Upper extremity prosthesis for children

Clinical Study Summaries

This document summarizes clinical studies conducted with upper extremity prosthesis for children. 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.

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Upper limb extremity prostheses for children – 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 dealing with a specific topic can be found in the document(s) above the overview table (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).

The studies presented in the table below are summarized here (Level 2):

When to fit a child with a prosthesis?
From which age is fitting with an active (myoelectric) device useful?
Why to fit a child with a (myoelectric) prosthesis?
Compliance - Do children use the prostheses?
Does a prosthesis influence development of any physical/ psychological complications later in life?
Training for children with myoelectric prosthesis – when and how?
Psychosocial adjustment and health related quality of life in children with upper limb congenital deficiency

Reference		Category								Prosthesis
		Body Functions		Activity			Participation	Others		
Author	Year	Mechanics	Pain	Grip patterns Force	Manual dexterity	ADL	Satisfaction QoL	Training	Technical aspects	
Michielsen	**2010**					x	x			Passive and active prostheses
Huizing	**2010**				x	x	x			Myoelectric, body-powered, cosmetic
Egermann	**2009**					x	x		x	Elektrohand 2000 vs previous prosthesis or no prostheses
Meurs	**2006**					x	x			Passive and active prostheses
Hermansson	**2005**						x			Children with myoelectric prosthesis vs. healthy controls
Crandall	**2002**					x	x			Myoelectric, body-powered, cosmetic
Total number: 6		**0**	**0**	**0**	**1**	**5**	**6**	**0**	**1**	

2 Summaries of categories

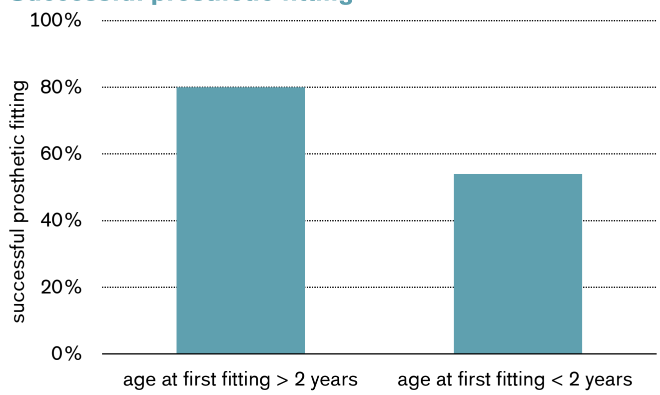
On the following pages you find summaries of specific questions researched in several studies. At the end of each summary you will find a list of reference studies contributing to the content of the particular summary.

When to fit a child with a prosthesis?

Major Claims

→ **The recommended age for first prosthesis fitting ranges from 2 months to 25 months, most recommendations are for the age of 6 months.**
→ **Majority of clinics fit a passive terminal device as the first prosthesis.**
→ **First fitting before the age of 2 seems to be related to higher acceptance rates.**
→ **The first fitting before 1 year of age might be related to longer use of the prosthesis.**

Successful prosthetic fitting



80%of children before the age of 2 and 54% of children over the age of 2 years were fitted successfully (*Meurs et al., 2006*).

Clinical Relevance

In children, upper limb deficiency is mainly caused by congenital malformations. The annual prevalence of limb reduction deficiencies is estimated at 5–6.7/10 000 births and as many as 80% of these children may have upper-limb reduction deficiencies (69%upper limb only, 11% both upper and lower limb) (*Hermansson et al., 2005*). The central question concerning juvenile upper-limb amputees refers to the best time to fit a prosthesis to a child with an upper-limb deficiency.

Summary

Children with upper limb deformities can be provided with a passive prosthesis or an active device (body-powered/myoelectric prosthesis). The recommended age for first fitting ranges from two months to 25 months (*Shaperman et al., 2003*; *Meurs et al., 2006; Huizing et al., 2010*). Usually, a child is first fitted with a passive prosthesis when it is able to sit in a stable position, approximately at the age of 6 months. A passive device supports a child to use both hands and eases a transition to an active prosthesis. Studies show a trend of lower rejection rates later in life in children who were provided with their first prosthesis at less than two years of age. Furthermore, functional outcomes seem to be more favourable in those children fitted before two years of age (*Meurs et al., 2006; Huizing et al., 2010; Toda et al., 2015*). Additionally, results demonstrated that fitting before one year of age might be related to relatively longer use of the prosthesis (*Huizing et al., 2010)*.

References

Hermansson L, Eliasson AC, Engström I. Psychosocial adjustment in Swedish children with upper-limb reduction deficiency and a myoelectric prosthetic hand. Acta Paediatr. 2005 Apr;94(4):479-88. PubMed PMID: 16092464.

Huizing K, Reinders-Messelink H, Maathuis C, Hadders-Algra M, van der Sluis CK. Age at first prosthetic fitting and later functional outcome in children and young adults with unilateral congenital below-elbow deficiency: a cross-sectional study. Prosthet Orthot Int. 2010 Jun;34(2):166-74. doi: 10.3109/03093640903584993. PubMed PMID: 20298129.

Meurs M, Maathuis CG, Lucas C, Hadders-Algra M, van der Sluis CK. Prescription of the first prosthesis and later use in children with congenital unilateral upper limb deficiency: A systematic review. Prosthet Orthot Int. 2006 Aug;30(2):165-73. Review. PubMed PMID: 16990227.

Shaperman J, Landsberger SE, Setoguchi, Y.Early Upper Limb Prosthesis Fitting: When and What Do We Fit? American Academy of Orthotists & Prosthetists, JPO, 2003 Vol. 15, Num. 1, pp. 11-17

Toda M, Chin T, Shibata Y, Mizobe F. Use of Powered Prosthesis for Children with Upper Limb Deficiency at Hyogo Rehabilitation Center. PLoS One. 2015 Jun 30;10(6):e0131746. doi: 10.1371/journal.pone.0131746. PubMed PMID: 26125974; PubMed Central PMCID: PMC4488333.

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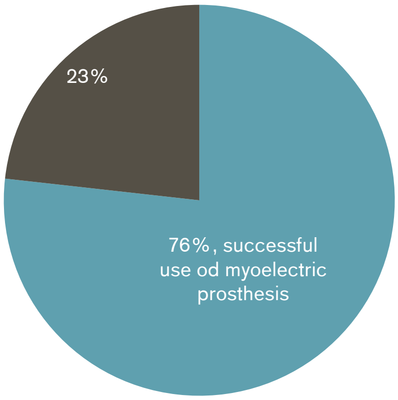
From which age is fitting with an active (myoelectric) device useful?

Major Claims

→ **The recommended age for changing to a more advanced terminal device ranges from 12 to 60 months, the most recommended age is 18 months, depending on developmental readiness.**
→ **Developmental readiness to use a myoelectric prosthesis is between 24 and 36 months of age.**
→ **All studied children (from 2 to 6 years old) learned to open a myoelectric prosthetic hand.**
→ **76% of studied children (from 2 to 6 years old) successfully used myoelectric prostheses.**

Myolectric prosthesis use



During the mean study observation period of 2.0 ± 1.3 years, 76% of the children successfully used their prosthesis. The successfully use was define as capability to open and close the prosthesis, grasp an object, and use the prosthesis in activities of daily living (hygiene, eating, playing inside, outside, in kindergarten, riding a bi-, tricycle). The time of first fitting ranged from 2 to 6 years of age (*Egermann et al., 2009*).

Clinical Relevance

Upper limb deficient children can be provided with three types of prostheses: passive device, body-powered and myoelectric prostheses (active devices). When and with what device to fit to a child has always been a substantial point of discussion.

Summary

Usually, a child is first fitted with a passive prosthesis when he/she is able to sit in a stable position. The next step is the transition from a passive to an active (body-powered or myoelectric) device. The mostly recommended age for changing to a more advanced terminal device and activation of the control system is 18 months, with a range from 12 to 60 months (*Shaperman et al., 2003*). Developmental signs used to determine readiness for a more advanced terminal device/control system than the one first fitted are:

- cognitive readiness (e.g. awareness of cause and effect);
- predictors of use of the prehensile function of the terminal device (e.g. attempts to hold objects, to open the terminal device manually, and to insert objects);
- predictors of ability to participate in a training program (e.g. willingness to follow directions).

It is sometimes seen as practical to add the new terminal device and control system at the time the child has outgrown the first prosthesis, even if the preferred age and other developmental indicators are absent (*Shaperman et al., 2003*).

Multidisciplinary team approach, adequate rehabilitation, training, detailed follow-up and involvement of the parents are seen as important factors when introducing an active prosthesis to a child (*Hermansson et al., 2011; Toda et al., 2015*).

It also needs to be mentioned that many experts believe that children should be fitted as soon as possible with myoelectric prostheses or as early as at 24 to 36 months of age (*Egermann et al., 2009, Hermansson et al., 2011*). Fittings at 24 months of age with myoelectric prostheses resulted in earlier ability to reach the first level of control, but children fitted at the average age of 36 months show faster progression, resulting in catching-up at 42 months of age. This catch-up was partly explained by the child´s capability to follow the training process between 32-41 months of age (*Hermansson et al., 2011*). These results were confirmed by another study (*Egermann et al., 2009).* 76% of all children fitted with myoelectric prosthesis (age range from 2 to 6 years) successfully used their prostheses during the study mean observation period of 2 years and the success was associated with appropriate prosthetic training. Children learned how to open a myoelectric prosthesis at the age of two and showed a higher daily wearing time when compared to the children who were fitted with a myoelectric prosthesis at the age of four or older (*Egermann et al., 2009)*. Therefore, infants can profit from myoelectric hand prostheses, with the developmental readiness to use a myoelectric prosthesis as well as to follow training starts at 3 years of age (*Hermansson et al., 2011*).

References

Egermann M, Kasten P, Thomsen M. Myoelectric hand prostheses in very young children. Int Orthop. 2009 Aug; 33(4):1101-5. doi: 10.1007/s00264-008-0615-y. PubMed PMID: 18636257; PubMed Central PMCID: PMC2898999.

Hermansson L, Sjöberg L. Long term results of early myoelectric fittings. "MEC 11 Raising the Standard," Proceedings of the 2011 MyoElectric Controls/Powered Prosthetics Symposium Fredericton, New Brunswick, Canada: August 14-19, 2011. Copyright University of New Brunswick.

Shaperman J, Landsberger SE, Setoguchi, Y.Early Upper Limb Prosthesis Fitting: When and What Do We Fit? American Academy of Orthotists & Prosthetists, JPO, 2003 Vol. 15, Num. 1, pp. 11-17

Toda M, Chin T, Shibata Y, Mizobe F. Use of Powered Prosthesis for Children with Upper Limb Deficiency at Hyogo Rehabilitation Center. PLoS One. 2015 Jun 30;10(6):e0131746. doi: 10.1371/journal.pone.0131746. PubMed PMID: 26125974; PubMed Central PMCID: PMC4488333.

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Why to fit a child with a (myoelectric) prosthesis?

Major Claims

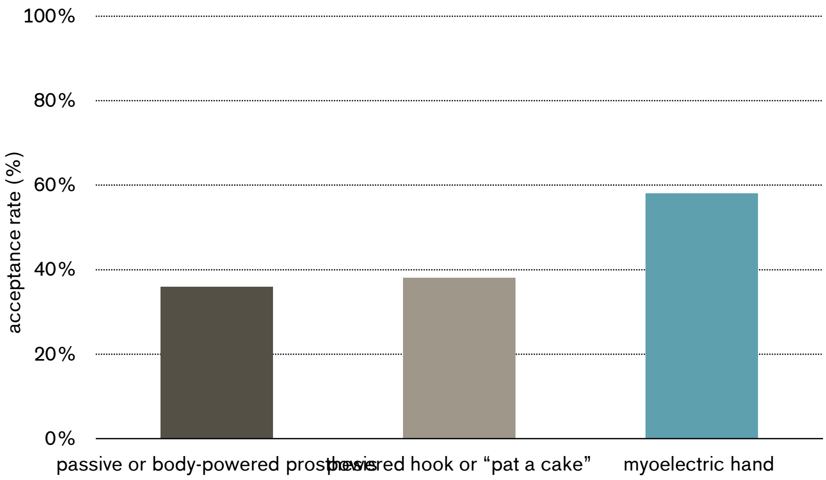
→ Prosthetic fitting in children may support:
- **development of bimanual skills,**
- **prosthetic acceptance and integration into the body image,**
- **natural body symmetry and posture, and**
- **social acceptance.**

→ Supplying children with an active prosthetic hand limits the development of overuse injuries.

→ Supplying children with a myoelectric prosthetic hand may have a beneficial impact on the children's psychosocial health.

→ In comparison to passive and body powered prostheses myoelectric prostheses can deliver more benefits to children:
- **Users were more satisfied with the appearance of myoelectric prostheses.**
- **Acceptance increased by 20% when the myoelectric hand was introduced.**
- **The general acceptance rate (76%) of myoelectric prostheses in preschool children is similar to the acceptance rate of myoelectric prostheses in adults.**

Acceptance rate in children



36% of children accepted a passive or body-powered prosthesis, while 38% accepted a powered hook or "pat a cake". Acceptance increased considerably (58% acceptance rate) when the myoelectric hand from Ottobock was introduced. (*Nichols et al., 1968*).

Clinical Relevance

Prosthetic fitting in children may support (*Tervo et al., 1983; Uellendahl et al., 2000; Kuyper et al., 2001; James et al., 2006*):

- development of bimanual skills,
- execution of useful prehensile activities,
- integration of the prosthesis into the body image,
- acceptance of the prosthesis and longer wearing time in life,
- natural muscle development and body symmetry
- prevention of an asymmetrical posture and consequent problems
- social acceptance.

Summary

Supplying children with prosthetic hands with a cosmetic appearance and a functional grip, as in a myoelectric prosthetic hand, combined with subsequent training and support in using the prosthesis, may have a beneficial impact on the children's physical (*Sato et al 1999*) and psychosocial health (*Hermansson 2005*). The presence of an active prosthesis may limit the development of overuse injuries when compared to the use of a passive prosthesis or no prosthesis at all (*Sato et al 1999*). Second, when fitted with a myoelectric prosthetic hand children showed social competence and behavioural/emotional problems similar to healthy children, while non-users showed significantly more delinquent behavioural problems than full-time users (*Hermansson et al., 2005*).

In comparison to passive and body powered prostheses, myoelectric prostheses can deliver more functional benefit and satisfaction to children (*Egermann et al., 2009*). When the myoelectric hand was introduced prosthetic acceptance in children increased by 20% (*Nichols et al, 1968*). Based on the search of the literature of the past 25 years the general acceptance rate of myoelectric prostheses in preschool children is 76%, similar to the acceptance rate of myoelectric prostheses in adults (77%) (*Bidiss et al., 2007)*. Children who wore an active prosthesis were more than twice as likely to wear it longer period of time (≥ than three years) than children who wore a passive prosthesis (*Shida-Tokeshi 2005*). Additionally, children who were fitted with a myoelectric prosthesis at the age of two showed a higher daily wearing time when compared to the children who were fitted at the age of four or older (*Egermann et al., 2009*).

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Bidiss E, Beaton D, Chau T: Consumer design priorities for upper limb prosthetics. Disabil Rehabil 2007, 2(6): 346-357

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Kuyper MA, Breedijk M, Mulders AH, Post MW, Prevo AJ. Prosthetic management of children in The Netherlands with upper limb deficiencies. Prosthet Orthot Int 2001;25:228–234.

Nichols PJR, Rogers EE, Clark MS, Stamp WG. The Acceptance and Rejection of Prostheses by Children With Multiple Congenital Limb Deformities. O&P Library, Artificial Limbs, 1968, Vol 12, Num 1, pp. 1 - 13

Sato Y, Kaji M, Tsuru T, Oizumi K. Carpal tunnel syndrome involving unaffected limbs of stroke patients. Stroke 1999;30: 414–418.

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Compliance - Do children use prostheses?

Major Claims

→ Prosthetic acceptance can be increased:

- **when the first prosthesis is fitted before the age of 2 years**
- **when an active prosthesis is fitted (more than twice as high as with a passive prosthesis)**
- **when a myoelectric hand is fitted (increase by more than 20% compared to active prostheses)**

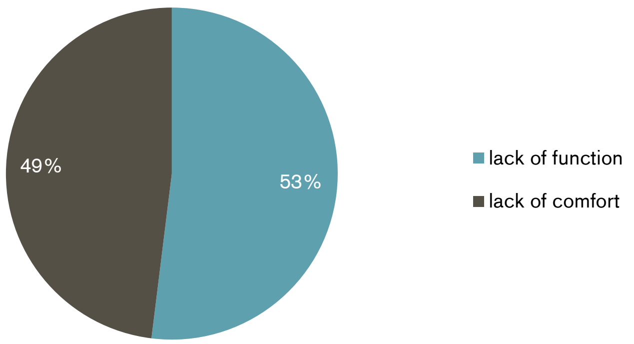
→ Factors that drive prosthesis acceptance in children are:

- **cosmetic appearance,**
- **prosthetic support in conducting specific tasks,**
- **natural body posture and symmetry,**
- **adequate training**
- **positive parental influence.**

→ Factors that can lead to prosthetics rejection in children are:

- **identity challenges,**
- **low level of deficiency,**
- **lack of sensory feedback,**
- **prosthetic speed, weight, and discomfort,**
- **negative parental influence.**

The principal reasons for rejection of a prosthesis



The principal reasons for rejection of a prosthesis were lack of function (53% of 135 non-users) including some cases in which the device impaired function, and lack of comfort (49% of non-users)(*Wagner at al., 2007*).

Clinical Relevance

A child will wear a prosthesis only if it is useful. If the prosthesis is not functional, the prosthesis will be discarded (*Routhier et al. 2001*). Children with congenital deficiencies have no sense of limb-loss and develop compensatory skills for bimanual tasks. Because children develop compensatory skills and since 90% of all activities of daily living can be performed with only one hand (*Beasley at al., 1986,*) the primary focus for fitting a prosthesis should not be the need for function for daily activities, but rather a tool to assist with the execution of specific tasks (*Wagner at al., 2007*).

Summary

The factors that drive prosthesis acceptance differ from those that are leading to the prosthesis rejection.

Possible reasons why children choose to wear a prosthesis are (*Vasluian et al., 2012; Egermann et al., 2009; Scotland et al., 1983*):

1. Cosmetic appearance - prostheses were chosen and worn primarily to provide cosmesis, especially in contact with the public. The cosmetic appearance was especially important during transitional periods such as puberty.
2. Functionality reasons - functionality was important to children and adolescents in the process of choosing and wearing prostheses, mostly in conducting specific activities and sports.
3. Physical reasons - some prosthesis wearers considered wearing a prosthesis as something beneficial for muscle development, locomotion, posture, and balance.
4. Prosthetic training - appropriate prosthetic training and support in using the prosthesis increase prosthetic acceptance.
5. Positive parental influence - parents play an important role in the process of children's´ acceptance and wearing of prostheses. Some parents had based their choice on the information about and instructions on the benefits of early fitting, other parents had followed their personal beliefs or they wanted to overcome the emotional stress of having a child with an upper-limb impairment.

In the USA, many children (41%) use multiple prosthetic devices in their daily activities (*Crandal et al., 2002*). Of those children who used only one prosthesis, 44% selected a simple passive hand as their prosthesis of choice, 41% a body-powered prosthesis and 15% a myoelectric hand. Another study reported that in England (*Nichols et al., 1968*) 36% of children accepted a passive or body-powered prosthesis, while 38% accepted a powered hook or "pat a cake". Acceptance increased considerably (58%) when the myoelectric hand was introduced. Based on the evaluation of the literature of the past 25 years, the general acceptance rate of myoelectric prostheses in preschool children was 76%, similar to the acceptance rate of myoelectric prosthesis in adults (77%) (*Bidiss et al., 2007)*.

First fitting before 2 years of age seems to be related to higher acceptance rates (*Huizing et al., 2010*). 50% of children fitted at an age older than two years abandoned their prostheses compared to only 22% of children who had been fitted before the age of two years (*Scotland et al., 1983*). For the final type of prosthesis, children who wore an active prosthesis were more than twice as likely to wear it longer in life than children who wore a passive prosthesis (*Shida-Tokeshi 2005*).

Possible reasons why children choose NOT to wear a prosthesis are (*Vasluian et al., 2012; Egermann et al., 2009*):

1. Identity challenges - paediatric non-wearers aimed for acceptance and respect from the environment without having to wear a prosthesis. Some adolescents experienced self-confidence and self-identity without a prosthesis.
2. Level of deficiency - children with higher levels of upper limb deficiency tend to wear their prosthesis longer. Children amputated above the elbow wore myoelectric prostheses more than 8h per day on average, while kids with amputation below the elbow wore prostheses only for an average of 5h per day
3. Speed of conducting activities - children and adolescents felt faster or more dexterous without prostheses.
4. Technical and interface reasons - prosthetic weight, discomfort caused by the interface contact with the residual limb like irritations, sweating, bad odor, and difficulties fixing the residual limb in the socket, as well as the limited number of movements and grip functions are some of the reasons for prosthetic rejection.
5. Lack of sensory feedback and pain - non-wearers were disturbed by the lack of sensory feedback from the residual limb, along with arm and shoulder fatigue, and pain from using prostheses.
6. Negative parental influence - some parents wanted to see their children´s functionality without a prosthesis or found a prosthesis to be not useful.

34% of tested children with trans-radial congenital limb deficiency between the ages of 2-20 years (n=498) rejected their prosthesis (*Wagner at al., 2007).* The principal reasons for rejection of a prosthesis were lack of function (53% of 135 non-users) including some cases in which the device impaired function, and lack of comfort (49% of non-users). Wearers and non-wearers regarded the prosthesis as a "useful assistive device" for activities like managing school tasks, cutting, grasping, holding, and lifting. Especially activities such as lifting heavy objects, playing sports like volleyball or hockey, or doing some jobs such as delivering newspapers were not performed without a prosthesis by several early adolescents. Activity-specific use was noticed in early and late adolescents for activities such as cycling and driving more safely, or for leisure purposes such as playing sports like volleyball, hockey, and football. At other times, participants managed to function perfectly without prostheses. Wearers, on the other hand, specified that they did not use their prostheses for activities like eating, playing, tying shoelaces, manual work at school, or working with a computer, because they were more dexterous or had better grip without them (*Wagner at al., 2007, Vasluian et al., 2012*).

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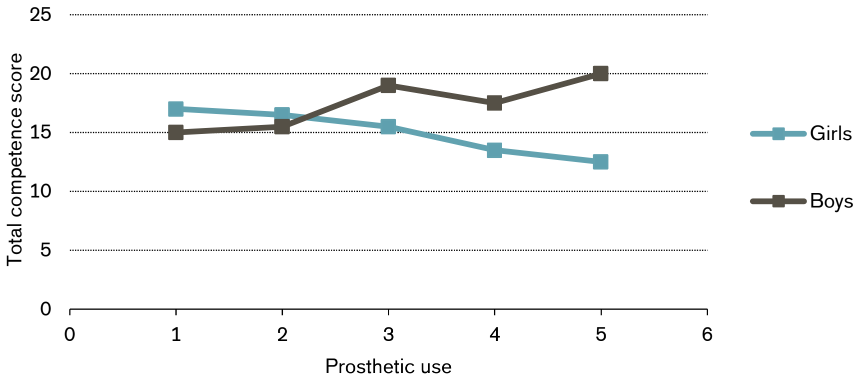
Does a prosthesis influence development of any physical/ psychological complications later in life?

Major Claims

→ **An active prosthesis may limit the development of overuse injuries when compared to a passive prosthesis or no prosthesis at all.**
→ **Supplying children with a myoelectric prosthetic hand may have a beneficial impact on the children's psychosocial health.**
→ **Children with a myoelectric prosthesis showed social competence and behavioural/emotional problems similar to standardized norms.**
→ **Children who used myoelectric prostheses full time had less delinquent behavioural problems compared to non-users.**
→ **With increasing prosthetic use girls displayed less psychological problems.**

Relation between total competence score and myolectric prosthesis use in boys and girls



The total competence score identifies behavioural and emotional problems and social competence in children and adolescents with limb deficiencies. Prosthesis use is represented on a scale 1–5, where 1 indicates full-time user, and 5 non-user. With decreasing prosthesis use the competence score was decreased in girls, and increased in boys. (*Hermansson et al., 2005*)

Clinical Relevance

Upper limb amputees are confronted with psychological and physical adjustments to the missing limb. When it comes to physical adjustment, they are at risk of overuse syndrome at some point in life (*Gambrell, 2008*). Although this is recognized by most prosthetists, there is currently no empirical research available to repotst the prevalence of overuse injuries in upper limb amputees, nor is there any research that addresses how to recognize and treat overuse symptoms before they become serious injuries in this patient population. An overuse injury can be defined as microtraumatic damage to a bone, muscle, or tendon that has been subjected to repetitive stress without sufficient time to heal or undergo the natural reparative process (*Verdon, 1996*). Overuse injuries can be classified into four stages:

1) pain in the affected area after physical activity,
2) pain during activity, without restricting performance,
3) pain during the activity that restricts performance, and
4) chronic, unremitting pain even at rest.

The risk factors to develop an overuse injury include repetition, high force, awkward joint posture, direct pressure, vibration, and prolonged constrained posture (*Verdon, 1996*).

The chronic strain of living with upper limb deficiency has, in addition to physical adjustment, a potentially negative impact on the psychological adjustment (e.g. on self-esteem, depressive symptoms and low perceived physical appearance) of children born with such congenital malformation (*Varni et al., 1992*). The findings have been discussed in terms of a "new hidden morbidity" in paediatric practice.

Summary

The most effective treatment of overuse injuries is prevention, early detection of symptoms, and consequent lifestyle changes. According to the *Sato et al* (1999), the presence of an active prosthesis may limit the development of overuse injuries when compared with the use of a passive prosthesis or no prosthesis at all. The more impaired the affected limb is, the more likely the unaffected side will suffer from overuse.

When it comes to psychological adjustment to a missing limb, children fitted with a myoelectric prosthetic hand showed social competence and behavioural/emotional problems similar to able-bodied children (*Hermansson et al., 2005*). However, withdrawn behaviour was significantly higher in all children with upper limb deficiency, social competence was significantly lower in girls, and social activities were significantly lower in older children with upper-limb reduction deficiency. Moreover, there was a significant difference associated with prosthesis use. Non-users had significantly more delinquent behavioural problems than full-time users. There was an interaction between gender and prosthesis use in their effect on competence and behavioural/emotional problems, yielding two contrasting patterns. The total competence score decreased with decreasing prosthesis use in girls, and increased with decreasing prosthesis use in boys (*Hermansson 2005*).

Interestingly, in adults with congenital upper limb deficiency the health-related quality of life was significantly reduced, due to impaired physical health and increased bodily pain (*Johansen et al., 2016*). As stated above, this was not observed in children. This may indicate that strain and overuse problems due to the strenuous compensatory techniques first appear in adulthood. Therefore, measures that can reduce pain and the loss of function should be given particular attention. (*Johansen et al., 2016*). This indicates that supplying children with prosthetic hands with a cosmetic appearance and a functional grip, as in a myoelectric prosthetic hand, combined with subsequent training and support in using the prosthesis, may have a beneficial impact on the children's physical and psychosocial health (*Hermansson 2005*).

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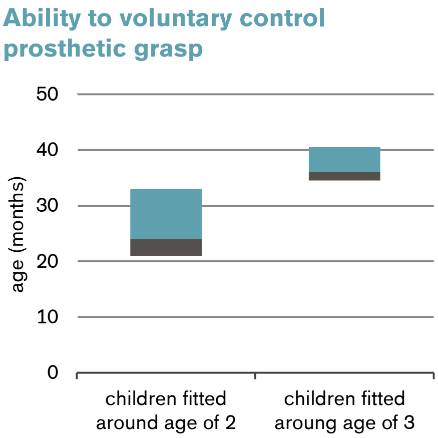
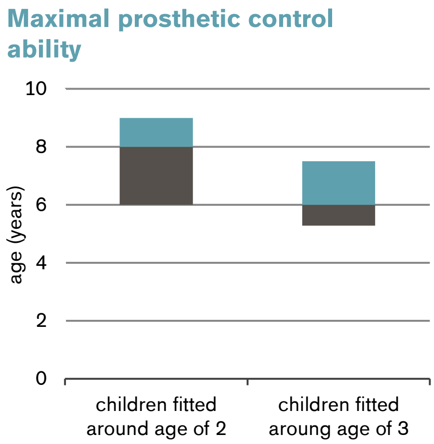
Training for children with myoelectric prostheses - when and how?

Major Claims

→ **Developmental readiness to follow training for myoelectric prostheses starts at age of 3.**
→ **The adequate prosthesis training can increase prosthetic acceptance.**





Children who were fitted with myoelectric hands at 24 months age are capable to voluntary control prosthetic grasp as successfully as children who are fitted at 36 months of age (left graph, *$p<0.05$*). This shows that the child´s readiness to use a myoelectric prosthesis starts as early as 2 years. Nevertheless, both groups of children (fitted at 24 and 36 months of age) reached maximal prosthesis control ability at a similar time, between 6 and 8 years of age (right graph). This means that children who were fitted later were able to catch up with children who were fitted earlier. This supports the assumption that children should be fitted with myoelectric prosthesis at the age of 3, when the children is also capable to follow prosthetic training. (*Hermansson et al., 2011*).

Clinical Relevance

Occupational therapy in children with upper limb deficiency should enable the child to achieve age-appropriate independence and ability to perform desired activities (e.g. bimanual activities of daily living, use of prosthesis as a normal, non-dominant hand). The training goal should be orientated on helping the child to (*Hermansson et al., 2011)*:

1. wear the prostheses in order to establish a wearing habit, and
2. use the prosthetic hand actively in activities of daily living.

Summary

The published training concept is based upon a structured way of describing the accomplishments of a child fitted with a myoelectric prosthesis, called the Skill Index Ranking Scale (SIRS) (*Hermansson et al., 2011)*. By using the SIRS when designing the training session, the therapist can progressively increase the demands presented to the child. The SIRS guideline is divided in two parts:

- items 1-4 can be used for passive use of the myoelectric prosthesis (e.g. wearing a prosthesis, support of an object) or of the passive devices;
- items 5-14 are tasks for training the active use of the prosthesis (e.g. active grasping, control of grip strength).

Training for myoelectric prostheses for children is based on the following principles (*Hermansson et al., 2011; Hermansson 1991*):

1. The parents' support is vital, since they have to support the child through trials and errors.
2. Before the training commences, the therapist should observe the child to determine his/her current capability of prosthesis use.
3. Thereafter, the therapist may choose an activity which should increase the demands and permits the child to improve his/her ability. The activities chosen should be age-appropriate.
4. The training should be fun and encourage prosthesis use.
5. The relationship between the therapist and the child is very important. Parents may be present until the child feels safe and secure with the therapist.
6. Group sessions may be arranged in a group of children with similar prostheses, problems and abilities, so that the children can get support and help to further develop their abilities.
7. Videotape recordings might be used to show the child's ability, and they sometimes get "homework" to practice until the next training session.
8. A very important factor for successful prosthetic fitting is to have a follow-up every 6 months.

Importantly, the adequate prosthetic training can increase prosthesis acceptance (*Egermann et al., 2009)*.

References

Egermann M, Kasten P, Thomsen M. Myoelectric hand prostheses in very young children. Int Orthop. 2009 Aug; 33(4):1101-5. doi: 10.1007/s00264-008-0615-y. PubMed PMID: 18636257; PubMed Central PMCID: PMC2898999.

Hermansson L, Sjöberg L. Long term results of early myoelectric fittings. "MEC 11 Raising the Standard," Proceedings of the 2011 MyoElectric Controls/Powered Prosthetics Symposium Fredericton, New Brunswick, Canada: August 14-19, 2011. Copyright University of New Brunswick.

Hermansson L. Structured training of children fitted with myoelectric prostheses. Prosthet Orthot Int. 1991 Aug;15(2):88-92. PubMed PMID: 1923728.

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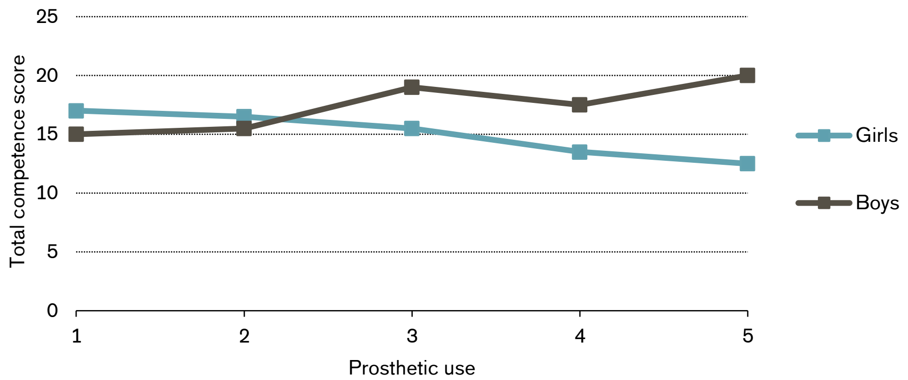
Psychosocial adjustment and health related quality of life in children with upper limb congenital deficiency

Major Claims

- → **Quality of life is similar between children with unilateral upper limb deficiency and the general paediatric population.**
- → **Prosthesis wearers had higher quality of life with respect to school functioning than non-wearers.**
- → **Children who used myoelectric prostheses full time had less delinquent behavioural problems compared to non-users.**
- → **With increasing prosthetic use girls presented less psychological problems.**
- → **Supplying children with myoelectric prosthetic hands may have a beneficial impact on the children's psychosocial health.**

Relation between total competence score and myoelectric prosthetic use in boys and girls



The total competence score identifies behavioural and emotional problems and social competence in children and adolescents with limb deficiencies. Prosthesis use is represented on a scale 1–5, where 1 indicates full-time user, and 5 non-user. With decreasing prosthesis use it was decreased in girls, and increased in boys. (*Hermansson et al., 2005*).

Clinical Relevance

Participation and Quality of Life are considered essential outcomes in describing the health status in paediatric research. Participation is defined as the nature and extent of a person's involvement in life situations. For children and adolescents, involvement in life situations includes participation in recreational and leisure activities as well as school and work activities. Quality of Life can refer to aspects of a person's well-being (physical, psychological, social), as well as aspects of the environment and a person's standard of living (*Michiellsen et al., 2010*).

Summary

Children with limb deficiency other than hand demonstrated greater behavioural and emotional problems and lower social competence than the normative sample. On the other side, no such social, emotional or behavioural problems were reported in children with upper limb deficiency (*Michiellsen et al., 2010*; *Hermansson et al., 2005*). However, withdrawn behaviour was reported to be significantly higher in all children with upper limb deficiency, social competence was significantly lower in girls, and social activities were significantly lower in older children with upper-limb reduction deficiency when compared to the normative data. Additionally, prosthetic use and gender had a significant role. Non-users had shown more delinquent behavioural problems than full-time myoelectric prosthesis users. The prosthesis wearers had lower behaviour/emotional problems with respect to school functioning than non-wearers. The total competence score decreased with decreasing prosthesis use in girls, and increased with decreasing prosthesis use in boys (*Hermansson 2005*).

Interestingly, in adults with congenital upper limb deficiency the health-related quality of life was significantly reduced, due to impaired physical health and increased bodily pain EQ-5D scores (*Johansen et al., 2016*). As stated above, this was not observed in children. This may indicate that strain and overuse problems due to strenuous compensatory techniques first appear in adulthood. Therefore measures that can reduce pain and the loss of function should be given particular attention. (*Johansen et al., 2016*). This indicates that supplying children with prosthetic hands with a cosmetic appearance and a functional grip, as in a myoelectric prosthetic hand, combined with subsequent training and support in using the prosthesis, may have a beneficial impact on the children's physical and psychosocial health (*Hermansson 2005*).

References

Harding L. Children's Quality of Life assessments: A review of generic and health related quality of life measures completed by children and adolescents. Clin Psychol Psychother 2001;8:79–96.

Hermansson L, Eliasson AC, Engström I. Psychosocial adjustment in Swedish children with upper-limb reduction deficiency and a myoelectric prosthetic hand. Acta Paediatr. 2005 Apr;94(4):479-88. PubMed PMID: 16092464.

Johansen H, Østlie K, Andersen LØ, Rand-Hendriksen S. Health-related quality of life in adults with congenital unilateral upper limb deficiency in Norway. A cross-sectional study. Disabil Rehabil. 2016 Nov;38(23):2305-14. doi: 10.3109/09638288.2015.1129450. PubMed PMID: 26778109.

Michielsen A, Van Wijk I, Ketelaar M. Participation and quality of life in children and adolescents with congenital limb deficiencies: A narrative review. Prosthet Orthot Int. 2010 Dec;34(4):351-61. doi: 10.3109/03093646.2010.495371. Review. PubMed PMID: 20704518.

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3 Summaries of individual studies

On the following pages you find summaries of studies that researched Helix 3D hip joint system. 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

Michielsen A., Wijk Van I., Ketelaarc M.

Rudolf Magnus Institute of Neuroscience and Centre of Excellence for Rehabilitation Medicine, University Medical Centre Utrecht and Rehabilitation Centre De Hoogstraat, Utrecht, The Netherlands

Participation and quality of life in children and adolescents with congenital limb deficiencies: A narrative review

Prosthetics and Orthotics International, December 2010; 34(4): 351–361.

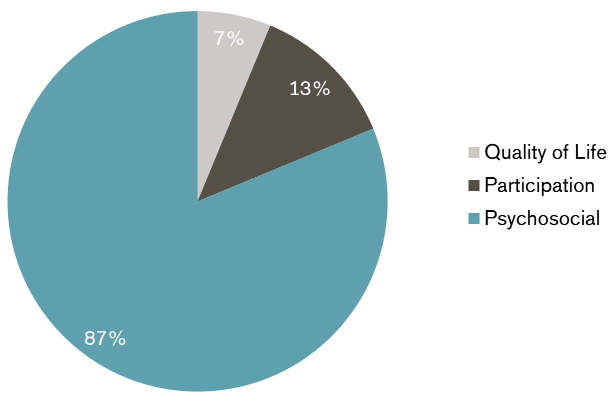
Products

Passive and active prosthesis

Major Findings

- **→ Quality of life was similar between children with unilateral upper limb deficiency and the general population.**
- **→ The prosthesis wearers had higher quality of life with respect to school functioning than non-wearers.**
- **→ Children with limb deficiency demonstrated greater behavioural and emotional problems and lower social competence than the normative sample, but these results were not observed with myoelectric prosthesis.**

Symmary of studies



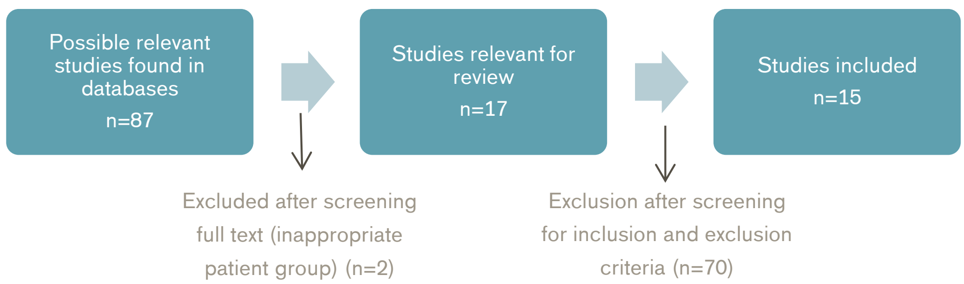
Thirteen studies (87%) focused on psychosocial adaptation in children and adolescents with limb deficiencies. Participation had only been studied in two studies on different aspects like sports and going to school, but not as a concept of overall functioning. Quality of life was addressed in only one study.

Population

Subjects:	21 - 489 children with congenial limb deficiency
Previous prostheses:	n.a.
Amputation aetiology:	congenital malformation
Age (range):	from 8.4 to 14.8 years
Time since amputation(range):	from 8.4 to 14.8 years

Study Design

A narrative review:



Included publications:	Cross-sectional studies (15)
Quality assessment:	The 15 included studies were all classified as cross-sectional descriptive studies with low methodological quality. The included literature spanned the years from 1988 to 2006.

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
Satisfaction and Quality of Life (QoL)	Quality of life was found to be similar between children with unilateral upper limb deficiency and the general population.	1	n.a
	Quality of life was found to be similar when comparing children with unilateral upper limb deficiency wearing a prosthesis with children not wearing a prosthesis, with the exception of school functioning (significant higher quality of life was reported for prosthesis wearers compared with non-wearers).	1	n.a
	Eleven to twenty-year-old children with unilateral upper limb deficiency felt significantly happier than children in the general population, regardless of prosthesis use.	1	n.a
	Children with limb deficiency were not significantly different in how they perceive their physical appearance, social support, and their self-esteem compared with the general population.	13	n.a
	Children with limb deficiency were not more depressed and they do not experience a greater number of hassles than physically healthy peers.	13	n.a
	Children with limb deficiency demonstrated greater behavioural and emotional problems and lower social competence than the normative sample. In the subgroup of children fitted with myoelectric upper limb prosthesis no such symptoms were reported.	1	n.a
Activities of daily living (ADL)	No significant differences were found in children with unilateral congenital upper limb deficiency in the domains “sports/physical function”, “happiness” and “global function” when compared to the general population.	1	n.a
	No significant differences were found in the domains “sports/physical function”, “happiness” and “global function” between unilateral upper limb prosthesis wearers and non-wearers.	1	n.a

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

Author's Conclusion	"This review reveals a lack of knowledge on how children with congenital limb deficiencies participate and how their QoL is perceived. Their psychosocial functioning, although described as at risk, appears to be comparable to healthy peers. Participation and QoL are relatively new concepts in rehabilitation medicine and can be considered as key outcomes. Nowadays different measurement tools are available to measure both concepts. Children and adolescents with congenital LD are a considerable diagnosis group in rehabilitation medicine and therefore further studies are required to describe how they participate and how they perceive their QoL. This is important to guide the development of interventions to promote optimal participation and QoL in this population. Furthermore, identification of factors that influence participation and the relationship with QoL in children and youth with limb deficiencies needs to be explored. (*Michielsen et al. 2006*)."

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Reference

Huizing K, Reinders-Messelink H, Maathuis C, Hadders-Algra M, Van Der Sluis C.

Department of Rehabilitation – Developmental Neurology, University Medical Center Groningen, The Netherlands

Age at first prosthetic fitting and later functional outcome in children and young adults with unilateral congenital below-elbow deficiency: A cross-sectional study

Prosthetics and Orthotics International June 2010; 34(2): 166–174.

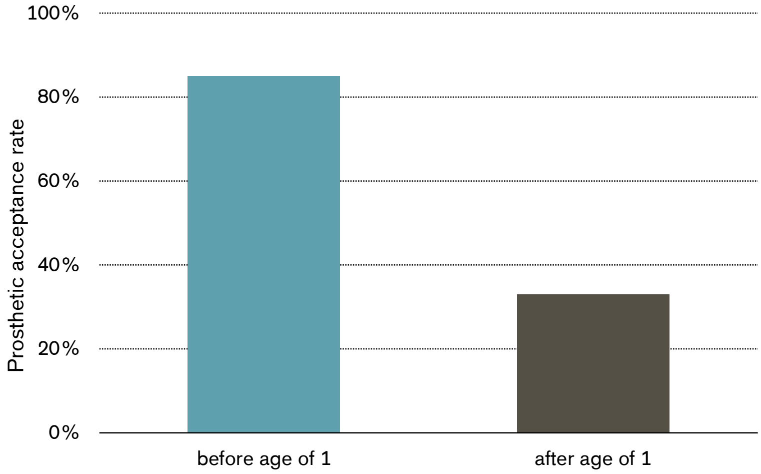
Products

Passive, body-powered and myoelectric prosthesis

Major Findings

- → **Prosthesis fitting before the age of one year was related to a longer period of prosthetic usage.**
- → **Users could use their prostheses in 92% of the activities, either actively or passively.**
- → **The prosthesis was found to be very useful in activities such as: riding a bicycle, using scissors, and playing sports.**
- → **80% of users were fitted with a myoelectric prosthesis.**

Prosthetic acceptance rate



85% of children who received their first prosthesis before the age of one but only 33% children who received their prosthesis after being one year old accepted their prosthesis.

Population

Subjects:	20 children with unilateral congenital below-elbow deficiency (5 prosthesis users and 15 non-users)
Previous prosthesis:	n.a.
Amputation aetiology:	congenital malformation
Median age:	14.2 years (range: 6–21 years)
Median time since first fitting:	6.5 years (range: 1.5–17 years)

Study Design

Observational, cross-sectional study

The objective of this study was to evaluate whether prosthesis fitting before the age of one year is associated with better outcomes in children with unilateral congenital below-elbow deficiency compared to children fitted after the age of one.

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 non-users vs users	Sig.*
Activities of daily living (ADL)	Prosthetic Upper Extremity Functional Index (PUFI)	Non-users performed tasks with more ease compared to users with a prosthesis.	-
		Prosthesis users found their prostheses useful in 39% of daily activities.	n.a.
		The prosthesis was found to be very useful in activities such as: • riding a bicycle, • using scissors, • playing sports.	n.a.
		Users could use their prostheses in 92% of the activities, either actively or passively, while they were actually using their prostheses in only 44% of the activities .	n.a.
Satisfaction	Rejection rate	Prosthetic fitting before the age of one year was related to longer use of the prosthesis (longer than four years).	+
		Of 5 prosthesis users, 4 were fitted with a myoelectric and one with a passive device.	n.a.
	The Child Amputee Prosthetics Project-Prosthesis Satisfactory Inventory (CAPP-PSI)	Satisfaction ratings were relatively high for users and non-users.	0
		Parents of prosthesis users showed higher scores than those of non-users on the item “aids in daily activities” for both the parent-rated child satisfaction and the parent satisfaction subscales.	+
		Parents of users were not satisfied with prosthesis manufacturing and repair times.	n.a.
Manual dexterity	Videotapes	No difference was observed between users and non-users in the quality of motor behaviour.	0
		The evaluation of the quality of motor behaviour revealed that 6 (4 non-users) of the 20 individuals showed impaired adaptation of movements in at least three out of the 10 tasks.	+

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

Author’s Conclusion

“In conclusion, our study suggests that fitting a prosthesis prior to one year of age may have a limited impact on prosthetic use during later stages of life. The limited impact may indicate that the hypothetical disadvantages of prosthesis use in early life, such as interference with sensory exploration using the affected limb, outweigh the hypothetical advantages associated with early fitting, such as an increased repertoire of motor strategies. Both prosthetic users and non-users with a unilateral congenital transverse below-elbow deficiency (UCBED) function very well and use their residual limb actively in bimanual activities. Persons with UCBED use the prosthesis for specific activities rather than for general activities in daily life. Our data suggest that one of the factors that determine whether a person with UCBED will benefit from a prosthesis is superior adaptive motor behavior – a suggestion which deserves exploration in future studies." (*Huizing et al. 2015*)

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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

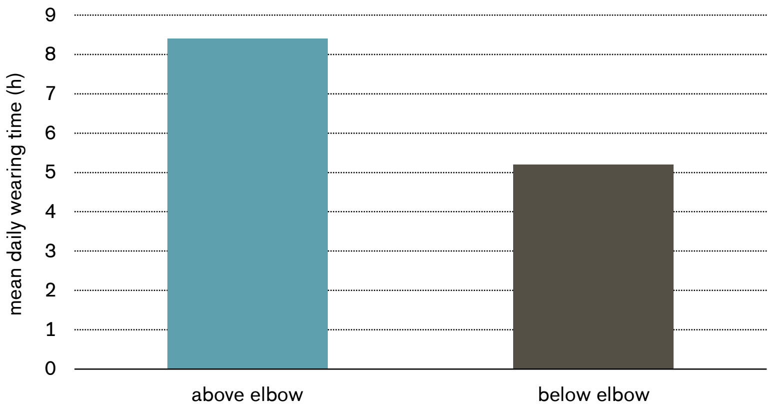
Myoelectric prosthesis with "Elektrohand 2000" vs previous prostheses

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



Children amputated above elbow wore myoelectric prostheses more than 8h per day on average, while children with amputation below elbow wore prostheses more than average 5h per day.

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."

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Reference	Meurs M, Maathuis C.G.B., Lucas C., Hadders-Algra M., Van Der Sluis C.K..

Meurs M, Maathuis C.G.B., Lucas C., Hadders-Algra M., Van Der Sluis C.K..

Paediatric Physical Therapy, Groningen, The Netherlands

Prescription of the first prosthesis and later use in children with congenital unilateral upper limb deficiency: A systematic review

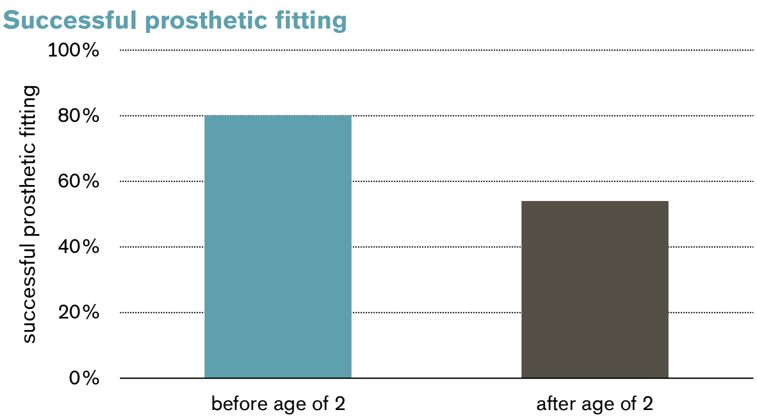
Prosthetics and Orthotics International, August 2006; 30(2): 165 – 173.

Products

Passive and active prostheses for children

Major Findings

When children are fitted with a first prosthesis prior to the age of 2:
→ Lower rejection rates were observed (up to 22 years follow-up)
→ Functional outcomes seem to be more favourable



80%of children younger than 2 years and 54% of children older than 2 years were successfully fitted. The successful fitting was reflected through prosthesis wearing time, operating skill, applied use and acceptance of the prosthesis.

Population

Subjects:	32 - 166 patients with congenial unilateral upper limb deficiency
Previous prostheses:	no fitting vs. passive/ active fitting before age of 2 y
Amputation aetiology:	congenital malformation
Mean age:	not reported
Mean time since amputation:	< 2 years n= 168 > 2 years n= 115

Study Design

Systematic Review:

Included publications:	Retrospective cohort studies (4), follow up ranging from 1 - 22 years

Quality assessment:	All selected studies were retrospective cohort studies with low methodological quality. The included publication spanned the years from 1965 to 1999.

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
Satisfaction	Lower rejection rates were reported in children who were provided with their first prosthesis prior to the age of two years.	4	Low
	80% of children younger than 2 years and 54% of children older than 2 were successfully fitted. The successful fitting was reflected through prosthesis wearing time, operating skill, applied use and acceptance of the prosthesis.	1	Low
Activities of daily living (ADL)	Functional outcomes seem to be more favourable in those children fitted before two years of age.	2	Low
	Active prehension was better in children fitted prior to the age of 2.	1	Low
	Prosthesis adjustment score was improved when children were fitted with the prosthesis before age of 2. Improvement was observed in categories: - Wearing time - Operating skill - Applied use - Acceptance	1	Low

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

Author's Conclusion

"Our results make clear that there is only little evidence available in literature concerning the preferential age the first prosthesis should be prescribed in children with a congenital deficiency of the upper limb. Until now the relation between the age of the first prescription of a prosthesis and rejection rates or functional outcomes in this patient category has not been investigated properly. As such, we may conclude that all currently used guidelines concerning prosthetic prescription procedures are experience-based instead of evidence-based. The high costs associated with the prescription of upper limb prostheses make this statement very interesting and is of societal relevancy. We recommend that a randomized controlled trial should be performed to answer questions regarding at what age prostheses should be prescribed in children with congenital upper limb deficiencies. However, we realize that such a design is not easy to carry out, since only small numbers of patients are available and the follow-up time should be of considerable length. This implies that there is a need for cooperation between national and international centres dealing with paediatric prosthetic management. (*Meurs et al. 2006*)."

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Reference	Hermansson L, Eliasson AC, Engstrom I.

Limb Deficiency and Arm Prosthesis Centre, Department of Paediatrics, Orebro University Hospital, Orebro, Sweden

Psychosocial adjustment in Swedish children with upper-limb reduction deficiency and a myoelectric prosthetic hand

Acta Pædiatrica, 2005; 94: 479–488.

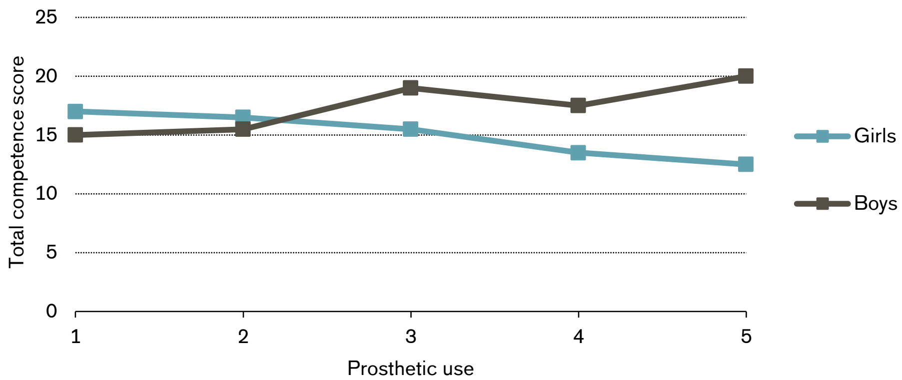
Products

Children with upper limb congenital deficiency fitted with myoelectric prostheses vs. able-bodied children

Major Findings

- **Children with upper-limb deficiency and a myoelectric prosthesis showed social competence and behavioural/emotional problems similar to standardized norms.**
- **Children who used myoelectric prostheses full time had significantly less delinquent behavioural problems compared to non-users.**
- **With decreasing prosthetic use girls displayed more psychosocial problems.**
- **58.1% of the children used their myoelectric prosthesis every day.**

Relation between total competence score and myoelectric prosthetic use in boys and girls



The total competence score identifies behavioural and emotional problems and social competence in children and adolescents with limb deficiencies. Prosthesis use is represented on a scale 1–5, where 1 indicates full-time user, and 5 non-user. With decreasing prosthetic use total competence score was decreased in girls, and increased in boys.

Population

Subjects: 62 children (37 of them adolescents)
Previous prosthesis: n.a.
Amputation ethology: 57 congenital malformation; 5 acquired amputation
Mean age: children: 12.6 years; adolescents: 14.8 years
Median time since first fitting: 6.5 years (range: 1.5–17 years)

Study Design	Observational, cross-sectional study The aim was to study psychosocial adjustment and mental health in children with upper-limb reduction deficiency and a myoelectric prosthetic hand. Sixty-two parents of children answered a questionnaire concerning competence and behavioural/emotional problems in their children. Additionally, 37 adolescents (62 of these children) completed questionnaires concerning competence, problems and mood state. The results were compared with Swedish normative data.

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 children fitted with myoelectric prosthesis vs. able-bodied children	Sig.*
Satisfaction and Psychosocial adjustment	Prosthetic use scale (in the last 6 months)	58.1% of the children used their myoelectric prosthesis every day, 12.9% used it occasionally, 8.1% used it sporadically and 21% no longer.	+
		Boys with partial hand deficiency used prostheses significantly less than boys with trans-radial deficiency.	**--**
	Child behaviour checklist (Social competence)	Social competence was similar between children with upper limb deficiency and normative data.	0
	Child behaviour checklist (Social competence, differences based on gender and age)	**Social competence was significantly lower in girls with upper-limb deficiency.**	**++**
		Social activities were significantly lower in older children with upper-limb deficiency.	**++**
	Child behaviour checklist (Social competence, differences based on prosthetic use and gender)	The total competence score decreased with decreasing prosthesis use in girls.	+
		The total competence score increased with decreasing prosthesis use in boys.	-
		The total problems score increased with decreased prosthesis use in girls.	+
	Child behaviour checklist (Behaviour/ Emotional problems)	Total score for behavioural/ emotional problems were similar between children with upper limb deficiency and normative data.	0
		Withdrawn behaviour was significantly higher in all children with upper-limb deficiency.	**--**
	Youth self-report (differences based on prosthetic use)	**Children who used myoelectric prostheses full time had significantly less delinquent behavioural problems than non-users.**	**++**
	Youth self-report (differences based on gender)	**Girls had a significantly higher:** • **total problem score,** • **withdrawn behaviour problem score,** • **thought problem score**	**--**

Category	Outcomes	Results for children fitted with myoelectric prosthesis vs. able-bodied children	Sig.*
		Boys had significantly lower score for somatic complaints.	++
	Youth self-report (differences based on age)	**Older children (12 to 16 years) showed significantly higher:** • **anxious/depressed behavioural problems,** • **attention behavioural problem scores**.	--
	Children's depression inventory	Depressive symptoms were similar between children with upper limb deficiency and normative data.	0

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

Author's Conclusion

"In conclusion, the main result of this study is that children and adolescents with ULRD fitted with myoelectric prostheses exhibit good mental health as measured both by instruments assessing general behaviour problems and symptoms and by instruments aiming at describing the mood state and depressive symptoms. Girls and older children, however, display more problems than the group as a whole, indicating that they should be monitored and supported more carefully. We believe that a specialized centre for medical support of children with ULRD is necessary in order to help these children adjust to their deficiency." (*Hermansson et al. 2015*)

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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.

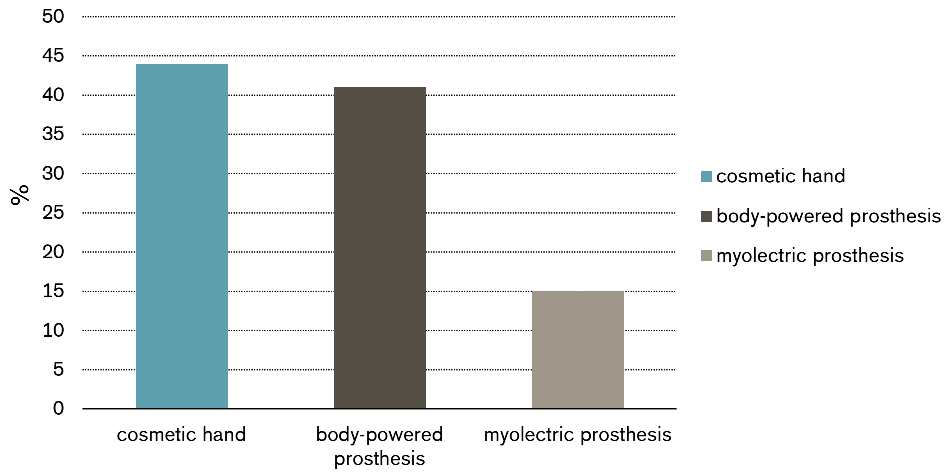
Products

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."

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