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Consumer concerns and the functional value of prostheses to upper limb amputees

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Abstract

This paper reports a study of 66 upper limb amputees in County Funen, Denmark who were visited in their homes by the author. The purpose of the study was to evaluate the consumer concerns about their prostheses and to see if these were related to cessation of prosthetic use. It was also intended to estimate functional levels of both prosthetic users and non-users. The number of amputees investigated corresponds to the annual number of persons becoming upper limb amputees in Denmark.

There were 3 prosthetic systems in use, two active systems and one passive system. At review there was a group of 18 amputees which did not use a prosthesis at all.

It appeared that active and partially active users are younger persons with a relatively short time-lapse since amputation. Passive users are older persons with a long time-lapse since amputation. Only 4 out of 18 prosthetic non-users stopped prosthetic use as a consequence of prosthetic problems or discomfort.

Active prostheses had the highest number of consumer problems. Most problems were concerned with the socket, and for the body powered prostheses also with the suspension and control system.

It was shown that an awareness of the amputee's working conditions is important at the fitting stage, especially the daily working situation. As a consequence strictly individual fitting is needed with attention being given to the manner in which the individual will use the prosthesis.

This investigation clearly shows that active fitting is a worthy effort. In daily living the active users have a superior performance over the passive and non-users. It was observed that amputees despite many years of training still have problems with activities of daily living, particularly in relation to independent functions.

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Introduction

In Denmark upper limb amputation represents 3% of all amputations (Andersen-Ranberg and Ebskov, 1988). In other countries such as Israel and the USA upper limb amputations constitute from 10-25% (Steinbach, 1979; Davies *et al.*, 1970).

One of the main goals is to restore functional possibilities as fully as possible, with or without a prosthesis. In a well developed country with a high grade social system such as Denmark all new amputees are offered a prosthesis (Kejlaa, 1992). Today there is one passive and three active prosthetic systems available.

The standard supply has for many years been a body-powered active prosthesis, or alternatively a passive prosthesis. The body-powered system is based on an idea which is over 150 years old and with the Dorrance split hook in 1909 the system became the main prosthetic choice. After World War II, a number of research programmes started and improvement began to appear in socket design and materials. Externally-powered prostheses were developed in Germany and the UK in the fifties spurred by the Thalidomide tragedy. The pneumatic system is not in regular use in Denmark. However, from the early seventies myoelectric prostheses have become more predominant in Denmark.

The purpose of this investigation was to

evaluate the prosthetic consumer concerns about their prostheses and to see if these were related to cessation of prosthetic use and also to estimate the functional levels of both prosthetic users and non-users.

Method

The number of upper limb (UL) amputees in the County of Funen, Denmark was not known. The Amputation Register (Ebskov, 1986) could only provide information from 1972. Therefore the material was collected from all the hospitals and prosthetic centres in the county. All registers were examined. The material therefore includes all amputees who have been treated in the County of Funen in the period 1 January, 1900 to 31 December, 1987.

All amputees were visited in their homes by the author. This gave the opportunity to see and register their daily surroundings and their prostheses and function as well as to meet their families.

Two sets of questionnaires were constructed, one for amputees under 18 years and one for amputees over 18 years of age.

All prosthetic users were divided into two groups, one group which used their prostheses more than 8 hours a day and one group which used their prostheses less than 8 hours a day. The amputees were characterised as active users (i.e. active prosthesis use more than 8 hours a day), partially active users (i.e. active prosthesis use less than 8 hours a day), passive users (i.e. only users of a passive prosthesis) and prosthetic non-users (i.e. no use of prosthesis at all).

The amputees were divided according to the cause of amputation, prosthetic type and to the functional group in which they were placed.

The amputees were classified by their prosthetic type in relation to their age, mean time since amputation, loss of dominant hand and loss of elbow and their working conditions.

Table 1. Working conditions for the amputees scaled according to their daily loading.

Load scale	Working conditions
0	Unemployed; pensioners
I	Light sitting work
II	Light standing work
III	Combined sitting/standing work
IV	Heavy variable work
V	Heavy monotonous work
VI	Exceedingly heavy work

Table 2. Total number of upper limb amputees registered.

Cause of amputation	Female	Male	Total	Percent
Trauma	4	49	53	50
Congenital	9	5	14	13
Brachial plexus lesion	1	5	6	6
Vascular disease	13	8	21	20
Tumour	4	7	11	11
Total	31	74	105	100

The working conditions were classified in accordance with Table 1.

The consumer concerns were related to prosthetic types. The prosthetic users and non-users were investigated in relation to their activities of daily living (ADL). These activities were classified in main groups as: eating; hygiene, grooming and dressing; employment activities; communication; recreation activities. When more than 25% of the amputees had problems it was identified as a major task problem, when 10-25% had problems it was denominated a general task problem and as a minor task problem when less than 10% had problems. The task problems for active, passive and non-users were correlated with the number of amputees in each prosthetic group, the mean years the amputees had been in the relevant functional group at the time of review, the mean time lapse since amputation and age at review.

Results

Some 105 UL amputees were registered; 32 were dead and 7 would not participate (3 were in conflict with the hospital system, one had psychiatric reasons and 3 did not give any reasons) (Table 2). Consequently 66 amputees were included in the survey and visited in their homes by the author (Table 3). The mean age at amputation was 24.5 years (0-72 years). Mean age at review was 45.1 years (4-83 years).

Table 3. Number of upper limb amputees visited.

Cause of amputation	Female	Male	Total	Percent
Trauma	3	40	43	65
Congenital	6	4	10	15
Brachial plexus lesion	1	5	6	9
Vascular disease	3	1	4	6
Tumour	1	2	3	5
Total	14	52	66	100

Table 4. Amputees' characteristics correlated to the three prosthetic systems used.

Prosthesis	use >8h	use <8h
Mechanical		
number	20	5
mean age at review	38.2 (4-77) years	47.2 (25-83) years
loss of dominant hand	13	4
loss of elbow	1	2
mean age at amputation	23.7 (0-51) years	26.6 (18-38) years
mean working load	III (0-IV)	I (0-III)
Myoelectric		
number	6	1
mean age at review	32.8 (21-51) years	26.0 (26) years
loss of dominant hand	5	1
loss of elbow	1	0
mean age at amputation	19.0 (0-31) years	20.0 (20) years
mean working load	II (I-III)	I (I)
Passive		
number	11	5
mean age at review	62.8 (43-79) years	71.2 (64-75) years
loss of dominant hand	6	1
loss of elbow	6	0
mean age at amputation	23.5 (13-40) years	27.0 (18-38) years
mean working load	I (0-IV)	0 (0-I)

The mean time lapse from amputation to review was 20.6 years (0-63 years).

At review 32 were active prosthetic users of which 6 used their prostheses less than 8 hours a day; 16 were passive users of which 5 used their prostheses less than 8 hours a day; 18 did not use a prosthesis at all. These functional groups were related to the cause of amputation (Fig. 1).

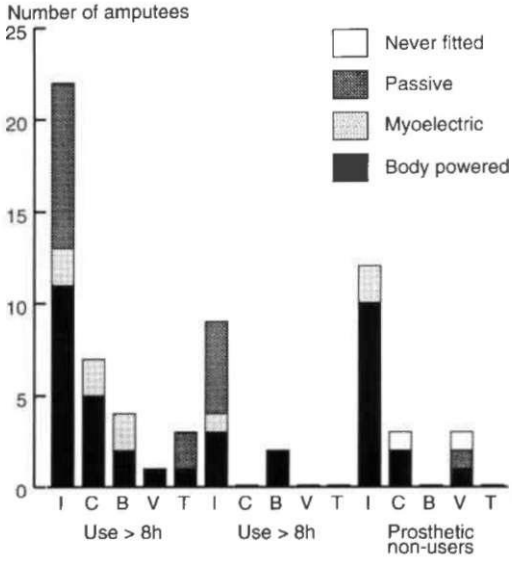

Figure 1. Amputees' functional groups at review correlated to the cause of amputation and primary fitting. I: Trauma; C: Congenital; B: Brachial plexus lesion; V: Vascular disease; T: Tumour.

There were 3 prosthetic systems used. Two active systems, a body powered mechanical system and a myoelectric system and one passive system.

The relation of the three prosthetic systems to the age of the amputees, time lapse since amputation, loss of dominant hand and elbow and the amputees' working conditions are shown in Table 4. It is seen that active and partially active users are younger persons with a relatively short time lapse since amputation. Passive users are older persons with a long time lapse since amputation and the youngest were using their prostheses more than 8 hours a day. The working conditions reflect the use of prostheses and the system used. Heavy workers used a conventional prosthesis and the myoelectric prosthesis was used by amputees with office work or undergoing education. Passive prosthetic users were either light workers or pensioners. Partially active users were all light workers.

The main consumer concerns for the three prosthetic systems studied in this investigation are illustrated in Figure 2.

Body powered prostheses were heavy and warm to wear. The suspension system gave irritation in the axillae, and were often wet with perspiration which could lead to operation failure. When washed the suspension system curls up. The control system could fail when wires slackened or broke. Control wires connected to the socket often damaged clothing

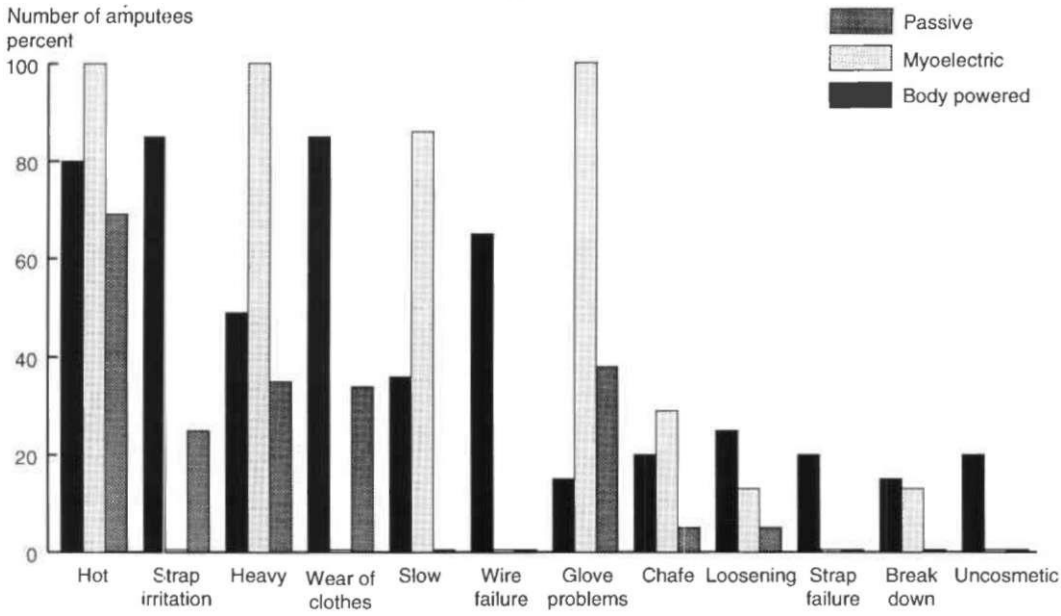

Figure 2. Main consumer concerns for the three prosthetic systems studied in this investigation.

at the wrist and elbow. Underwear was also damaged by the suspension system. Women had problems with low cut dresses and men had to wear an undershirt otherwise the suspension system could be seen under their shirts. Sixty per cent of those who primarily were fitted with a conventional prosthesis were given a mechanical hand, only 2 used this device regularly at review. The hand was too heavy and slow, became dirty and required more power to operate than the hook. Those in heavy work such as farming or working in industry experienced socket problems sometimes leading to pressure sores. Heavy workers also had problems with loosening of the prosthesis, especially when lifting with an extended arm or flexed elbow, when the socket pressed the upper arm. These problems were solved to some extent with auxiliary suspension and a U-shaped relief on the volar side of the socket. Some experienced cosmetic problems with the hook, especially in the early years after fitting.

All amputees who used myoelectric prostheses had 3 major complaints: their prostheses were heavy and hot and their gloves were difficult to keep clean. Especially those (n=3) who had primarily been fitted with a conventional prosthesis considered that the myoelectric prostheses were slower in action and more difficult to don. The close fitting Munster socket could give discomfort with heavy loads. When there was a prosthetic failure it was always necessary to contact a prosthetic centre or a prosthetist.

Passive prostheses are lighter and the socket and suspension system are only required to maintain the prosthesis in position. The main problems for the passive users were concentrated on the socket and the suspension system, expressed as heat problems in the socket and worn clothing. Otherwise there were glove problems. Forequarter amputees had an

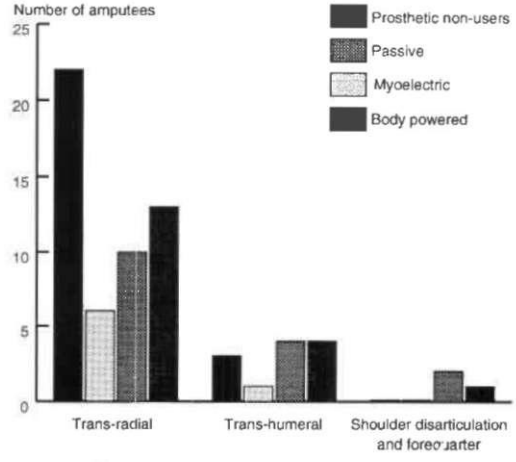

Figure 3. Amputation level correlated to prosthetic types and prosthetic non-users.

Table 5. Main causes of cessation of prosthetic use correlated to body powered (BP), myoelectric (ME) and passive (PAS) prosthetic systems and prosthetic non-users (NOP).

Cause of cessation	BP	ME	PAS	NOP
Prosthetic failure	0	1	0	0
Prosthetic discomfort	2	1	0	0
Delayed prosthetic supply	3	0	0	1
No prosthetic need	4	0	0	0
Illness and attenuation	2	0	1	1
Phsychological reasons	2	0	0	0
Total	13	2	1	2

extensive socket and harness system and complained of heaviness and worn clothing.

Figure 3 shows the level of amputations correlated to prosthetic types and to prosthetic non-users.

Seventy-seven percent were trans-radial amputees, 18% were trans-humeral amputees and 5% were amputated at or above shoulder level. Eleven out of 15 (73%) who had lost the elbow were either passive or prosthetic non-users. One person amputated at trans-humeral level was fitted with both a myoelectric elbow and hand. No bilateral amputees were identified.

Table 5 illustrates the main causes of cessation of prosthetic use. It is seen that only 2 amputees had never used a prosthesis. Only one from the passive functional group had stopped prosthetic use. The rest were all active users. Only 4 had stopped prosthetic use as a consequence of prosthetic problems or discomfort, all were active users two of whom were myoelectric users. So in this investigation 22% (4 out of 18) of cessation of prosthetic use was related primarily to prosthetic problems.

The activities of daily living (ADL) were of interest for active users versus passive users and non-users. In this regard it is important to know that most passive and non-users formerly had used an active prosthetic system. The passive users and non-users lack a pinch grip and cannot perform tasks controlled by this grip. Figure 4 illustrates the loss of function and task problems for the 3 groups. It is seen that active users had fewest problems, that non-users had the greatest number of amputees with major problems, but passive users had the most problems. The active and passive users had equal percentages of amputees in the 3 identified task groups.

The results show that active users had significantly fewer problems than the other two

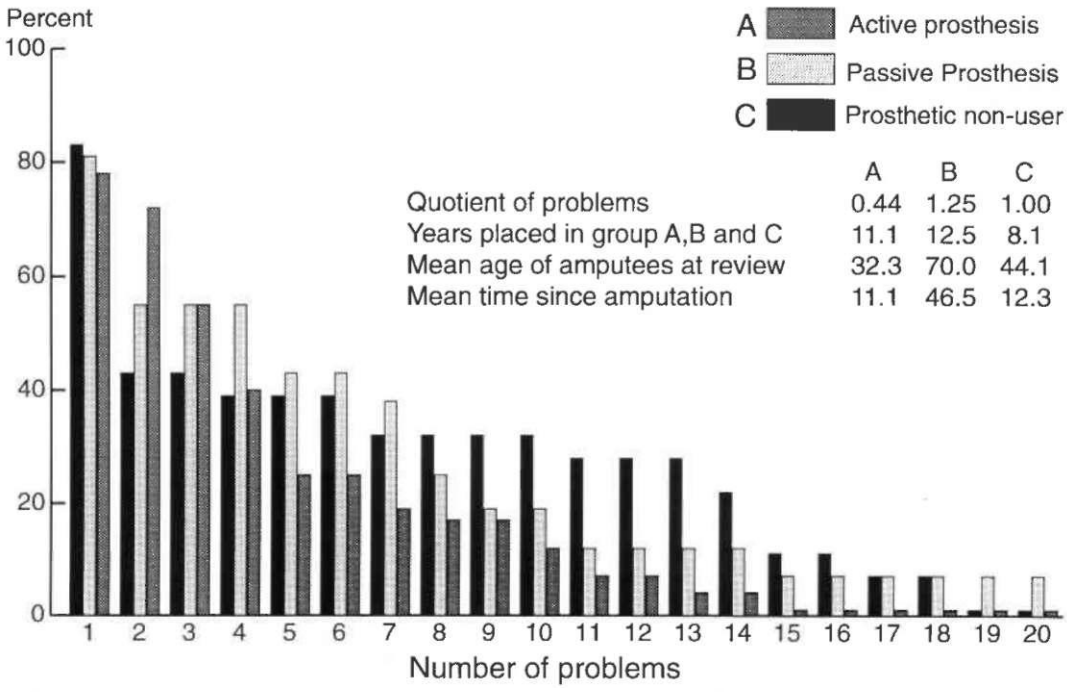

Figure 4. Functional loss and task problems for active prosthetic users, passive users and prosthetic non-users.

functional groups, but the passive users had the highest number of task problems. When correlated with the mean years in the relevant functional group the sequence was that active users had the fewest problems followed by passive users and finally the non-users. The non-users had the lowest experience as a group in years. It is seen that the longer time lapse since amputation the fewer task problems there are, and that older amputees have a lower activity level.

Figure 5 shows that there were most problems in hygiene, grooming and dressing, then employment activities followed by eating. It was noted that the amputees did not have any task problems in communication and recreational activities.

Discussion

The number of amputees investigated happens to correspond with the annual number of persons who become UL amputees in Denmark (Andersen-Ranberg and Ebskov, 1988).

The good social system in Denmark has been of great importance to the amputees. All have been offered a prosthesis and have had the opportunity to become rehabilitated (Kejlaa, 1992). With time there is a prosthetic progression from active to passive prosthesis or prosthetic cessation (Kejlaa, 1991).

All prostheses are hot to wear. The higher the level of amputation and the more complex the prosthesis, the heavier it is.

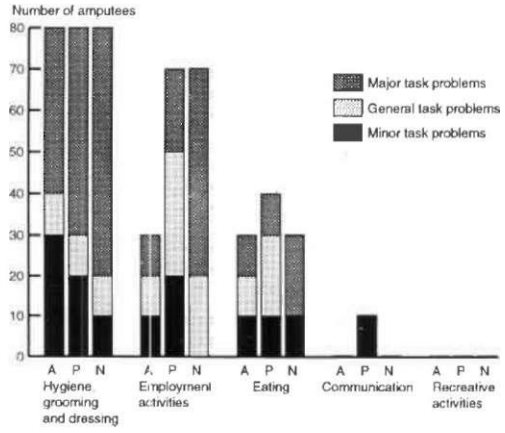

Figure 5. The main groups of ADL correlated to major, general and minor tasks problems and the prosthetic functional groups. A: Active prosthesis, B: Passive prosthesis, N: No prosthesis.

Improvement of conventional prostheses should be concentrated on the suspension and control systems. Wires in the system should be re-positioned to avoid interference with clothing. Straps should be constructed from another material to avoid curling and the resulting irritation. These changes would improve the use of prostheses in a safe and comfortable manner.

It is demonstrated here how important it is at the time of fitting to be aware of the amputees working conditions, especially the daily working load.

Therefore strictly individual fitting is needed, not only concentrated on the conditions of the stump, but certainly to the manner in which the individual will use the prosthesis.

The socket must be properly designed for heavy work to minimize the load or force at the stump. Also it is necessary to consider the conditions at elbow level for amputees where heavy lifting is performed providing a U-shaped relief on the volar side in the socket or auxiliary suspension on the dorsal side of the elbow to ensure that the socket does not become loose. In the socket design the prosthetist must be aware of the pressure areas at the stump especially with heavy loads.

The mechanical hand seems to be unpopular with amputees. It is too heavy and difficult to use. When the amputee gets used to his handicap he prefers the hook to the hand, and he does not need the cosmesis of the more troublesome hand.

Myoelectric prostheses are preferred by amputees where cosmesis is important and who are employed in clean and light work. It is important to be aware of the stump condition when fitting an amputee with a myoelectric prosthesis. The stump will become more muscular with time especially when the amputee formerly had used a conventional prosthesis and this can give problems with electrode contact and may lead to consumer problems.

Passive prostheses have the same socket problems as the two active prosthetic systems and also some lesser problems from the suspension system.

Effort in the future must be concentrated on new socket designs and also reconstruction of the suspension and control system for body powered prostheses. This may minimize

consumer problems without loss of function, and may reduce the number of amputees who cease prosthetic use.

The glove problem is well known. The relatively new silicone gloves have the advantages of easy cleaning, but do not seem to be as durable as PVC gloves. They are also more expensive. Research work must continue in this area.

This investigation clearly shows that active fitting is worth the effort involved. In ADL the active users are superior in performance to the passive and non-users. Attention must be given to the time lapse from amputation to primary fitting. This interval must not exceed 6 months otherwise there are risks for prosthetic failure (Carter *et al.*, 1969; Kejlaa, 1991).

It is seen that amputees despite many years of training still have problems with activities of daily living. The problems are concentrated on activities of daily necessity which make a person an independent individual. The amputee must wash and care for him or herself and eat. Employment activity is required for daily survival. Communication was not identified as a problem. With the years, amputees adjust themselves in recreation and the activities which they select for pleasure. It is interesting to note the security of daily existence, supported by the amputees' lower divorce rate and by the fact that only 14% live alone (Kejlaa, 1992).

The perfect prosthesis has not yet been found and may never be found. However, with continued research and the application of current knowledge individual fitting can give this group of patients a secure life as independent persons, and can minimize cessation of prosthetic use.

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