered prostheses. A comparative study with respect to presently available prosthesis types which takes into account all relevant factors is not known to the authors. Therefore it was decided to conduct a post-clinical study among a group of amputees who had been treated in two of the co-operating rehabilitation centres. Most of the data which will be reported here were obtained during the period 1977–1978.

Procedures and definitions

The question to be answered by this investigation can be formulated as follows: which conditions are necessary for adults with a

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unilateral, traumatic amputation, in order to function in the broadest sense with the aid of technical provisions? The investigation was directed at two main topics of interest, firstly the amputee, the problems he has to cope with, and the role the prosthesis plays in the life of an amputee, and secondly the prosthesis, its use, and its potential benefits and burdens. Five measurement methods were applied in the investigation. The following three were applied during a one day visit of the amputee to the rehabilitation centre:

a medical examination;
two psychological tests;
a questionnaire consisting of 92 multiple choice questions, mainly directed to the prosthesis and its use.

The following two methods were applied during a two-day visit of an occupational therapist at the amputee's home:

a semistructured interview based on 220 questions, covering the psychosocial aspects and the prosthesis;
observations of the actual use of the prosthesis for about 50 daily life activities.

The group of participants satisfied the following selection criteria:

Dutch nationality;
traumatic amputation;
unilateral amputation;
age 18 years or older;
amputation took place at least one year ago.

The participants were recruited from the records of two rehabilitation centres. From the original list of 101 amputees 42 persons finally took part in the project. The other 59 came into one of the following categories: address unknown (6), no reaction (25), negative reaction (6), not satisfying the selection criteria (20), withdrawal after initial consent (2). Before starting the investigation, the procedure was tested with 5 amputees from a third rehabilitation centre. The semi-structured interview initially consisted of a smaller number of items. Together, with the observations it took about one day. As a result of this tryout, where the interview had a more open character, the contents were enlarged to the present scope.

The data obtained could be divided into two groups, namely quantifiable data and purely qualitative data. The first group consisted of all answers which can be classified into a limited number of categories. To this group belong the medical data, the results of the pyschological tests, the multiple choice questionnaire, the activities of daily living (ADL), and also part of the data obtained in the interview. These data could be reduced to histograms, frequency tables in which variables are mutually related, correlation coefficient estimates, or outcomes of a factor analysis. The second group consisted of descriptions of events, thoughts and feelings, explanations of answers, etc. These data in the form of literal citations were sorted and filed according to subject matter. In general the operations just described will be clear from the results presented. Only the ADL-analysis requires a further explanation of the terms used. In order to characterize the way the prosthesis is used, a number of functions have been defined, Stassen et al, (1977) which can be classified as follows:

Mechanical or motor functions

Fixation in the prosthesis, or grasping.
Fixation between prosthesis and body.
Fixation between prothesis and environment.
Bilateral fixation, i.e. fixation between own hand and prosthesis.
Carrying.
Supporting.
Pushing or shoving.

For the grasping function a subdivision can be made in direct and indirect. Use of the *direct grasping* function means that an object is grasped directly by the prosthesis without interference of the amputee's own hand. The grasping function is called *indirect* when an object is put into the prosthesis by the amputee's own hand. A further distinction which can be made, is that between active and passive use. *Active* use of the grasping function refers to the opening and closing of the hand by means of a control action. *Passive* use refers to the situation that an object is forced into the prosthesis by the other hand. This is possible, for instance, with some types of cosmetic hands, which are provided with a spring loaded thumb.

Sensory functions

For the human hand two types of sensory function can be distinguished.

Exteroception, concerning the skin senses which give information about the exterior world like shape, roughness, hardness, temperature and wetness of objects touched by the hand. Although the terminology is not quite correct, in this study it will be briefly indicated as *touch.*

Proprioception, concerning the information from muscle spindless, tendon organs and joint receptors about positions and internal forces in hand and arm.

Cosmetic functions

The cosmetic functions refer to the natural appearance and thus to the degree of unobtrusiveness of the amputee with his prosthesis. In this study three types of cosmesis have been distinguished.

Passive cosmesis, this is the look of the prosthesis determined by its shape, size, texture and colour. This type of cosmesis is entirely prosthesis dependent.

Cosmesis of wearing, this is the naturalness of the way of moving of an amputee wearing a prosthesis, for instance when walking in a street. This type of cosmesis mainly depends on the person, particularly on the extent to which he has integrated the prosthesis in his body scheme.

Cosmesis of use, this is the naturalness of using the prosthesis in task execution. This type of cosmesis depends both on the possibilities of the prosthesis and on the proficiency of the wearer in using these possibilities.

Characteristics of the group considered

Before giving the results about the use of the prosthesis and about the way people cope with their handicap, a short description of the group will be given. Table 1 shows some general characteristics, whereas Table 2 refers to the types of prostheses worn and to some of the medical factors concerning the amputation. In general it can be stated that for the majority of the group the medical factors did not obstruct the use of the prosthesis.

The psychological tests, in particular the Amsterdam Biographical Questionnaire, made it possible to compare the group on a number of psychological characteristics with the Dutch population in general (Wilde, 1970). It was found that the group contained more extrovert people than might be expected if it had been a representative sample of the population. On the test attitude scale more self-defensive people were found. The other two scales namely neuroticism and psycho-somatic complaints did not show significant deviations.

Table 1. General characteristics of the group of 42 traumatic amputees who participated in the investigation.

Characteristic	Number	Classification
Sex	39	Male
	3	Female
Dominance	40	Right-handed
	2	Left-handed
Amputation side	26	Dominant
	16	Non-dominant
Amputation level	12	Above-elbow
	16	Fore-arm
	14	Wrist
Age at accident	11	8-20 years
	20	20-35 years
	11	35-60 years
Time between accident and investigation	11	1-5 years
	12	5-10 years
	19	10-35 years
Nature of accident	27	Industrial
	7	Traffic
	7	War
	1	Home

The prosthesis and its use

The observations of the ADL performance showed that for many tasks which are executed two-handedly by non-amputees, a number of alternative ways exist for the amputee to cope with the task, with or without prosthesis. As an

Table 2. Type of prosthesis worn and some of the medical factors concerning the amputation for the 42 participating amputees.

Characteristic	Number	Classification
Type of prosthesis	5	Cosmetic hand
	12	Body powered prosthesis
	19	Myoelectric hand
	2	Switch operated hand
	4	No prosthesis
Stump condition	36	Reasonable to very good
	6	Bad
Stump pain	37	Rarely or never
	2	Regularly
	3	Continuously
Frequency of phantom sensations	4	Never
	18	Sometimes
	8	Often
	12	Always
Nature of phantom sensations	27	Normal anatomy and position
	2	Normal anatomy, abnormal position
	9	Abnormal anatomy
Frequency of phantom pain	35	Rarely or never
	5	Regularly
	2	Continuously

example, the handling of a purse will be considered. In the first manner, the purse is handed to the prosthesis by the amputees own hand, and opened with the own hand (use of the active indirect grasping function). In the second one, the purse is put down with the own hand, for instance on the counter in a shop, fixed by putting the prosthesis on it, and opened by the own hand (fixation with respect to the environment). In the third way, the purse is clasped to the body, and opened with the own hand (fixation with respect to the body). In the fourth one, the purse is placed on the prosthesis, and handled by the own hand (carrying function). In the fifth manner, the purse is placed on the counter, and handled with the own hand only (own hand only). In the sixth way, all money is carried in the trouser pocket (avoidance of purse handling). A seventh method, which was not applied for this activity, but which was noticed for a number of other activities, was asking for help.

The ADL analysis resulted in a number of tables which give the relations between individual user, type of activity and functional alternative. It was found that 26 activities out of the original list of 50 were executed by at least 4 participants (10%). Therefore this list of 26 activities was used for further processing. For each prosthesis type and amputation level, the average number of activities where the prosthesis was used was determined for each of the earlier defined motor functions, and also for the activities executed with aid. For the body powered prosthesis a distinction has been made in users who mainly used the hand, and those who mainly used the hook. Only one person with a body powered prosthesis used hand and hook about equally. Therefore, in the calculations of the average he is considered to count for half a person in each of the two categories. The results are presented in Table 3 as a percentage of the 26 activities considered. Before looking at the percentages in the table, it should be noticed that the number of persons in most of the groups is rather small (5 or less). Only the group of below-elbow amputees fitted with a myoelectric hand consists of 15 persons. Looking at the percentages, the table shows that the use of the grasping function (fixation with respect to the prosthesis) is highest for wearers of a myoelectric hand, followed by wearers of a body powered hook.

Below-elbow amputees use the grasping function more often than above-elbow amputees. The passive grasping function is sometimes used by wearers of a cosmetic hand. Furthermore, it should be mentioned that direct use of the grasping function is an exception; in general, active grasping is executed indirectly. Furthermore, the table shows that fixation with respect to the body or to the environment are frequently used alternatives for grasping. The bilateral fixation function does not occur in the table, because it is mainly used in activities outside the list of 26 items. In the interviews it was mentioned as a frequently used function. For the other fixation functions, however, the use over the 26 items can be considered as representative for use in general.

Table 3. The average percentage of activities out of a list of 26 items, where a certain function was used, or where the amputee was aided, distinguished according to prosthesis type and amputation level.

Prosthesis and amputation level (below- or above-elbow—b, a)		Number	Fixation with respect to			pushing	carrying	with aid
			prosthesis	environment	body			
Cosmetic hand	b	4	1	18	18	4	4	18
	a	1	—	—	4	4	—	23
Body powered hand	b	5.5	7	10	15	3	1	13
	a	1	—	—	8	—	—	—
Body powered hook	b	2.5	17	2	32	3	—	11
	a	3	3	9	5	3	—	9
Myoelectric hand	b	15	31	12	10	4	—	7
	a	4	12	10	7	3	3	8
Switch operated hand	a	2	4	2	—	—	—	27

When asked for what kind of activities they thought their prosthesis to be important, 28 people mentioned hobbies, 17 driving or cycling, 14 work, and 6 ADL. Table 4 gives a list of hobbies which were mentioned 3 or more times. Some people wore their prosthesis during sport, others did not. Some amputees wished to have a special cosmetic hand for sport, made of soft material. The role of the prosthesis in bicycle riding and car driving is indicated in Table 5. The table shows that there is a striking difference in use between above-elbow and below-elbow amputees.

On being asked what was liked and not liked about the prosthesis a number of positive and negative items were mentioned, which are categorized in Table 6. Complaints with respect to the cosmesis mainly refer to the vulnerability of the cosmetic glove with respect to dirt, discolouration and damage. It should be mentioned that criticism with respect to the cosmesis comes from the people who also mention the positive cosmetic properties. In the same way, the comments about the technical reliability mainly come from the people who appreciate the motor functions, and who have a user score above the group average. Complaints about the harness come from wearers of a body powered prosthesis. Complaints about perspiration are mentioned mainly by wearers of a myoelectric prosthesis. Physical and mental effort to operate the prosthesis are judged to be low, and are not considered to be important by the users.

Table 4. Hobbies mentioned by 3 or more amputees for which the prosthesis was considered useful.

Hobby	Times mentioned
Repair and maintenance jobs	18
Gardening	18
Card playing	8
Fishing	6
Soccer	5
Bird keeping	5
Tennis/badminton	3
Shooting	3
Billiards	3
Photography	3

Table 5. The role of the prosthesis in bicycle riding and car driving in relation to the amputation level.

	Amputation level with respect to elbow	
	above	below
Amputees	11	31
Bicycle riders	6	24
Wearers of prosthesis on bicycle	6	22
Users of prosthesis on bicycle	0	22
Car drivers	7	25
Drivers with a modified car	5	12
Wearers of prosthesis while driving	7	22
Users of prosthesis while driving	1	22

Table 6. Number of positive and negative comments concerning the properties of arm prostheses.

Comment	Times mentioned
POSITIVE	
Cosmesis	35
Motor functions	16
NEGATIVE	
Cosmesis	20
Technical reliabilty	13
Lack of touch	6
Hindrance due to harness	6
Hindrance due to socket and perspiration	9

Of the 42 participants, 22 still wear the type of prosthesis they first obtained. Table 7 shows the transfers which have taken place. With the introduction of the myoelectric prosthesis, 6 wearers of a body powered prosthesis changed to this type. An advantage of the myoelectric prosthesis which was often mentioned by below-elbow amputees is the lack of a harness, and thus of the hindrance it causes. The table also shows that 4 persons who originally had a cosmetic hand changed to a hand with a grasping function. On the other hand, 9 persons who originally had a prosthesis with a grasping function changed to a cosmetic hand or to no prosthesis at all. This group did not care much about having a grasping function. The 4 persons who do not wear a prosthesis any more felt especially hampered by the prosthesis because it took away their sense of touch. With their long fore-arm stumps they had a good motor function and they did not consider the passive cosmesis as very important, contrary to the other participants, who valued their prosthesis very highly and felt unhappy without it.

Based on the individual scores for intensity of use of the motor functions of the prosthesis, the group could be divided into 21 users with a total score higher than average and 21 users with a lower score. For each of the two groups the answers to a number of interview questions and

Table 7. Distribution of initial prosthesis and transfers of one type to another for 42 participants.

		Present type				
Original type	Total	Cosmetic	Body powered	Myoelectric	Switch operated	No prosthesis
Cosmetic hand	4	—	2	—	2	—
Body powered hand/hook	24	4	10	6	—	4
Myoelectric hand	13	1	—	12	—	—
Switch operated hand	1	—	—	1	—	—
Total	42	5	12	19	2	4

also the medical data and the results of the psychological tests were analysed. Thus, possible relations between a number of factors and the use of the prosthesis could be identified. Besides the use of the prosthesis as measured by the total score over all motor functions, the use of the gripping function only was also considered. In the latter case the analysis was based on the wearers of a body powered or myoelectric prosthesis because they had a reasonable gripping function at their disposal. By means of a chi-square test those factors were identified which showed a difference between the two groups of a 0.05 or lower significance level. The results are given in Table 8. The table shows that for use in general the amputation level is of influence. Much help from others goes with a low score both for use of the prosthesis in general and for use of the gripping function in particular. A short time between the amputation and provision with a prosthesis has a positive influence on the use of the gripping function. As could also be deduced from Table 3, wearers of a myoelectric prosthesis make more use of the gripping function than wearers of a body powered prosthesis.

As can be seen in Table 2, the number of people with a medical factor which might hamper the use of the prosthesis is too small to yield results in a significant test. This does not mean that it can be concluded that there is no influence. For instance, the fact that 7 out of 9

Table 8. Items which were found to be related to the intensity of use of the prosthesis over all motor functions for the whole group of amputees, and items which were related to the use of the gripping function only for the wearers of a body powered or myoelectric prosthesis. For each item the significance level according to a chi-square test for rejecting the nulhypothesis is given.

Use of prosthesis functions in general (42 persons)				
		user score		
Item	Category	high	low	sign. level
Amputation level	lower arm	18	12	0.05
	upper arm	3	9	
Help from the environment	not much	17	9	0.02
	much	4	12	
Use of gripping function (31 persons)				
Time between amputation and provision with a prosthesis	$>$ 0.5 year	11	6	0.02
	$\leq$ 0.5 year	3	11	
Prosthesis type	myoelectric	12	7	0.02
	body powered	2	10	
Help from environment	not much	12	9	0.05
	much	2	8	

people, who have phantom sensations with an abnormal anatomy, have a low user score may be an indication. A number of factors could be identified, however, as having no influence on the intensity of use of the prosthesis in general and of the gripping function in particular. To mention a number of these factors: whether the dominant or the non-dominant hand was amputated; clinical or polyclinical rehabilitation; duration of the rehabilitation; number of treatment periods; whether the amputee was satisfied or not with the treatment; and the scores on the psychological tests.

Coping with the amputation

The purpose of rehabilitation is to enable the amputee to function again in his own environment. A very important step towards this goal is that the person learns to accept his state. For many people, though not for all, the prosthesis plays an important role in this process. There are however, a number of other important aspects which were brought out in the interviews. In many cases the cause of the amputation, often an industrial accident, is something which still keeps people occupied. Sometimes they have reasons to reproach themselves or others. In some cases people had been involved in a law-suit which was lengthy and sometimes yielded disappointing results. The positive or negative reaction of the environment to the accident can also be important. Especially during the period in the hospital, people have a need to talk with others about the accident and about their expectations for the future. The period between the hospital and the rehabilitation centre is a difficult one. They are no longer regarded as a patient and they discover the consequences of their handicap. Admittance to a rehabilitation centre is often mentioned as a positive turning point. Something is going to be done with their sitiuation. The amputee often discovers that there are people in a worse situation, which makes them feel less handicapped, although some people feel shocked and distressed at the sight of severely handicapped persons. An important help for coping with their amputation is the possibility of talking with other amputees. An important event is the provision of the first prosthesis. On the one hand there is a feeling of being complete again, on the other there is an alien object which has to be incorporated in their body scheme. Initially, the attention is mainly focussed on the cosmetic function of the prosthesis. The motor function comes secondly. Then, people first discover what they cannot do with the prosthesis, before they learn what they can do with it. People often mention that the training was not adjusted to their specific needs, so that they were left to find out things for themselves afterwards. For many amputees a difficult period begins again after rehabilitation. In the rehabilitation centre, where there are many handicapped, people do not mind showing their prosthesis or their stump; back in society they often do not dare to move freely. They feel uncertain also with respect to their expectations about the future. The question whether they can return to their old job or, if not, whether they can find another one is a worry from the beginning. Applying for a job is more difficult for an amputee, because most employers prefer a non-handicapped candidate. Confrontation with the outside world is often hard because people sometimes react rather tactlessly on seeing someone with an arm prosthesis. As a result, amputees are sometimes hard on themselves and on others. In small communities everbody is informed and things are less difficult. The attitude of the amputee's own family is very important. They can have a very positive influence by stimulating the amputee to do things himself, which increases his self-confidence. Hobbies which require a certain manual dexterity can also have a positive effect. In some cases the amputation was the cause for further study, resulting in a more attractive job. In general, it is very important to have an outlook for the future.

Of the 42 persons, 26 could be considered to have coped with their amputation, whereas 16 still had difficulties. By looking at the answers to some interview questions, a number of positive and negative factors could be identified. Table 9 gives a list of items on which the group with acceptation problems differs from the others on a significance level of 0.05 or less according to a chi-square test. As has been already mentioned the Amsterdam Biographical Questionnaire showed that the group of participants in the investigation as a whole contained more extrovert people than might be expected in a random sample from the Dutch population. It was found that the extrovert people were mainly found in the group who had learned to cope with

Table 9. Items in the semi-structured interview and in the Amsterdam Biographical Questionnaire which are related to problems in accepting the handicap, together with their significance level in a chi-square test.

Item	Sign. level
Trauma plays an important role in amputee's life	0.001
Difficulty in making contacts	0.002
Poor adaptability	0.01
Feeling a different person after accident	0.01
Feeling stared at by people	0.01
Often thinking back about accident	0.02
Feeling handicapped	0.02
Not extrovert according to ABQ-score	0.05
Sensitive to reactions of others	0.05

their amputation. Therefore, it could be deduced that the group as a whole was a positive selection with respect to the way they had coped with their handicap. People who still had difficulties should mainly be found in the group who had not participated in the investigation. Taking into account this effect, the number of amputees in general who satisfy the earlier mentioned selection criteria, and who still have difficulties in coping with their handicap, should amount to at least 60% instead of the 40% found in this particular group.

Conclusions

The prosthesis.

With respect to the value of the prosthesis and the way it is used the following conclusions could be drawn from the field study.

For the majority of the group, the cosmetic function of the prosthesis is very important.

Many people who value the cosmesis highly, pay much attention to the passive cosmesis of the prosthesis, but are less aware of the cosmesis of wearing and the cosmesis of using the prosthesis. As a result they often look conspicuous because of their tendency to hide the prosthesis.

Those amputees who have learned to move in a natural way, with or without prosthesis, taught themselves this ability. The cosmesis of wearing had not been taught in the rehabilitation centre.

Although not everyone is aware of the cosmesis of using, in general they avoid activities with their prothesis which require unnatural arm motions.

The motor functions are thought worthwhile for hobbies, transport, work, and activities of daily living; in that order of importance.

Use of the direct grasping function is an exception. If an object is picked up directly by the prosthesis, in most cases the orientation differs from the desired one. Therefore, in two-handed tasks the object is given to the prosthesis by the users own hand. It is easier and looks very natural.

The direct grasping function is used only for activities like picking up a suitcase or grasping the handlebars of a bicycle.

People are very willing to demonstrate the use of the direct grasping function in activities in which they have been trained, like picking up a glass. In practice, however, these activities are always executed with their own hand.

Frequently used alternatives for the grapsing function are fixation with respect to the body or fixation with respect to the environment.

In assessing the use of the prosthesis for task execution in general, it has to be borne in mind that the prosthesis has to compete with a number of alternative strategies such as:

use of the stump;
use of other body parts, for instance the remaining hand;
asking for help from other people;
avoidance of a certain activity.

An important disadvantage of a prosthesis in task execution is the lack of sensory feedback to the user, he is therefore very dependent on visual feedback.

Bearing in mind the previous points, the use of the grasping function or the use of the prosthesis at all should not be considered as a matter of course for unilateral amputees.

A mutual comparison shows that the wearers of a myoelectric prosthesis use their prosthesis more frequently than wearers of a body powered hook, who in turn use their prosthesis more than wearers of a body powered hand.

Body powered prostheses often require compensatory motions in order to operate the grasping function in different locations. These compensatory motions may look unnatural, and they are avoided if there is a less obtrusive alternative.

The body powered hook is especially advantageous for hobbies and jobs which require some manual skills because of the following properties:

It provides good sight of the grasped object.
It is not easily damaged.
It is easy to clean.

Whether or not a wearer of a body powered prosthesis will use his hand or his hook will also depend on the social context, which determines whether the wearer considers the passive cosmesis as important or not. For instance, for gardening some persons used the hook in the backyard, the hand in the front yard.

The myoelectric prosthesis is valued, because the wearers feel less hampered. In particular, below-elbow amputees do not need a harness. The latter point is also mentioned as cosmetically attractive.

Below-elbow amputees use their prosthesis more frequently than above-elbow amputees, which can be understood from the fact that in the first case the remaining body functions facilitate the positioning of the prosthesis.

Whether an amputee will wear and use a prosthesis or not depends on its potential benefits and burdens. Benefits are the cosmetic and motor functions; burdens can be divided into burdens inherent to wearing only, like the inconvenience caused by a harness if present and by the fitting, and in burdens related to the use of the prosthesis like the physical and mental effort to operate the prosthesis, the lack of touch, an obstructed view, the weight, and the susceptibility to dirt and damage.

For many users the burdens of wearing are the most annoying properties, due to their constant presence.

Unilateral amputees wearing a prosthesis with one active degree of freedom do not consider the mental load as important.

The cosmetic glove is considered very important for the passive cosmesis, but it is also the most vulnerable part of the prosthesis.

Some people with a long fore-arm stump who do not value the passive cosmesis very highly prefer not to wear a prosthesis thus avoiding its burdens. They often move very naturally and thus are less obtrusive than some wearers of a prosthesis.

Rehabilitation.

From the data concerning rehabilitation the following conclusions could be drawn.

No relationship was found between the duration of the rehabilitation process and the amputation level and the prosthesis type provided. Neither was a relationship found between the duration and the intensity of use of the prosthesis or the degree to which the amputee had learned to cope with his amputation.

Those who had learned to move in a natural way while wearing a prosthesis, had taught themselves this ability. The cosmesis of wearing had not been taught in the rehabilitation centre.

The personal contacts with other amputees and with the staff of the rehabilitation centre are highly valued. The contacts with the limb fitter are mentioned as especially positive and important.

There is a desire for prosthesis training which is more in accordance with the specific needs of the individual amputee.

In many cases, people were not prepared for the kind of problems generally encountered after returning to their own environment.

Coping with the amputation.

With respect to this subject the following conclusions could be drawn.

Accidents often result from human errors. Therefore the victims may reproach themselves or others. It was found that these feelings often keep people occupied even after many years.

The effects of an amputation are of many kinds. The loss of a limb may cause a feeling of incompleteness. Moreover, it also implies a loss of motor and sensory functions, which reduces the amputee's abilities. This reduction of abilities may change his life pattern and his professional career. Socially the amputee may feel stigmatized, sometimes being confronted with undesired attention.

The way the amputee will cope with these problems will partially depend on his personality structure and partially on social factors. Talking about the problems of an amputation to people with an understanding attitude is an important help in finding a state of acceptance of the amputation. In this respect, extrovert people have advantages over introvert people, as was found in this investigation.

The reduction of abilities brought about by amputation is something many people realize almost immediately after the accident. As a consequence their outlook for the future is often broken down. A restoration of their perspective for the future with respect to job and family life is often mentioned by amputees as a positive stimulus.

The prosthesis was found to play an important role in coping with the handicap. It can reduce

the amputee's sense of incompleteness and obtrusiveness, and it thus helps to increase his self-reliance.

The results of the investigation indicate that a majority of all amputees who have lost a hand due to an accident, still have problems with the acceptance of their handicap after a number of years. This suggests that more attention should be paid to this aspect in the rehabilitation process.

Recommendations

The field evaluation described in this paper had a rather broad scope because the investigators were of the opinion that the prosthesis and its use could not be isolated from the total problem of the rehabilitation of amputees. It was also the intention to arrive at recommendations for all categories involved in this problem field, i.e. the amputees and their families, the members of the treatment teams in the rehabilitation centres, and the designers of arm prostheses. As a consequence the recommendations have been categorized according to those three target groups.

Amputees

For this group it is important to receive early information about the consequences of the amputation, the kind of help the rehabilitation centre can offer, and the problems to be expected after rehabilitation. Although people do get information at an early stage, it is often incomplete; moreover much of the information passes over their head at this time. The present investigation has yielded a lot of information about the experiences of other amputees. Therefore it is the intention to write a special booklet (in Dutch) with information for amputees. It will cover the following subjects: problems during the first period; treatment in the rehabilitation centre; information about the available prosthesis types, their benefits and burdens; problems which may be encountered after the rehabilitation period; and finally a list of institutions and societies which can be of use for the amputee. Here it should be noted that such a booklet is highly related to the social structure of a particular country.

Rehabilitation teams.

The purpose of amputee rehabilitation is to enable them to function again in their own environment as well as possible. Three global subgoals can be distinguished which, however, have a mutual interaction. The first is help to accept the amputation with its causes and effects. The second is to restore the functional possibilities as fully as possible, with or without a prosthesis. The third is to restore the previous life pattern or to achieve a new one within the limitations imposed by the handicap. In order to be able to accomplish these goals, it is necessary to have sufficient information about the life style of the amputee before the accident, his feelings about the amputation, the attitude of people in his direct environment, his expectations for the future and his expectations with respect to rehabilitation. The best way to obtain this information seems to be a home visit where much more insight can be gained into the particular circumstances of the amputee than during one or more talks in the rehabilitation centre. On the other hand, the representative of the rehabilitation centre can inform the amputee about the treatment programme and answer other questions he may have in relation to his situation.

The time between amputation and admission to the rehabilitation centre should be as short as possible. After admission to the rehabilitation centre, much time should be spent on discussing the benefits and burdens of the different prosthesis types in relation to his specific situation, so that a justified choice can be made. If a prosthesis will be provided, it is important to involve the amputee in the construction of the prosthesis. It should be realized that for most people the cosmetic function is of primary importance, certainly in the beginning. At this stage, much attention should be given to teaching the amputee to move in a natural way with and without the prosthesis. After the amputee has learned to operate the prosthesis, he should be given task training which is fitted to his needs. For each task, the different alternatives for execution, with or without the prosthesis, should be considered in order to arrive at the best individual solution. As soon as the amputee feels sufficiently proficient with his prosthesis, he should be confronted with the outside world in activities such as shopping, making use of public transport, etc. thus increasing his self-confidence by lowering a threshold which is often encountered after the period in the rehabilitation centre. Some of the participants in the evaluation study mentioned that they still felt embarrassed in public. Some

activities, which are rather specific to the individual environment should preferably be taught at home. This may involve making special arrangements, however, it offers an opportunity to involve the family in the rehabilitation process. Opportunities should be created to talk about problems with other amputees and with staff members. One of the things people worry about is their return to work, therefore contacts should be made at an early stage in order to restore lost prospects in this field.

Designers of arm prostheses

For designers of arm prostheses it is important not only to consider the potential benefits of a prosthesis to be designed, but also the potential burdens. In the case of unilateral amputees, it has to be borne in mind that the prosthesis, if it is used, has the function of a non-dominant hand, and that it has to compete with a number of alternative ways of task execution. The functional benefits only play a role at the moments that they are used. Some of the potential burdens, however, like the hindrance due to fitting and sometimes a harness, are constantly present. For this reason, a reduction of these burdens may be of more importance to the amputee than an increase in functional possibilities. The cosmetic function of the prosthesis is valued very highly by most of the wearers. The need for a less vulnerable cosmetic glove, however, was often mentioned.

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