BOLD kids

BRAIN ORGANISATION IN LIMB DIFFERENCES

A guide to motor development in children with limb differences

For parents, families, children, and supporters.

UNIVERSITY OF CAMBRIDGE

Durham University

Reach

Where can I find information on my child's motor development?

You have come to the right place!

This booklet summarises work that has been conducted, since 2018, by a team of researchers from Durham University, Cambridge University, and UCL. The focus of this work is on motor skills in children with limb difference.

Working together with families, and with the support of Reach, we have gathered data on how motor development typically occurs in children with an upper limb difference.

In this guide we will share information with you regarding

- Motor milestones
- Everyday motor skills
- Brain development
- Cognitive skills

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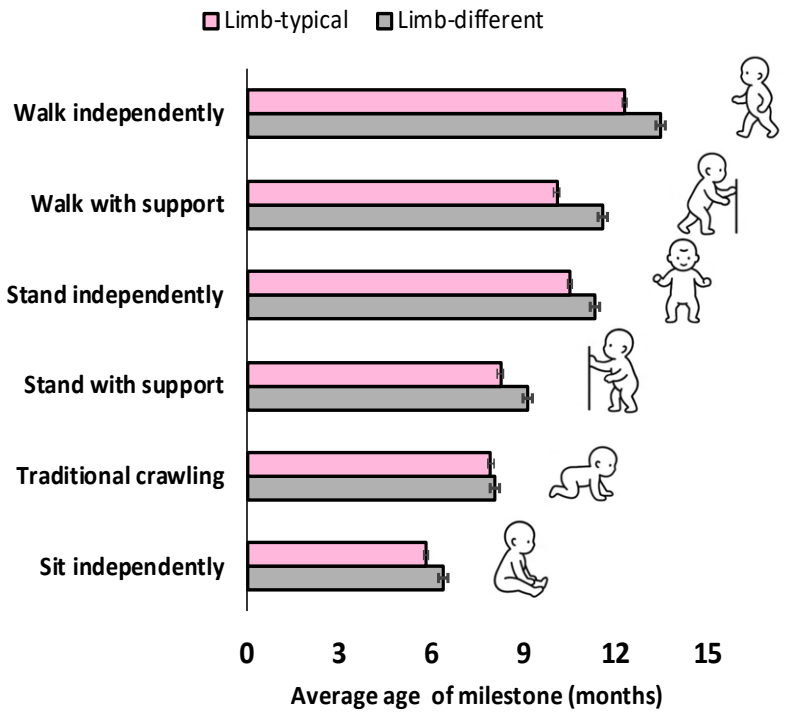
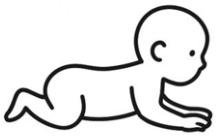
Motor milestones in children with limb differences

Your child's gross motor milestones may come up in conversation with friends, family, or health visitors. Given your child's limb difference, how and when will they learn to crawl and walk?

We surveyed parents who had a child under 8 years old, including 86 children with and 154 children without upper limb difference. This included above and below-elbow differences, but did not include any children with no hands. We asked parents to recall when their child achieved their milestone.

On average, limb-different children were within typical range for World Health Organisation milestones. Relative to our limb-typical sample they showed small delays (graph below). The largest delay (<6 weeks) was for walking. Limb-different children tended to crawl at the same time as their limb-typical peers, and used a much wider variety of strategies (table below), which did not impact their subsequent walking age.





%age of group who used these crawling strategies:

	Limb-typical	Limb-different
Hands and	84	51
Commando	10	26
Bum shuffle	4	22
Other	2	1

Motor milestones are always subject to significant individual variation. A limb different child will on average achieve gross motor milestones at a typical age, around 2-6 weeks later than a limb-typical child; and is more likely to crawl in a non-traditional manner.

More at www.boldkids.co.uk

Everyday motor skills in children with limb differences

From dressing or feeding yourself to playing sports or music, motor skills are a fundamental part of everyday life. How does a limb difference affect these everyday activities?

We conducted a unique study with 67 2-9-year-old children with one 'pincer-functional' hand (i.e. they could make a pincer grip with one hand only). For comparison we saw 44 children with no limb difference. Children completed a variety of everyday tasks which would be completed bimanually in children without limb difference.

Example tasks: *remove lid, thread beads, separate Lego bricks, put on glove*




Video recordings showed that while limb-typical children relied on the hands for nearly 90% of task time, for children with limb difference this was only 40%. Instead they relied on an array of body parts (below), using e.g. legs 38% of the time compared to 10% in two handed children, and torso 22% of the time compared to 5% in limb-typical children.


Limb different arm


Torso


Lower face


Legs


Feet

Body parts were very often used together. Some of the most common strategies were using the two arms together with the legs or torso. As children grew older, they tended to use particular combinations more consistently. Children without limb difference took on average 290secs to complete the series of tasks, while children with limb difference took 464secs. All children became faster with age.

Compared to those with below-elbow difference, children with above-elbow difference tended to use less the torso and most-limb-different arm, and more the feet and legs.

Limb different children complete everyday motor tasks in their own way, often using alternative body parts. With age, their efficiency improves and their strategies become more consistent. The strategy used may depend on the child's limb difference.

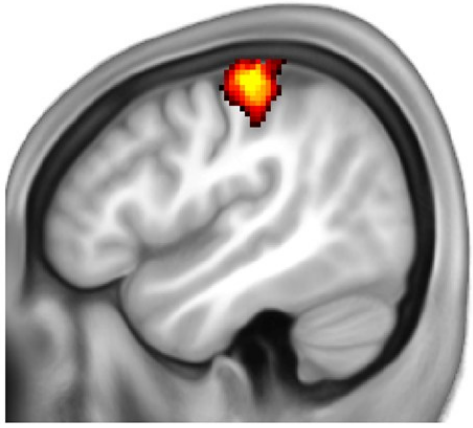
More at www.boldkids.co.uk

Brain development in children with limb differences

How does your child's brain support their unique motor skills? We know that adults born with a limb difference repurpose parts of the brain to support the use of different body parts, e.g. feet or mouth. When do these kinds of neural differences emerge?

16 children and 16 adults with limb difference took part in an fMRI neuroimaging study to determine how the brain of our limb-different participants was responding when we touched different body parts. Compared to a sample of limb-typical participants, we found widespread reorganisation of the entire area of the brain that responds to touch on the body. In limb-different participants, the area that typically supports hand function instead supported alternative body parts (e.g. arm, torso, feet). For the first time, we showed that this kind of brain reorganisation was present in children as young as 5 years old. That suggests that the brain of a child with a limb difference rewires itself early—perhaps in the womb or infancy—and is already prepared to support alternative behaviours.

We also showed some role of childhood experience. There were continued small changes to the brain between 5-7 years old and adulthood. Brain changes were also related to the behaviours we observed (see previous page). Taken together, these suggest that childhood behaviours may support brain development, and/or brain development may encourage the use of alternative body parts in limb-different children.



Brain development: *the area that typically supports hand function instead supports alternative body part use. Stimulating the limb-different arm produced more activity than for the non-dominant arm of limb-typical children (difference shown as yellow/red spot).*

Major neural developments take place early in life (before 5 years), while smaller changes take place after this. Neural and behavioural adaptations go together.

Cognitive skills in children with limb differences

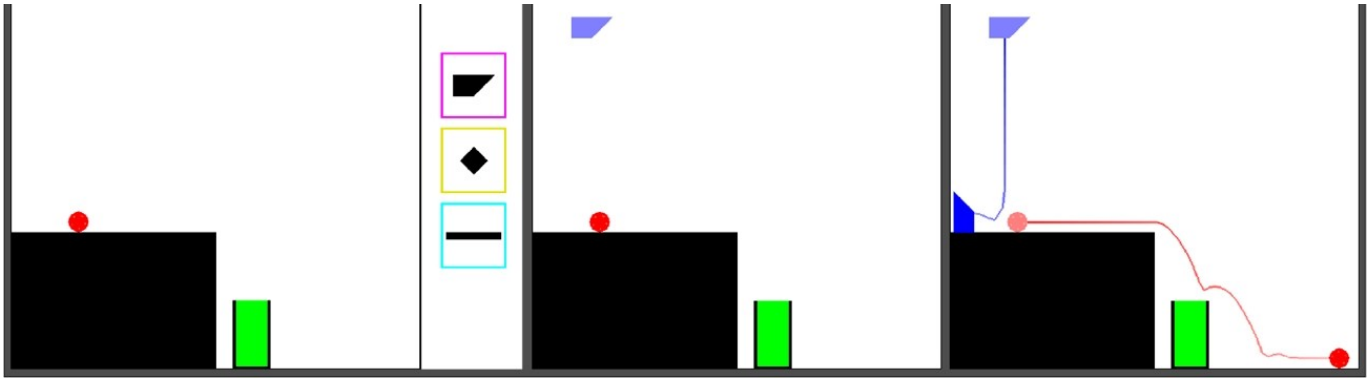
Through behavioural measurement we have looked at cognitive skills in children with limb differences.

In 50 children with limb difference, we found standard tests of cognitive ability to be in a very normal range.

This was true for verbal comprehension, measured by the British Picture Vocabulary Scale, and for visuospatial processing, measured by the Ravens Coloured Progressive Matrices.

In a computerised puzzle game, we also found that children with limb difference solved puzzles as fast as limb-typical children. However, but they tended to think for a little longer before choosing a first solution, and then make fewer attempts. This is a different, perhaps more 'thoughtful' style of problem-solving.

Problem-solving game: *using the shapes to get the red ball into the green goal.*



We find typical cognitive abilities in children with limb difference. Further, children with limb difference may tend to spend time thinking problems through before beginning to tackle them, and this produces good outcomes.

More at www.boldkids.co.uk

Summary

Children with limb difference develop motor skills suited to their developing bodies. They achieve efficient outcomes on everyday motor tasks. They may use different strategies to their two-handed peers (e.g. different crawling styles, use of alternative body parts, thinking a little longer), but progress and outcomes are often in line with their peers. We hope that you find the outcomes of this work reassuring.

We ask you to bear in mind that motor development is highly variable in any population. Finally we remind you to refer any concerns to your GP or health professionals.

There are lots of unanswered questions from this research, for example how very early motor skills develop; how childhood experiences impact upon later problem-solving and creativity; and how prosthetic use affects developing motor skills. With your help, we hope to address some of these issues in future work.

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If you have additional questions regarding the information in this guide, please contact boldkids@durham.ac.uk

You can find further information on the science behind this booklet at www.boldkids.co.uk or www.durham.ac.uk/staff/dorothy-cowie/

A special THANK YOU to all the children and families who took time to contribute to these projects. We are very grateful to you for making this work possible, and we hope that these results are helpful to you and your communities.

Thank you for reading!