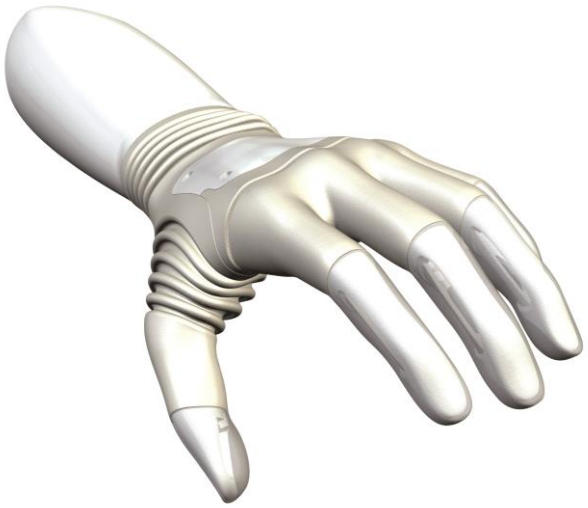
ottobock.

Myoelectric compared to body-powered prostheses



Quality for life

Clinical Study Summaries

This document summarizes clinical studies conducted with myoelectric compared to body-powered upper extremity prostheses. The included studies were identified by a literature search made on PubMed and within the journals Der Orthopäde, JPO Journal of Prosthetics and Orthotics, Orthopädie-Technik and Technology & Innovation.

Table of content:

1 Overview table

The summaries are organized in three levels depending on the detail of information. The overview table (Level 1) lists all the relevant publications dealing with a particular product (topic) as well as researched categories (e.g. level walking, safety, activities, etc). Summaries of all the literature researching a specific question can be found in chapter 2 (Level 2).

For those interested to learn more about individual studies, a summary of the study can be obtained by clicking on the relevant reference (Level 3).

Reference		Category								Prosthesis	Target group
		Body Functions		Activity		Participation	Others				
Author	Year	Mechanics	Pain	Grip patterns Force	Manual dexterity	ADL	Satisfaction QoL	Training	Technical aspects		
Carey	2015		x			x	x	x	x	Myoelectric vs body-powered prostheses	adults
Razak	2014						x			Biomechatronics wrist prosthesis vs Body-powered prosthesis	adults
Ostlie	2012					x	x			Myoelectric vs Body-powered vs Cosmetic	adults
Egermann	2009					x	x		x	Elektrohand 2000	children
Crandall	2002					x	x			Myoelectric vs Body-powered vs Cosmetic	children
Kooijmana	2000		x							Myoelectric, Body-powered, cosmetic prostheses	adults
Millstein	1986					x	x			Electrically vs Body-powered prostheses	adults
Stain	1983				x	x				Myoelectric (Ottobock6V) vs Body-powered prosthesis	adults
Northmore-Ball	1980					x	x			Myoelectric vs Body-powered prosthesis	adults
Total number			1		1	6	6		1		

2 Summaries of categories

On the following pages you find summaries of specific questions researched in several studies. At the end of each summary you will find a list of reference studies contributing to the content of the particular summary.

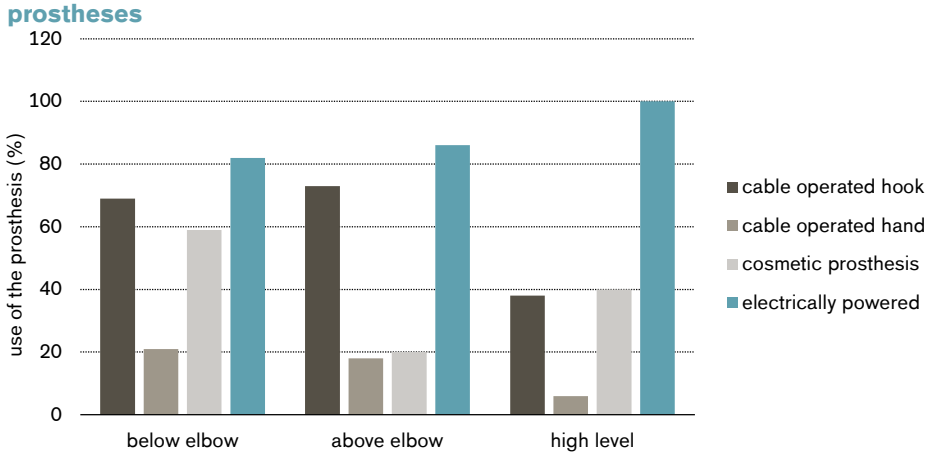
Myoelectric vs body-powered prostheses
Do amputees need both of them?

Major Findings

Myoelectric compared to body-powered prosthesis:

→ Myoelectric prosthesis gave to the user higher range of motion (RoM).
→ Task execution was faster with body-powered prosthesis.
→ The most preferred prosthesis was myoelectric prosthesis.
→ The cable operated hook was the second most favoured prosthesis.
→ 82% of below-elbow patients fitted with electrically powered prosthesis and 69% of below-elbow patients fitted with body powered reported using it.
→ 86% of above-elbow patients fitted with electrically powered prosthesis and 73% of above-elbow patients fitted with body powered reported using it.
→ 100% of high level amputees fitted with electrically powered prosthesis and 38% of high level amputees fitted with body powered reported using it.
→ The majority of amputees used more than one prosthesis for their functional needs and should be fitted with more than one type of prosthesis.

Acceptance of body-powered and ellectrically powered prostheses



Amputees reported that electrically powered prosthesis is the most preferred one, followed by the cable operated hook, cosmetic and cable operated hand. Acceptance rate for electrically powered was 82% at below elbow, 86% at above elbow and 100% at high level amputation. Acceptance rate for cable operated hook was 69% at below elbow, 73% at above elbow and 38% at high level amputation (Millstein et al., 1986).

Clinical Relevance

The prosthetic options to fit upper limb loss are passive (cosmetic) and active prosthesis (body-powered or myoelectric). The role of the prosthetic hand is not limited just to the restoration of the physical and functional movements, but it also plays a role in body gesture and posture, social life and communication. Sometimes more than one prosthesis is needed to fulfil patients´ needs.

Summary

A body-powered prosthesis usually employs a harness and cables and a variety of terminal devices (hooks, hands) can be attached. In summary advantages of body-

powered prosthesis include (Stain, et al., 1983; Millstein et al., 1986; Craig, et al., 2011):

- Low cost
- More robust
- More durable
- Less intensive training needed to learn how to control it
- Used for jobs that require heavy lifting objects, where materials handled are dirty, greasy or sharp
- Used in hot, humid weather conditions
- Preferred for home use (e.g. washing)
- Preferred for heavier and more vigorous sports activities

Myoelectric technology uses electromyographis (EMG) activity, from the voluntary activity in the stump muscles, to operate the terminal device. In summary advantages of myoelectric prosthesis include (Stain, et al., 1983; Millstein et al., 1986; Craig, et al., 2011)

- Increased comfort
- Control of the prosthesis is more natural
- The give a greater range of motion to the user
- User needs less compensatory motion to execute ADLs
- Users report perceived sensory feedback
- Bring more cosmetic acceptance
- Used for office related jobs, supervisory work or in contact with general public
- Preferred for home use (e.g. eating)
- Preferred for car driving
- Preferred for light sports activities

References of summarized studies

Millstein, S. H. H., & Hunter, G. A. (1986). Prosthetic use in adult upper limb amputees: A comparison of the body powered and electrically powered prostheses. Prosthetics and Orthotics International, (10), 27–34.

Stain, R., Walley, M. (1983). Functional Comparison of Upper Extremity Amputees Using Myoelectric and Conventional Prosthesis. Archives of Physical Medicine and Rehabilitation, 64.

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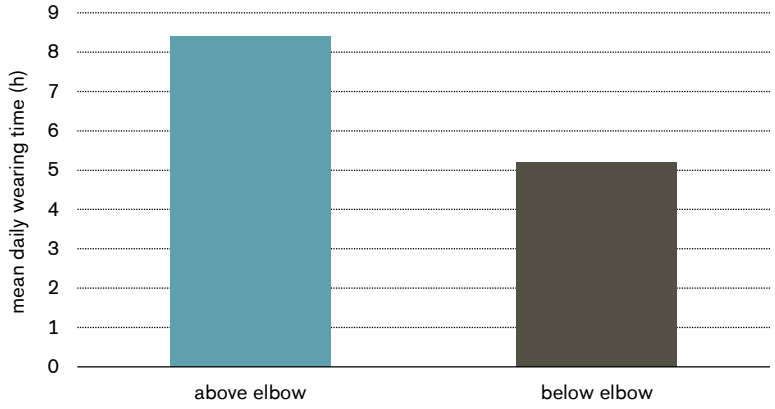
Fitting a child with myoelectric prosthesis

Major Claims

With Myoelectric prosthesis with "Elektrohand 2000" compared to previous prostheses (cosmetic, body-powered, myoelectric):

→ All children learned to open myoelectric prosthetic hand
→ 76% of studied children successfully used myoelectric prosthesis
→ Children amputated above elbow wore prosthesis more than 8h per day, while children with amputation below elbow wore prosthesis more than 5h per day
→ Prosthetic training accelerates successful use of the prosthesis
→ Developmental reediness to use myoelectric prosthesis is at 2 years of age

Mean daily wearing time of myoelecric prosthesis



Children amputated above shoulder wore prostheses more than 8h per day on average, while children with amputation below elbow wore prostheses more than on average 5h per day (Egermann et al., 2009)

Clinical Relevance

In very young children upper limb deficiency is mainly caused by malformations. Upper limb deficient children can be provided with three types of prosthesis: cosmetic (passive device), body-powered and myoelectric prosthesis (active devices). There still exists a disagreement in the community regarding right age and device to fit a child. Usually, child is initially fitted with a passive, cosmetic prosthesis as soon as being able to sit in stable position. With a passive device, child learns to use both hands, which supports brain development. A next step is transition from passive to an active device. Some experts believe that the child should receive body-powered prosthesis when it is able to stand and grasp an object or when child starts with kindergarten. The progression to the myoelectric prosthesis usually takes place at the age of ten or when the child has fully accepted active prostheses (Shaperman et al., 2003). Other experts believe that children should be fitted as soon as possible with myoelectric prosthesis (Atkins et al., 1996).

Summary

General prosthesis rejection rate of preschool children is very low compared to adults, although being strongly dependent on amputation level.. Literature suggests that children amputated above shoulder wore prostheses more than 8h per day on average, while kids with amputation below elbow wore prostheses more than average 5h per day. All children learned how to open myoelectric prosthesis, while 76% successfully used myoelectric prosthesis. This was associated with appropriate prosthetic training. Therefore, infants can profit from myoelectric hand prostheses and myoelectric prosthesis can be fitted as soon as child is 2 years of age (Egermann et al., 2009).

References of summarized studies

Egermann, M., Kasten, P., & Thomsen, M. (2009). Myoelectric hand prostheses in very young children. International Orthopaedics, 33(4), 1101–1105. doi:10.1007/s00264-008-0615-y

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3 Summaries of individual studies

On the following pages you find summaries of studies that researched myoelectric prostheses compared to body-powered prostheses. You find detailed information about the study design, methods applied, results and major findings of the study. At the end of each summary you also can read the original study authors' conclusions.

Reference

Carey SL, Lura DJ, Highsmith MJ.

Department of Mechanical Engineering, University of South Florida, Tampa, FL.

Differences in myoelectric and body-powered upper-limb prostheses: Systematic literature review

Journal of Rehabilitation Research & Development 2015; 52(3):247-262.

Products

Myoelectric vs body-powered prostheses

Major Findings

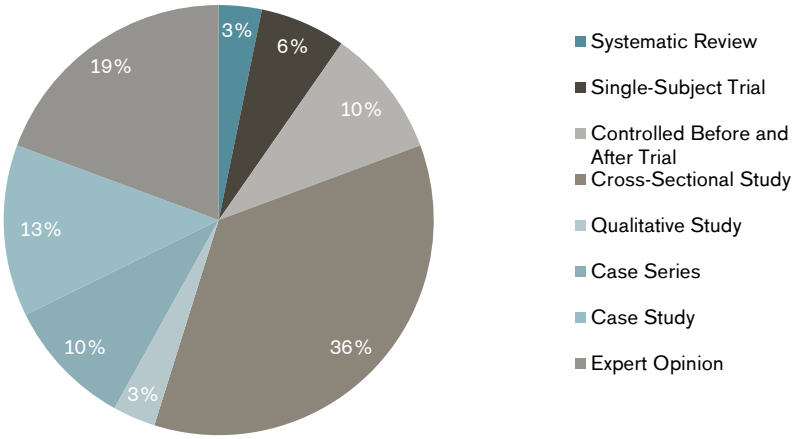
Advantages of myoelectric prostheses

- preferred for office related jobs
- preferred in contact with general public
- cosmetic acceptance
- more comfortable
- may reduce affect phantom limb pain when intensively used

Advantages of body-powered prostheses

- preferred for heavy jobs
- more robust and durable
- less maintenance needed
- less training time needed
- perceived sensory feedback

Studies included for analysis

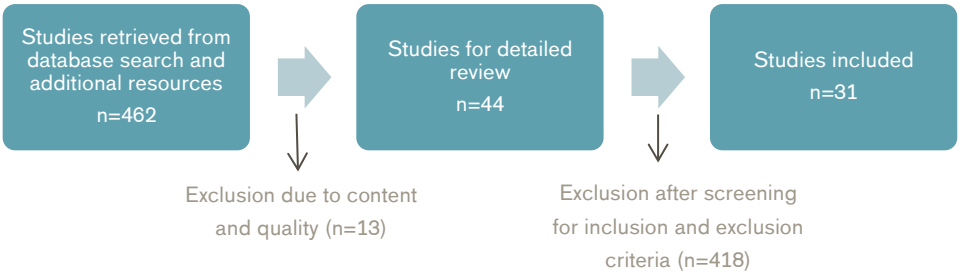


Population

Subjects:	1 - 1,216 adults per study (median: 12 subjects)
Previous prostheses:	not mentioned
Amputation causes:	not mentioned
Mean age:	43.3 yrs
Mean time since amputation:	not mentioned

Study Design

Systematic Review:



Included publications: Systematic Review (1), Single-Subject Trial (2), Controlled Before and After Trial (3), Cross-Sectional Study (11), Qualitative Study (1), Case Series (3), Case Study (4), Expert Opinion (6)

Quality assessment: Internal validity was low in 19 studies, moderate in 5 studies and high in 1 study; external validity was low in 5 studies, moderate in 8 studies and high in 12 studies; overall quality was rated as low in 18 studies, moderate in 11 studies and high in 2 studies.

The included publication spanned the years from 1993 to 2013, with the majority of publication occurring in 2012.

Results

Body Function		Activity			Participation	Others	
Mechanics	**Pain**	**Grip patterns / force**	**Manual dexterity**	**Activities of daily living (ADL)**	**Satisfaction and Quality of life (QoL)**	**Training**	**Technical aspect**

Category	Empirical Evidence Statements	Supporting publications	Level of confidence
Pain	Myoprosthetic use decreases cortical reorganization which leads to reduction of phantom-limb pain.	2	Low
Activities of daily living (ADL)	Depending on functional needs, control scheme familiarity and preference body-powered prostheses or myoelectric prostheses are advantageous. Myoelectric prosthesis are preferred for office related jobs, supervisory work or contact with general public, while body powered prosthesis are mostly used in jobs that required heavy lifting objects, materials handled were dirty, greasy or sharp.	10	Moderate
Satisfaction and Quality of life (QoL)	Compared with myoelectric prostheses, body-powered prostheses are more durable, require less adjustment, are easier to clean and function with less sensitivity to fit.	3	Low
	Body-powered prostheses provide more sensory feedback than myoelectric prostheses.	3	Low
	Cosmesis is improved with myoelectric prostheses compared to body-powered prostheses.	4	Low
	Proportion of rejections is same with myoelectric (mean 23%) and body-powered (mean 26%) pros-	3	Insufficient

Category	Empirical Evidence Statements	Supporting publications	Level of confidence
	theses.		
Training	Compared with myoelectric prostheses, body-powered prostheses require shorter training time.	3	Low
	Intuitive prosthetic control may require use of multiple control strategies. It should require less visual attention and ability to make coordinated motions of both joints. These should be evaluated for each prosthesis user.	8	Moderate
	Prosthetic rehabilitation plan addressing EMG site selection, controls and task training could improve function and long-term success of myoelectric prosthesis users.	2	Low
Technical aspects	Improvements in body-powered prosthetic operation should be made within harness and cabling systems.	3	Low
	Roll-on sleeve improves suspension and increases range of motion.	1	Low

* no difference (0), positive trend (+), negative trend (–), significant (++/––), not applicable (n.a.)

Author's Conclusion

"This report is a systematic review of publications related to upper-limb prostheses with the goal of identifying evidence comparing currently available MYO and BP prosthetic devices. Eleven EESs were generated addressing the areas of interest: control, function, feedback, cosmesis, and rejection. Conflicting evidence has been found in terms of the relative functional performance of BP and MYO prostheses. Several specific domains have been established that show advantages of each type of prosthesis. Activity-specific passive and BP prostheses can provide significant advantages to prostheses users and are typically lower cost than alternatives. BP prostheses have been shown to have advantages in durability; training time; and frequency of adjustment, maintenance, and feedback. Some evidence demonstrated BP prosthetic control can be improved by optimizing harness and cabling systems. MYO prostheses have been shown to provide a cosmetic advantage, are more accepted for light-intensity work, and may positively affect phantom limb pain when used actively. MYO prostheses can be improved with more advanced control methods; however, there is little evidence of these methods transitioning into larger controlled studies and further into clinical practice.

Outside of surveys, there is little evidence addressing the functional capabilities of prostheses users and fewer studies making a direct comparison of prostheses in a controlled setting. A few standardized tests to directly evaluate prostheses function were found in multiple studies. Currently, evidence is insufficient to conclude that either the current generation of a MYO or a BP prosthesis provides a significant general advantage. Selection of a prosthesis should be made based on a patient's individual needs with regard to domains where differences have been identified. A patient's personal preferences, prosthetic experience, and functional needs are all important factors to consider. This work demonstrates that there is a lack of empirical evidence regarding functional differences in upper-limb prostheses." (Carey et al. 2015)."

Reference

Razak A, Osman A, Kamyab M, Abas W, Gholizadeh H
Department of Biomedical Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur

Satisfaction and Problems Experienced with Wrist Movements

American Journal of Physical Medicine & Rehabilitation 2014;93:437Y444

Products

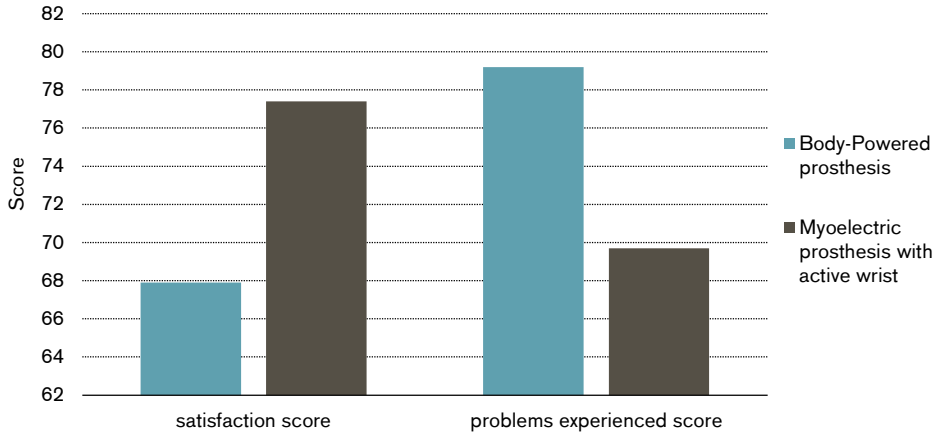
Myoelectric prosthesis with active wrist vs Body-powered prosthesis

Major Findings

With myoelectric prosthesis with active wrist compared to body-powered prosthesis:

→ Users were satisfied with the active wrist
→ The overall satisfaction score was 12% higher for the myoelectric prosthesis with active wrist than for body-powered prosthesis system.
→ The overall scores for problems experienced with the myoelectric prosthesis with active wrist were 13% lower than for body-powered prosthesis system.

Satisfaction and problems experienced scores with myolecetric prosthesis with active wrist and body powered prosthesis



Population

Subjects:	15 persons with transradial amputation
Previous:	body-powered prostheses
Amputation causes:	trauma
Mean age:	45.38 ± 11.25
Mean time since amputation:	n.a.

Study Design

Retrospective study

Participants were already fitted with myoelectric prosthesis with active wrist and the subjects were asked to recall their experiences with body-powered prosthesis.

Results

Body Function		Activity			Participation	Others	
Mechanics	Pain	Grip patterns / force	Manual dexterity	Activities of daily living (ADL)	Satisfaction and Quality of life (QoL)	Training	Technical aspect

Category	Outcomes	Results for myoelectric prosthesis with active wrist vs body-powered prosthesis	Sig.*
Satisfaction	Questionnaire (self-designed)	The overall satisfaction score was 12% higher for the myoelectric prosthesis with active wrist than for body-powered prosthesis system.	+
		The level of the subjects' satisfaction was higher for the myoelectric prosthesis with active wrist in terms of: - **pronation and supination,** - **flexion and extension** - **in ability to open a door**.	**++**
		Abilities to pick up, place and hold the cup were lower with myoelectric prosthesis with active wrist.	**--**
		No differences were observed in terms of sweating, wounds, irritation, socket, smell, sound, and durability.	0
		Fewer difficulties were observed with the myoelectric socket system in terms of pain.	+
		The overall scores for problems experienced with the myoelectric prosthesis with active wrist were 13% lower than for body-powered prosthesis system.	+

* no difference (0), positive trend (+), negative trend (–), significant (++/––), not applicable (n.a.)

Author's Conclusion

"Overall, this study revealed that most of the participants with transradial amputation were more satisfied with the biomechatronics wrist prosthesis than the common body-powered prosthesis. Some users prefer the body-powered prosthesis depending on the task they are doing. Further study should focus on comparing both prostheses while doing other daily life activities such as fishing, driving, and many more. The study of kinematics approach also needs to be considered for all parts of the upper limb while doing the task." (Razak et al. 2014)

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Reference

Østlie K, Lesjø IM, Franklin RJ, Garfelt B, Skjeldal OH, Magnus P

Innlandet Hospital Trust, Department of Physical Medicine and Rehabilitation, Ottestad

Prosthesis use in adult acquired major upper-limb amputees: patterns of wear, prosthetic skills and the actual use of prostheses in activities of daily life

Disability and Rehabilitation: Assistive Technology 2012;7(6):479-93

Products

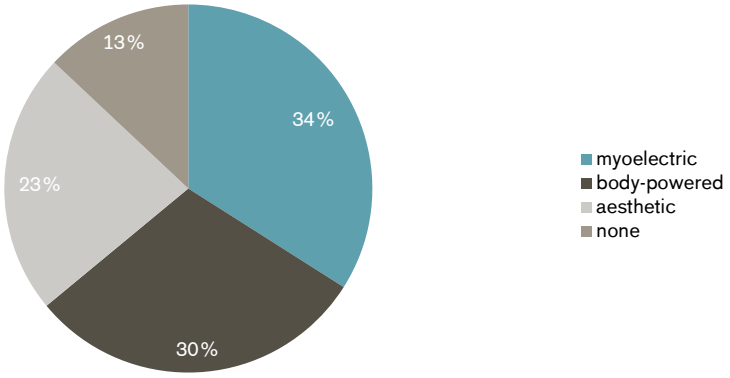
Myoelectric vs Body-powered vs Cosmetic prostheses

Major Claims

Prosthetic use in adult amputees:

→ 80.8% amputees wear prostheses
→ 90.3% consider their most worn prosthesis to be useful
→ Most prevalent prosthesis among adult amputees is myoelectric
→ Prostheses are used in only ½ activities of daily living
→ Increased actual use was associated with sufficient prosthetic training

The most worn prosthesis



Population

Subjects:	181 upper limb amputees (71% forearm/wrist, 29% elbow/upper arm)
Previous:	average of 2,5 prosthesis per a patient, mostly combination of myoelectric and body-powered
Amputation causes:	not listed
Mean age:	54.7 years
Mean time since amputation:	28.6 years

Study Design

Cross-sectional study

The purpose of this study was to describe prosthesis wear and perceived prosthetic usefulness as well to describe prosthetic skills and actual use of prosthesis in activities of daily life (ADL).

Results

Body Function		Activity			Participation	Others	
Mechanics	Pain	Grip patterns / force	Manual dexterity	Activities of daily living (ADL)	Satisfaction and Quality of life (QoL)	Training	Technical aspect

Category	Outcomes	Results for Myoelectric vs Body-powered vs Cosmetic prostheses	Sig.*
Activities of daily living	Clinical testing and interviews (n=50 patients)	Myoelectric prosthesis is used more than other prosthesis in ADL.	+
		With myoelectric prosthesis it is easier to perform bimanual tasks	+
		Bilateral amputees tend to use their prosthesis more than unilateral amputees (in ⅔ of ADL).	+
		Higher scores for “housework”, “shopping” and “desk procedures” with myoelectric prostheses.	+
		Lower scores for myoelectric prostheses for “cooking and washing”, “eating”, “communication”.	-
		Compensatory movements in myoelectric prosthetic users involved shoulder, shoulder girdle or torso.	n.a.
Satisfaction	Questionnaire (self-designed) (n=181 patients)	Average prosthesis wearing time is 4h per day.	n.a.
		82% amputees are satisfied with their prosthesis.	n.a
		Cosmetic prostheses were most useful for improving appearance.	-
		Myoelectric and body powered prostheses were more useful for ADL than cosmetics prostheses.	+
		44% amputees needed adjustment of the prosthesis less than once a year; 22% more than 4 times a year	n.a.
		65% amputees received a prosthetic training (only 44% of them rated a training as important for their prosthetic use)	n.a.

* no difference (0), positive trend (+), negative trend (–), significant (++/––), not applicable (n.a.)

Author’s Conclusion

“Prosthesis wear was found in 80.8% with each prosthesis wearing upper limb amputees (ULA) possessing an average of 2.5 prostheses at survey. The majority wore their most worn prosthesis for >8 hours a day. Our findings suggest that major ULAs choose to wear the prosthetic type(s) that best meet their functional needs and that these preferences are extremely individualised. In the process of fitting an ULA with a new prosthesis, type-specific usefulness profiles as those provided in our study may give a valuable contribution to an informed decision. The prosthesis-wearing amputees in our sample were mainly satisfied with their prostheses, reported their prostheses as useful and showed good prosthetic skills in ADL tasks – but

did not use their prostheses for more than about half of the ADL tasks carried out in everyday life. Our findings suggest that in unilateral ULAs, individualised and targeted prosthetic training may increase optimal, active prosthesis use in ADL and that the effect of sufficient prosthetic training on the Actual Use Index (AUI) may be mediated by a decrease in one-handed task performance. Individualised prosthetic training should probably be mandatory at every prosthetic fitting and extra prosthetic training should probably be offered when the functional needs of the amputee change. Furthermore, our findings suggest that fitting the amputee with myoelectric rather than passive prostheses may increase prosthesis use in ADL, regardless of amputation level. Prosthetic skills did not affect every day prosthesis use in our material." (Østlie et al. 2012)

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Reference

Egermann M, Kasten P, Thomsen M

Stiftung Orthopädische Universitätsklinik Heidelberg

Myoelectric hand prostheses in very young children

International Orthopaedics 2009; 33:1101–1105

Products

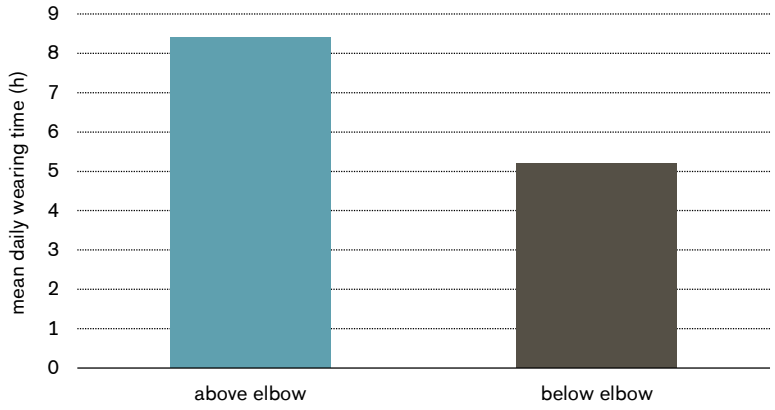
Myoelectric prosthesis with "Elektrohand 2000" vs previous prostheses

Major Findings

With Myoelectric prosthesis with "Elektrohand 2000" compared to previous prostheses (cosmetic, body-powered, myoelectric):

→ All children learned to open myoelectric prosthetic hand
→ 76% of studied children successfully used myoelectric prosthesis
→ Children amputated above elbow wore prosthesis more than 8h per day, while children with amputation below elbow wore prosthesis more than 5h per day
→ Prosthetic training accelerates successful use of the prosthesis
→ Developmental reediness to use myoelectric prosthesis starts with as early as 2 years of age

Mean daily wearing time of myoelecric prosthesis



Population

Subjects:	41 children (35 below elbow and 6 above elbow amputees)
Previous:	24 cosmetic, 10 body-powered, 7 myoelectric
Amputation causes:	36 congenital deformities, 5 traumas
Mean age:	3.9 ± 1.1 years
Mean time since amputation:	3.9 ± 1.1 years

Study Design

Retrospective study

This study retrospectively evaluated the fitting of myoelectric prostheses in 41 preschool children with unilateral upper limb amputation.

Results

Body Function		Activity			Participation	Others	
Mechanics	Pain	Grip patterns / force	Manual dexterity	Activities of daily living (ADL)	Satisfaction and Quality of life (QoL)	Training	Technical aspect

Category	Outcomes	Results for Myoelectric prosthesis with "Elektrohand 2000" vs previous prostheses	Sig.*
Activity of daily life	Questionnaire (self-designed)	**Children amputated above shoulder wore prostheses more than 8h per day on average, while kids with amputation below elbow wore prostheses more than average 5h per day.**	++
		Children that wore a body-powered active device prior to myoelectric prosthesis show a tendency towards higher wearing time compared to children with a passive device only.	+
		The myoelectric prosthesis was preferentially used for playing and in kindergarten.	+
Satisfaction	Questionnaire (self-designed)	Myoelectric prosthesis brought more functional benefit to the user.	+
		Users are more satisfied with appearance of myoelectric prosthesis.	+
Technical aspects	Questionnaire (self-designed)	Myoelectric prostheses were more sustainable for breakdown than body powered prostheses.	-
		Myoelectric prostheses were heavy.	-
		Life span of battery in myoelectric prosthesis was too short	-

* no difference (0), positive trend (+), negative trend (–), significant (++/––), not applicable (n.a.)

Author's Conclusion

"The prosthesis was used for an average time of 5.8 hours per day. The level of amputation was found to influence the acceptance rate. Furthermore, prosthetic use training by an occupational therapist is related to successful use of the prosthesis. The general drop-out rate in preschool children is very low compared to adults. Therefore, infants can profit from myoelectric hand prostheses. Since a correct indication and an intense training program significantly influence the acceptance rate, introduction of myoelectric prostheses to preschool children should take place at specialised centres with an interdisciplinary team." (Egermann et al. 2009)

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Reference

Crandall R, Tomhave W

Shriners Hospitals for Children/Twin Cities, Minneapolis

Pediatric unilateral below elbow amputees: Retrospective analysis of 34 patients given multiple prosthetic options

Journal of Pediatric Orthopaedics 2002, 22:380-383.

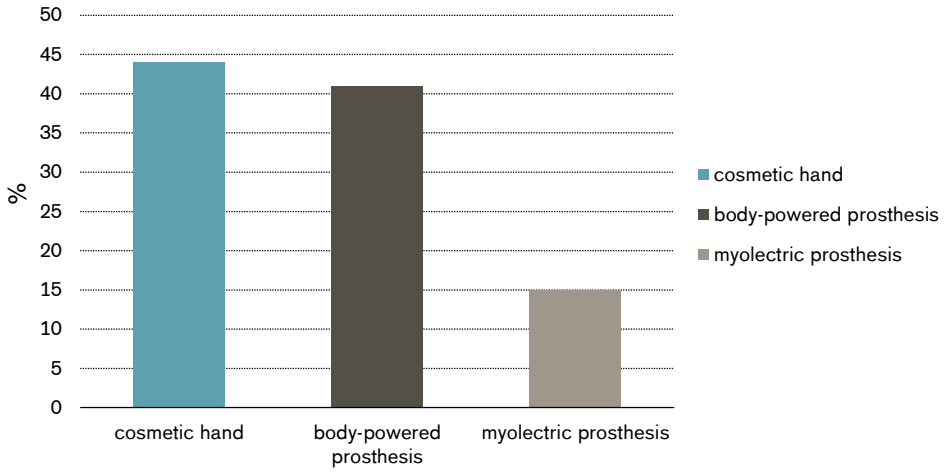
Products

Myoelectric vs body-powered vs cosmetic prostheses

Major Findings

- → **Average use of the prostheses in children is 9.72h per day.**
- → **44% children selected a simple cosmetic hand as their prosthesis of choice.**
- → **41% children selected the body-powered prosthesis as the prosthesis of choice.**
- → **15% children selected a myoelectric hand as their prosthesis of choice**
- → **41% children were multiple users.**

Children's preference of the prosthesis



Population

Subjects:	34 unilateral pediatric amputees
Amputation causes:	33 congenital deficiencies, 1 trauma
Mean age:	the average age with first visit was 2.8 years (range 1 month to 12.5 years); at the follow up was 15.7 years (6-21 years)
Mean time since amputation:	at the enrolment range 1 month to 12.5 years, after the follow up 6-21 years

Study Design

Retrospective 15.7 years follow up

Children were enrolled at the average age of 2.8 years and followed up for 15.7 years on average. The follow-up questionnaires were sent to all patients to retrospectively evaluate use of different prostheses.

Results

Body Function		Activity			Participation	Others	
Mechanics	Pain	Grip patterns / force	Manual dexterity	Activities of daily living (ADL)	Satisfaction and Quality of life (QoL)	Training	Technical aspect

Category	Outcomes	Results for myoelectric vs body-powered vs cosmetic prostheses	Sig.*
Activities of daily living	Questionnaire (self-designed)	Body-powered prostheses generated the most functional responses in all ADLs tested. Most notable among these were tying the shoelaces, hammering a nail, operating machinery, car maintenance, steering a bicycle, hitting a ball with a bat and putting a glove into the sound hand.	-
		Myoelectric prosthesis generated more functional response than the cosmetic hand	+
		59% decided to use only one prosthesis while 41% were multiple users	n.a.
		In the group who used one prosthesis 50% used cosmetic hand, 35% used body powered and 15% myoelectric prostheses.	-
		In the group of multiple users, preferable combination was body powered prosthesis with cosmetic hand used occasionally.	-
Satisfaction	Questionnaire (self-designed)	90% of participants indicated that they were currently using their prostheses	0
		The overall, average use of the prostheses was 9.72h per day.	0
		54% of participants considered themselves year-round full-time users.	0

* no difference (0), positive trend (+), negative trend (–), significant (++/––), not applicable (n.a.)

Author's Conclusion

"The authors conclude that successful unilateral pediatric amputees may choose multiple prostheses on the basis of function and that frequently the most functional device selected is the simplest in design. The authors strongly believe that unilateral pediatric amputees should be the offered a variety of prosthetic options to help with normal activities of daily living." (Crandall et al. 2002)

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Reference

Kooijmana C, Dijkstra P, Geertzena J, Elzingad A, van der Schans C

Department of Rehabilitation, University Hospital Groningen, The Netherlands

Phantom pain and phantom sensations in upper limb amputees: an epidemiological study

Pain 87 (2000) 33-41.Published by Elsevier Science.

Products

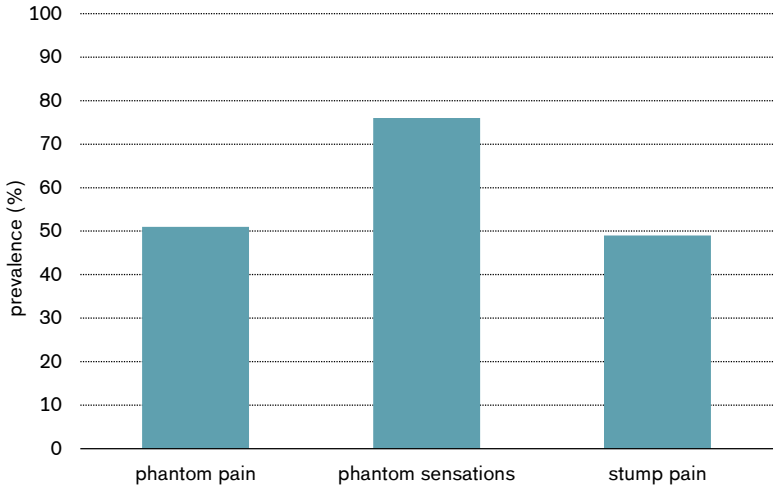
Myoelectric, body-powered, cosmetic prostheses

Major Findings

With phantom pain and phantom sensations in upper limb amputees:

- → **The prevalence of phantom pain was 51%, phantom sensations 76% and stump pain 49% in the subjects with acquired amputation.**
- → **Phantom pain was not reported in congenital group.**
- → **Phantom pain did not affect prosthetic usage or functional ability.**
- → **Phantom sensations and stump pain could lead to phantom pain.**

Prevalence in the group with acquired amputation



Population

Subjects:	99 upper limb amputees
Prosthesis:	myoelectric, body-powered, cosmetic prostheses
Amputation causes:	56 accident, 27 congenital malformations, 11 cancer, 2 vascular disease, 2 infection,
Median age:	congenital group – 30.5 years; acquired group - 44.2 years
Median time since amputation:	19.1 years

Study Design

Retrospective study

This study retrospectively evaluated the pre-amputation pain and frequencies of phantom sensations, phantom pain, and stump pain post-amputation. Additionally, the study reviewed the types of medical treatments received for phantom pain and/or stump pain as well as self-medication and prosthetic use. The median follow-up time was 19.1 years.

Results

Body Function		Activity			Participation	Others	
Mechanics	Pain	Grip patterns / force	Manual dexterity	Activities of daily living (ADL)	Satisfaction and Quality of life (QoL)	Training	Technical aspect

Category	Outcomes	Results for stump pain, phantom pain and sensation.	Sig.*
Pain	Questionnaire (self-designed)	Phantom pain was not reported in congenital group.	n.a.
		The prevalence of phantom pain in acquired group of amputees was 51%, of phantom sensations 76% and of stump pain 49%.	n.a.
		Pain before amputation was experienced by 14% of subjects that acquired amputation during their life.	n.a.
		Medical treatment was given to 4 subjects (transcutaneous electrical nerve stimulation, medication injections), two responded.	n.a.
		Medical treatment for stump pain was given to 5 subjects of which four subjects underwent an operation and one subject received massage. In three subjects the operation was effective.	n.a.
		In 20 subjects a spot was present which upon touching provoked phantom pain and stump pain.	n.a.
		The arm prosthesis was used for more than 8 h per day by 72% of amputees.	n.a.
		Phantom sensations associated with phantom pain: • Itching 25% • Movement 38% • Abnormal shape 9% • Abnormal position 22% • Something touching 7% • Warmth 11% • Cold 40% • Electric sensations 42%	n.a.
		The relative risk of experiencing phantom pain when having stump pain is about twice as high compared with those not experiencing stump pain.	n.a.
		Phantom pain was present in 97% of subjects experiencing phantom sensations.	n.a.

* no difference (0), positive trend (+), negative trend (–), significant (++/––), not applicable (n.a.)

Author's Conclusion

"In conclusion, phantom pain after upper limb amputation is a common problem. The determinants are still poorly understood." (Kooijmana et al. 2000)

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Reference

Millstein S, Heger H, Hunter G

Amputee Clinics, Ontario Workers´ Compensation Board, Ontario, Canada

Prosthetic use in adult upper limb amputees: a comparison of the body powered and electrically powered prostheses

Prosthetics and Orthotics International, 1986, 10, 27-34

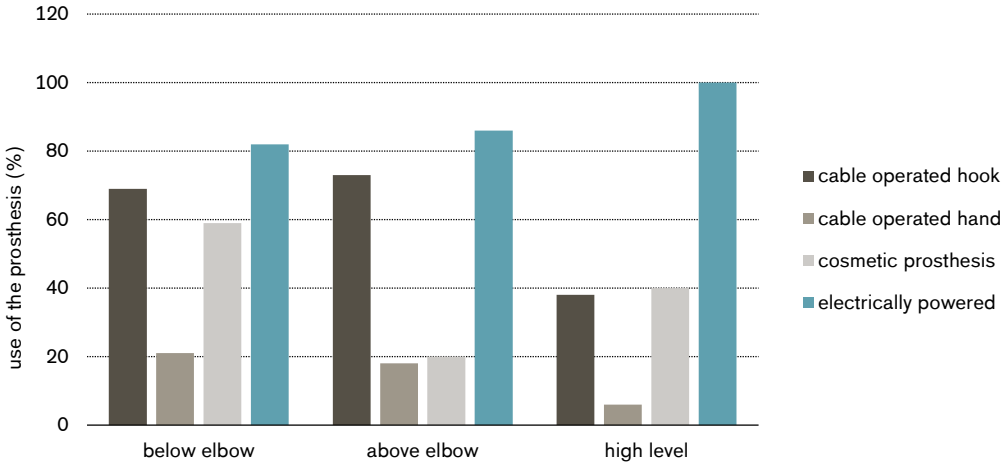
Products

Electrically vs body powered prostheses

Major Findings

- **→ The most preferred prosthesis was electrically powered prosthesis.**
- **→ The cable operated hook was the second most favoured prosthesis.**
- **→ 82% of below-elbow patients fitted with electrically powered prosthesis reported using it.**
- **→ 69% of below-elbow patients fitted with body powered prosthesis reported using it.**
- **→ The majority of amputees used more than one prosthesis for their functional needs suggesting that it is necessary to fit amputees with more than one type of prosthesis.**

Acceptance of body-powered and ellectrically powered prostheses



Amputees reported that electrically powered prosthesis is the most preferred one, followed by the cable operated hook, cosmetic and cable operated hand. Acceptance rate for electrically powered prosthesis was 82% at below elbow, 86% at above elbow and 100% at high level amputation.

Population

Subjects:	314 upper limb amputees
Prosthesis type:	cable operated hook, cable operated hand, cosmetic prosthesis, electrically powered
Amputation causes:	work related accident
Mean age:	49 years
Mean time since amputation:	15 years.

Study Design

Retrospective study:

The period between amputation and follow-up ranged from 1 to 49 years with a mean of 15 years. Evaluation after the follow-up period included the questionnaire and the review of patients´ records.

Results

Body Function		Activity			Participation	Others	
Mechanics	Pain	Grip patterns / force	Manual dexterity	Activities of daily living (ADL)	Satisfaction and Quality of life (QoL)	Training	Technical aspect

Category	Outcomes	Results for electrically vs body powered prostheses	Sig.*
Activities of daily living	Questionnaire (self-designed)	The electrically powered prosthesis was used 8h each day through the week. The cable operated hook was used for an average 8h each work day and 7h on weekend day. The cable operated hand was used for an average 5h each day and cosmetic hand was worn on average 4h per week day.	+
		Work use: Amputees who used electrically powered prosthesis primarily had jobs that involved office work, supervisory work or contact with general public. Amputees who used cable operated prostheses had jobs that required lifting heavy objects and handling objects that were dirty, greasy or sharp.	+ -
		Sports use: Both electrically and body powered prostheses were used for variety of sports.	0
		Social use: Electrically powered prosthesis was more acceptable in the social sphere than the cable operated hook.	+
		Home use: Electrically powered prosthesis was used most often for eating, holding objects and occasionally driving a car.	+
Satisfaction	Questionnaire (self-designed)	Complete or useful acceptance of an upper prosthesis was reported in 89% of below-elbow amputees, 76% of above-elbow amputees and 60% of high level amputees.	n.a
		Amputees reported that electrically powered prosthesis is the most preferred one, followed by the cable operated hook.	+
		Acceptance rate for cable operated hook was 69% for below elbow, 73% for above elbow and 38% for high level amputation. Acceptance rate for cable operated hand was 21% for below elbow, 18% for above elbow and 6% for high level amputation. Acceptance rate for cosmetic prosthesis was 59% for below elbow, 20% for above elbow and 40% for high level amputation. Acceptance rate for electrically powered was 82% for below elbow, 86% for above elbow and 100% for high level amputation.	+

Category	Outcomes	Results for electrically vs body powered prostheses	Sig.*

* no difference (0), positive trend (+), negative trend (–), significant (++/––), not applicable (n.a.)

Author's Conclusion

"The findings of the review of 314 upper limb amputees confirm that complete or useful acceptance of and upper limb prosthesis was reported in 89% of below-elbow, 76% of above-elbow and 60% of high level amputees. Prostheses are well used and essential to the amputees' personal and employment activities. Most upper limb amputees should be fitted with both a body powered and electrically powered prosthesis to meet their various functional requirements. The benefits of these prostheses far outweigh their costs. The cable operated hook s well accepted and used by the majority of amputees for heavy work and precision tasks at work and at home. It provides good sight of grasped objects is not easily damaged and is easy to clean. The cable operated hand and cosmetic prosthesis are used by a small number of amputees primarily for cosmesis at social occasions. In spite of the high initial cost and continued maintenance and repair, improvement in comfort, cosmesis and comfort and function have led to good levels of acceptance of the electrically powered prosthesis. For high level amputees, it provides better function, superior pinch force and requires less energy expenditure than the body powered prosthesis." (Millstein et al. 1986)

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Reference

Stain R, Walley M

Departments of Physiology and Occupational Therapy, University of Alberta, Edmonton, Canada

Functional Comparison of Upper Extremity Amputees Using Myoelectric and Conventional Prosthesis

Archives of Physical Medicine and Rehabilitation Vol 64, June 1983.

Products

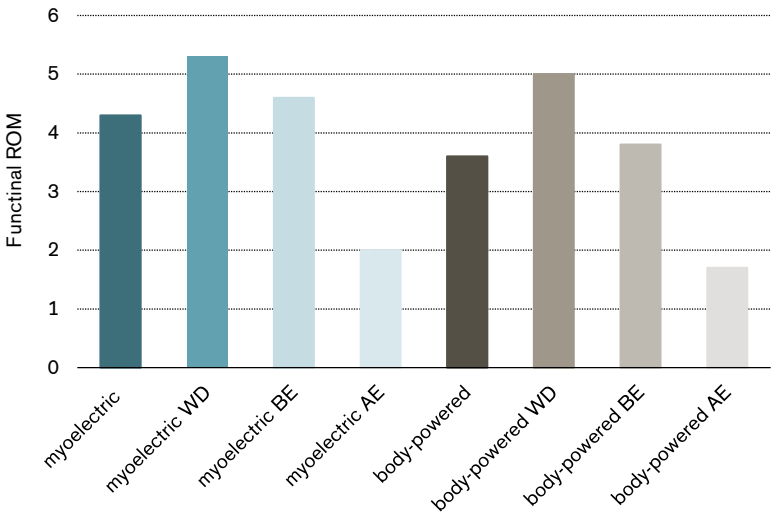
Myoelectric (Ottobock 6V) vs body-powered prosthesis

Major Findings

With myoelectric compared to body-powered prosthesis:

→ Myoelectric prosthesis provides to the user higher range of motion.
→ Task execution was faster with body-powered prosthesis, but with more compensatory movements.
→ 60% of amputees preferred myoelectric prosthesis.

Functional Range of Motion (RoM) for patients tested with myoelectric and body-powered prosthesis



The myoelectric amputees scored higher on average in test of functional range of motion (RoM) than body-powered amputees (4.3 compared to 3.6, dark blue and grey bars). A score of 4 means that the amputee could open his terminal device (hook or myoelectric hand) in 4 of the 5 positions tested (above shoulder level, at the mouth, behind the neck, far in front of the body, behind the back). Amputees fitted with body-powered prosthesis were unable to open the hook behind the back and the neck, because the cable became slack in these positions. (WD – wrist disarticulation, BE – below elbow, AE – above elbow)

Population

Subjects:	34 upper limb amputees
Products:	16 body-powered prostheses; 20 myoelectric prostheses (Ottobock 6V)
Amputation causes:	60% traumatic causes, 40% congenital malformation
Mean age:	body-powered group: 40 ± 17 years myoelectric group: 27 ± 14 years
Mean time since amputation:	body-powered group: 12.2 ± 12.9 years myoelectric group: 1.4 ± 1.5 years

Study Design

Observational study

Amputees were tested on standardised series of tasks using their myoelectric hand, conventional prosthesis and their normal hand. Questionnaires were also administered.

Results

Body Function		Activity			Participation	Others	
Mechanics	**Pain**	**Grip patterns / force**	**Manual dexterity**	**Activities of daily living (ADL)**	**Satisfaction and Quality of life (QoL)**	**Training**	**Technical aspect**

Category	Outcomes	Results for myoelectric vs body-powered prosthesis	Sig.*
Manual dexterity	Functional Range of Motion (RoM): • above shoulder level, • at the mouth, • behind the neck, • far in front of the body, behind the back	**The myoelectric amputees scored higher on average in test of functional range of motion (RoM) than body-powered amputees (4.3 compared to 3.6).**	++
		Amputees fitted with body-powered prosthesis were unable to open the hook behind the back and the neck, because the cable became slack in these positions.	+
	Tasks: • Pick up small objects • Simulated feeding • Stacking checkers • Picking up pegs • Picking up and rotating heavy objects • Strength of cylindrical grasp • Box and Block test • Endurance	Amputees performing tasks with myoelectric prosthesis took about twice as long as those with a conventional prosthesis, and nearly 5 times as long as when performing tasks with their normal arm.	-
		Although amputees were able to accomplish the task faster with the body-powered than with myoelectric prosthesis, they had to use extreme body movements such as rotating their trunk to rotate heavy objects, because of harnessing.	+
Activities of daily living	Questionnaire	The average scores on the ADL questionnaire were not different for myoelectric and conventional prosthesis users.	0
		Body-powered prosthesis was worn for a longer period of time (14h per day on average) than myoelectric prosthesis (9.6h per day on average).	--
		60% preferred to use myoelectric prosthesis compared to body-powered, which they had been fitted previously.	+

* no difference (0), positive trend (+), negative trend (–), significant (++/––), not applicable (n.a.)

Author's Conclusion

"Amputees who had been fitted only with a conventional prosthesis and used their prosthesis regularly, tended to wear the prosthesis more hours per day (14 hours) than amputees fitted with a myoelectric hand (9.6 hours), some of whom continued to use a conventional prosthesis for some jobs. However, the amputees with myoelectric prostheses had a greater functional range of motion (RoM) than those with a conventional prosthesis and many regular wearers of myoelectric prosthesis had long since rejected a conventional prosthesis. Amputees took about 2.5 times as

long to complete the tasks tested with a conventional prosthesis and about five times as long with myoelectric prosthesis than with their normal hand. Despite the slower function, more than 60% of below-elbow amputees accepted the myoelectric prosthesis, which they had all been fitted with previously. Others preferred to continue using a conventional prosthesis to which they become accustomed (13%) or no prosthesis (26%). The combination of function, RoM, and cosmetic appearance of myoelectric prosthesis is preferred by most below-elbow amputees, despite its slower performance at present time." (Stain et al. 1983)

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Reference

Northmore-Ball M, Heger H, Hunter G

Addenbrooke´s hospital, Hills Road, Cambridge, England

The below-elbow myoelectric prosthesis

The Journal of Bone and Join Surgery, VOL. 62-B No.3, 1980

Products

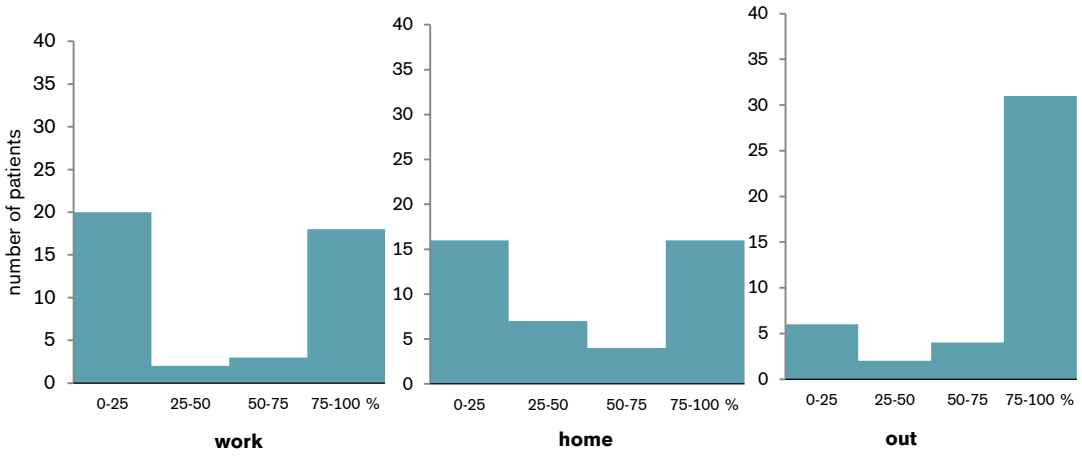
Myoelectric prosthesis, body-powered prosthesis

Major Findings

With myoelectric prosthesis:

- → **Nearly 50% of the patient used myoelectric prosthesis all the time at work**
- → **The myoelectric users that mostly benefited from prosthesis had office jobs**
- → **No patient had completely rejected the myoelectric prosthesis**

Use of myoelectric prosthesis



Histogram shows use of myoelectric prosthesis at work, home and during social time. Myoelectric prosthesis was worn almost all time at work by 42%, at home by 38% and when going out by 72% of patients.

Population

Subjects:	one bilateral, 42 unilateral transradial amputees
Previous prosthesis:	body-powered
Amputation causes:	n.a.
Mean age:	36 years
Mean time since amputation:	n.a.

Study Design

Retrospective study:

The study aimed to get reliable information about actual use of standard, prosthesis that the patients were fitted with myoelectric prosthesis. Each patient all possessed both a myoelectric prosthesis and a standard artificial limb.

Results

Body Function		Activity			Participation	Others	
Mechanics	Pain	Grip patterns / force	Manual dexterity	Activities of daily living (ADL)	Satisfaction and Quality of life (QoL)	Training	Technical aspect

Category	Outcomes	Results for myoelectric prosthesis	Sig.*
Activities of daily living	Questionnaire (self-designed)	Myoelectric prosthesis was worn almost all time at work by 42%, all time at home by 38% and all time when going out by 72% of patients.	+
		Patients who used the myoelectric hand predominantly at work tended to have office jobs (quality control inspector, chemist, student, computer programmer…).	+
		Type of jobs, where patients used myoelectric prosthesis less than 25% of their working time, were industrial jobs (machine operator, metal worker, factory worker…).	-
Satisfaction	Questionnaire (self-designed)	Common reason for not using myoelectric prosthesis at work (65%) was fear of damaging either the prosthesis itself or its glove.	-
		Myoelectric prosthesis had a functional use at work, but in the public its value tended to be more cosmetic and passive.	+
		Patients felt that myoelectric prosthesis gives them more sensory feedback than body-powered prosthesis.	+
		Patients felt that myoelectric prosthesis was more like a part of them than a body-powered prosthesis.	+

* no difference (0), positive trend (+), negative trend (–), significant (++/––), not applicable (n.a.)

Author's Conclusion

"The place of myoelectric prosthesis in below-elbow amputees has been reviewed, Forty-three patients were seen and all possessed both a myoelectric prosthesis and a standard artificial limb. Nearly half the patients used the never device almost all the time at work and many of these wore it for the majority of their working hours. Its use at work was mainly related to the patient's type of job and here in turn there was concern about damaging the device. It is suggested that acceptance would be further increased if greater attention were paid to the durability of the arm and its glove." (Northmore-Ball et al., 1980)

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