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# Standing in children with bilateral spastic cerebral palsy: Aspects of muscle strength, vision and motor function

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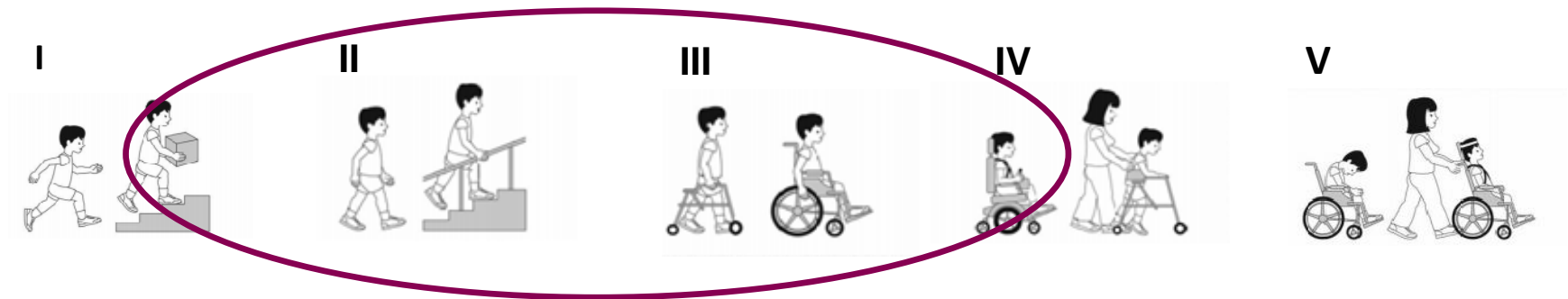
# Cerebral palsy (CP)

- Describes a group of disorders of **movement and posture**
- Lesion in the developing brain before two years of age

Activity limitations are presumed to be a consequence of the motor disorder

*(Rosenbaum et al. 2007)*

## Gross Motor Function Classification System - GMFCS



*(Palisano et al. 1997)*

- Prevalence for CP in Sweden: 2-3/1000
- Bilateral spastic CP (BSCP): 35%

<u>Subtypes</u>	<u>Distribution</u>	<u>Classification</u>
<ul style="list-style-type: none"><li>■ Spastic</li><li>■ Dyskinetic</li><li>■ Ataxic</li></ul>	<ul style="list-style-type: none"><li>Unilateral</li><li>Bilateral</li></ul>	Ambulation Manual ability

*(Rosenbaum et al. 2007, Himmelmann et al. 2014, Westbom et al. 2007, SCPE 2000, Palisano et al. 1997, Eliasson et al. 2006)*

# Accompanying disturbances in CP

*“...The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviour, by epilepsy, and by secondary musculoskeletal problems.”*

- Sensations: vision and other sensory modalities
- Perception: capacity to incorporate and interpret sensory and/or cognitive information

(Rosenbaum et al. 2007)

- Visual dysfunction influence motor functions
- Proprioceptive deficits have been related to instability in standing
- Perceptual impairments with disturbed interactions between the sensory systems may complicate posture modulation in CP

(Ferrari et al. 2010)

# Postural control

Interaction of the individual with the task and the environment controlling the body's **position in space** for **orientation** and **stability**

- **Postural Orientation**

Alignment of body segments

Maintenance of body position



- **Postural stability**

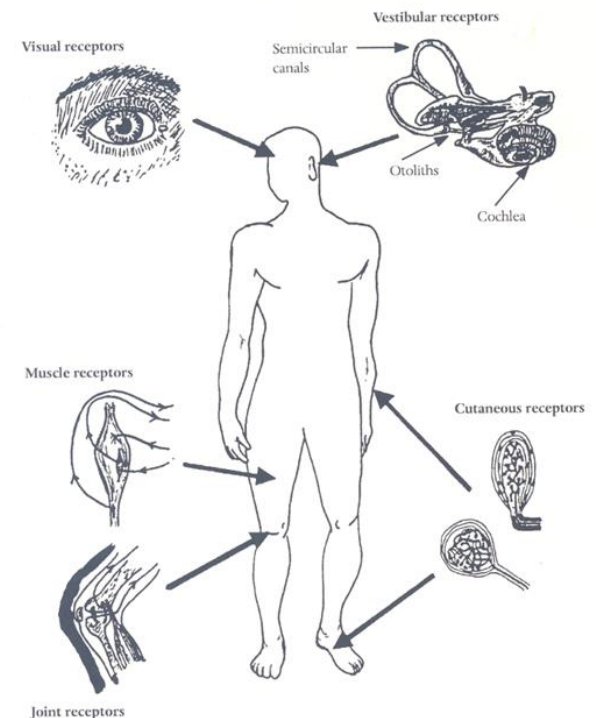
Controlling center of mass in relation to base of support

*(Shumway-Cook et al. 2012, Horak et al. 1996, Maisson et al. 2004)*

# Prerequisite for standing – Spatial perception of the body in space

A combination of sensory systems:

- Vision
  - Somatosensory (tactile, proprioception)
  - Vestibular
- Detect gravity as a reference frame enabling perception of the vertical



(Shumway-Cook et al. 2012, Berthoz 2000)

# What causes difficulties with standing?

- Activation of muscles?
- Muscle weakness?
- Sensory disturbances?
- Vision?
- Difficulties with spatial perception?

# Rationale

Children with CP usually have walking and standing difficulties

- The movement and posture disorder of CP is presumed to mainly be a consequence of the motor disorder
- Disturbances of sensations and perception have been suggested to influence motor function

This thesis is an attempt to investigate standing from a perspective that takes the influence of sensory processes into account

## General aim of the thesis

To investigate factors influencing standing in children with bilateral spastic CP, GMFCS levels I-IV, with respect to their various standing abilities

## Participants in total

55 children with CP

- 25 standing **with** support (CP-SwS)
- 30 standing **without** support (CP-SwoS)

CP-SwS

CP-SwoS

### **Reference group:**

46 typically developing (TD)children

### **Inclusion criteria**

- Bilateral spastic CP, GMFCS levels I-IV
- Standing ability 30 sec
- Age 5 –17 years

## Aim

To investigate postural orientation with body position and body movements during quiet standing

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### RESEARCH ARTICLE

# Postural Orientation During Standing in Children With Bilateral Cerebral Palsy

*Cecilia M. Lidbeck, PT, MSc; Elena M. Gutierrez-Farewik, PhD; Eva Broström, PT, PhD; Åsa Bartonek, PT, PhD*

Department of Women's and Children's Health (Ms Lidbeck and Drs Gutierrez-Farewik, Broström, and Bartonek)  
Karolinska Institutet, Stockholm, Sweden; KTH Mechanics (Dr Gutierrez-Farewik), Royal Institute of Technology,  
Stockholm, Sweden.

# Methods

## Participants

26 children with BSCP

- CP-SwoS: 15
- CP-SwS: 11

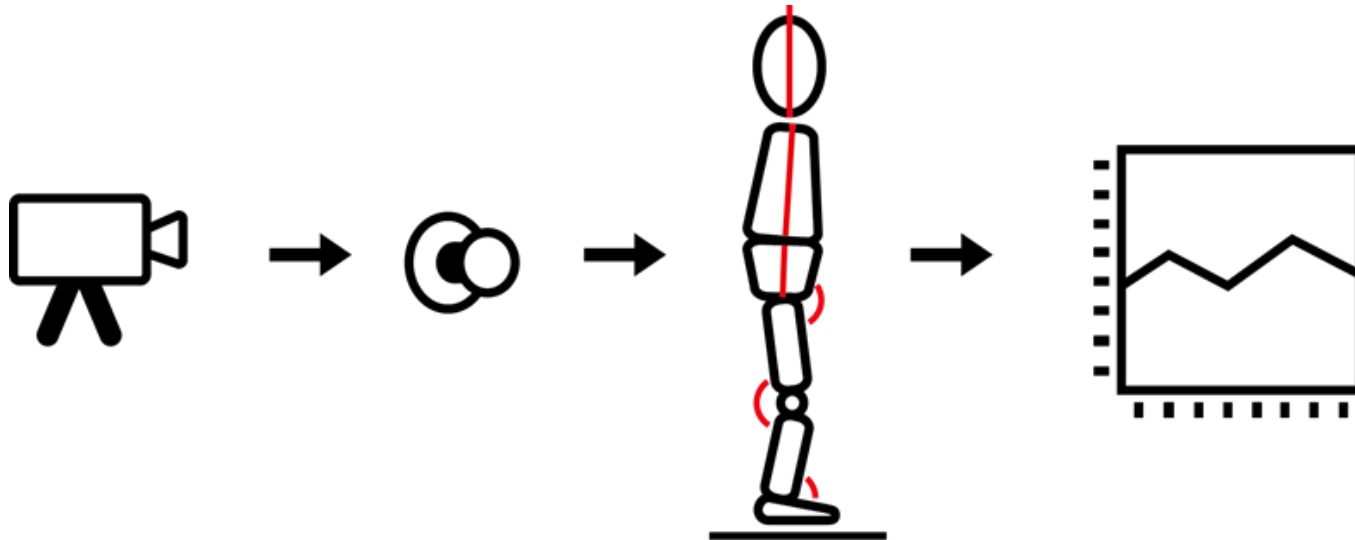
19 TD children

## 3-D motion analysis: Standing posture

- Standing 30 s with habitual shoes and orthoses
- The more weight-bearing limb was analysed

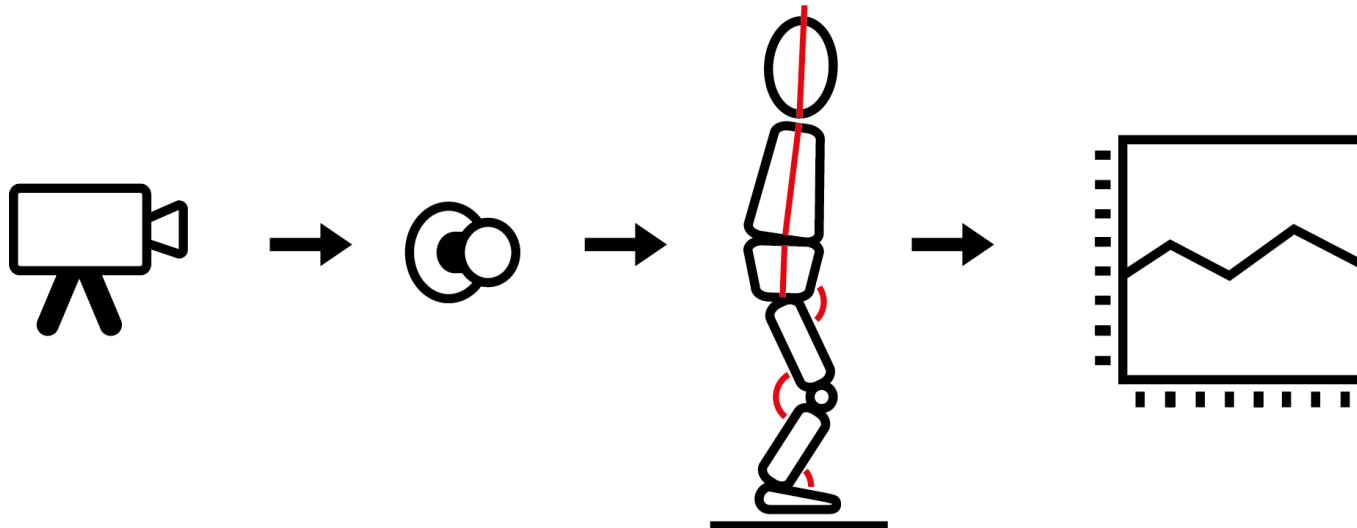
## 3-D Motion Analysis (Vicon® Oxford, UK) (Force plates, Kistler® Switzerland)

- Standing posture: **Body position** and Body movements



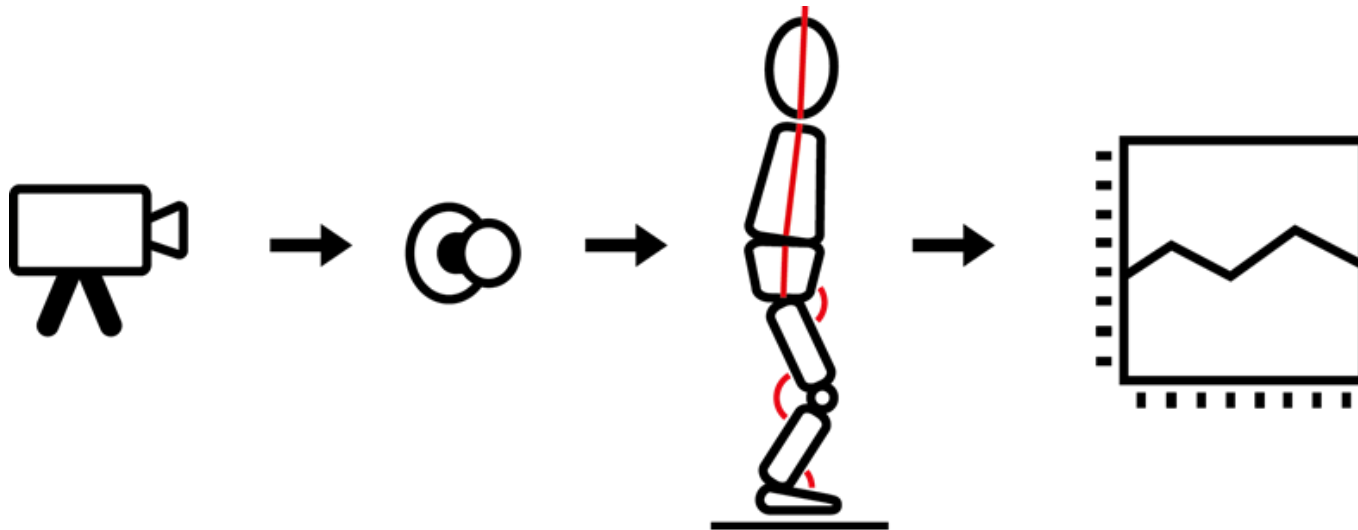
## 3-D Motion Analysis (Vicon® Oxford, UK) (Force plates, Kistler® Switzerland)

- Standing posture: Body position and **Body movements**



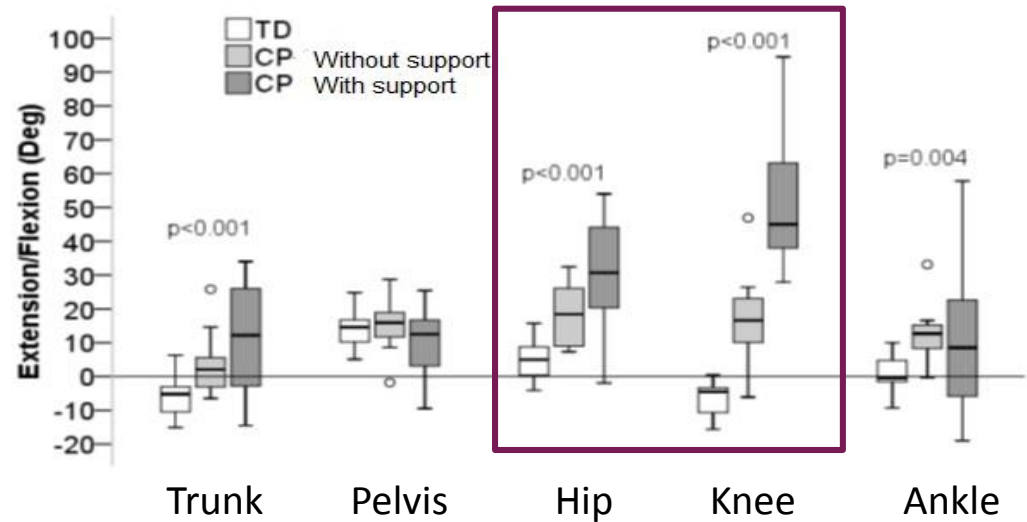
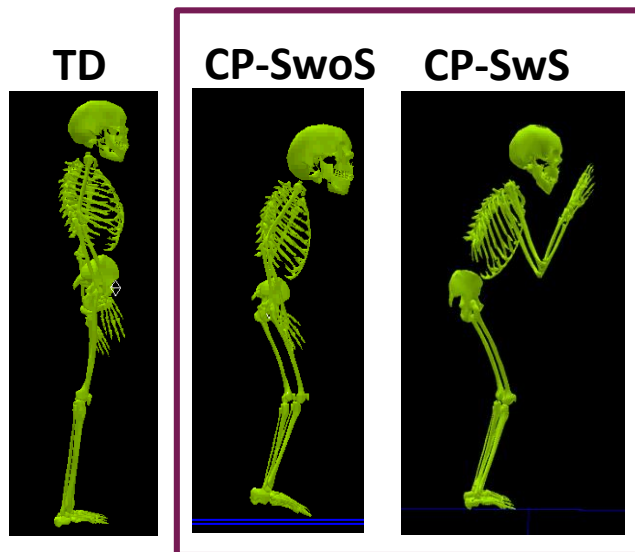
## 3-D Motion Analysis (Vicon® Oxford, UK) (Force plates, Kistler® Switzerland)

- Standing posture: **Body position** and **Body movements**



## Results - Body position angles° (median)

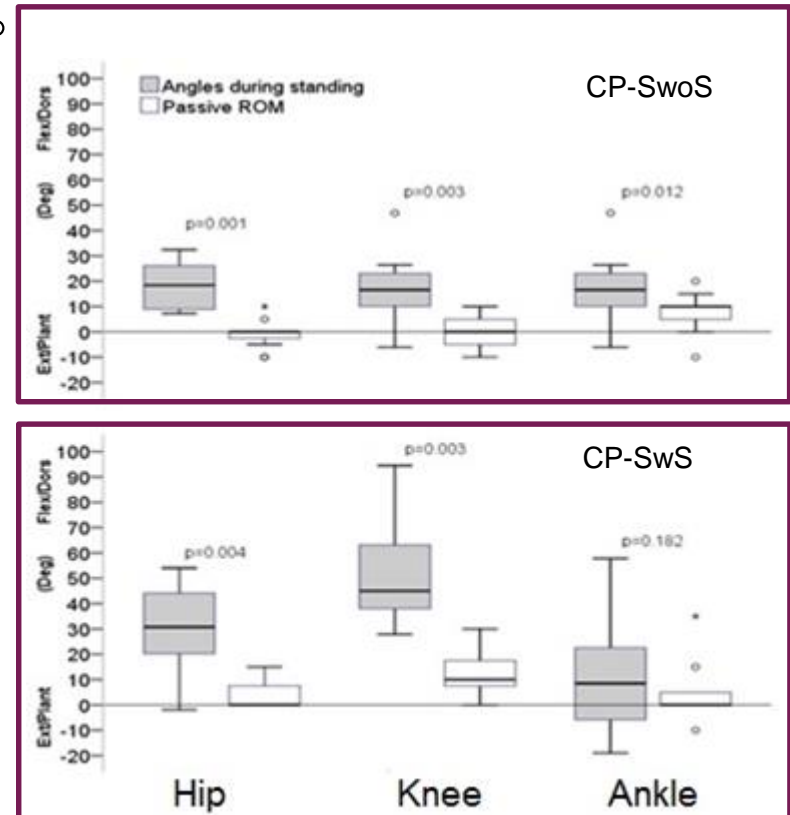
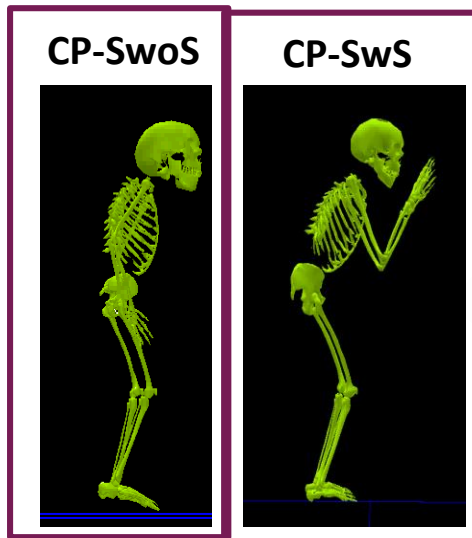
- TD children: erect position (hip 5°, knee -5°)
- CP-SwoS: flexed position (hip 20°, knee 15°)
- CP-SwS: flexed position (hip 30°, knee 45°)



p<0.05

## Results – Standing vs passive joint angles° (median)

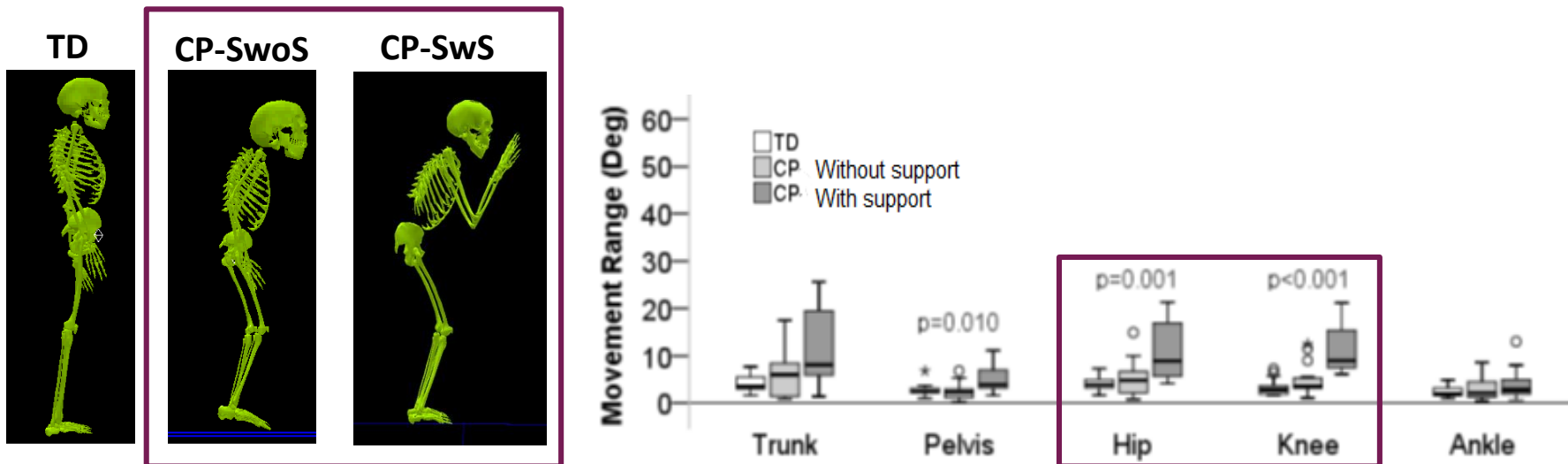
- CP-SwoS: hip 0° vs 20°, knee 0° vs 15°
- CP-SwS: hip 0° vs 30°, knee -10° vs 45°



p<0.05

## Results – Body movement range° (median)

- TD children: almost still in all joints < 5°
- CP-SwoS: movements hip and knee 5°
- CP-SwS: movements hip and knee 10°



(p<0.05)

## Conclusions

Children with CP had varying abilities to stand and maintain standing posture with or without support

- Both groups stood in a crouched body position with more flexion than their potential passive joint extension
- The crouched body position and the body movements were more obvious in the children standing with support

How **muscle strength** and **spatial perception** influence posture remains to be explored!

## Aim

Explore muscle strength in the lower limb muscle groups in children with BSCP with respect to their standing ability with or without support

Lidbeck et al. *BMC Neurology* (2015) 15:188  
DOI 10.1186/s12883-015-0441-y



RESEARCH ARTICLE

Open Access

### Muscle strength does not explain standing ability in children with bilateral spastic cerebral palsy: a cross sectional descriptive study



Cecilia Lidbeck\*, Kristina Tedroff and Åsa Bartonek

## Study II

# Methods

## Participants

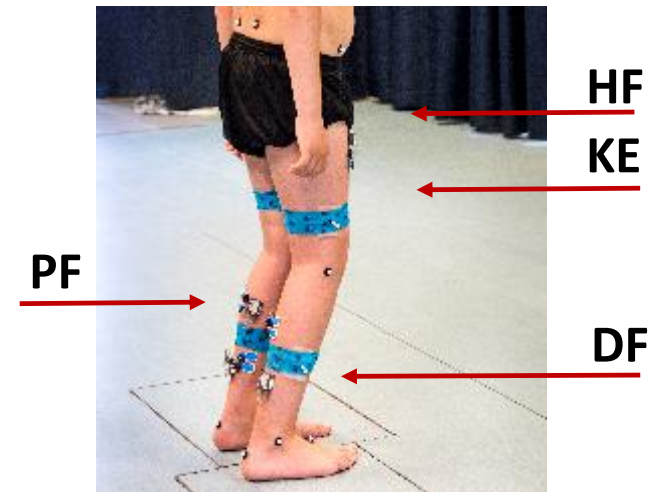
25 children with BSCP

- 11 CP-SwoS
- 14 CP-SwS

## Hand-held dynamometer (HHD) (Chatillon®)

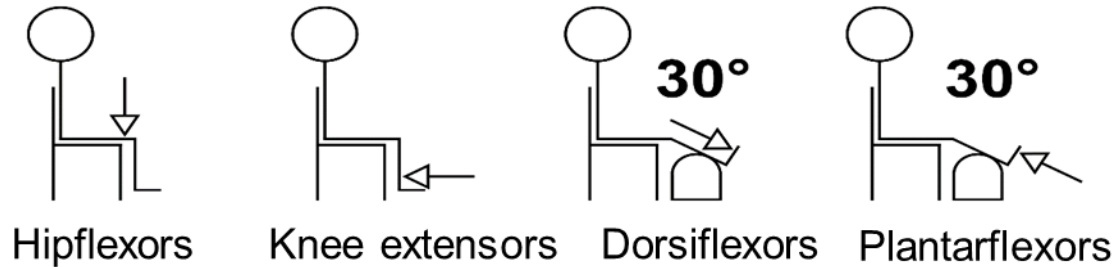
## Isometric muscle strength

- Hip flexors (HF)
- Knee extensors (KE)
- Dorsiflexors (DF)
- Plantarflexors (PF)



## Methods

Testing positions:

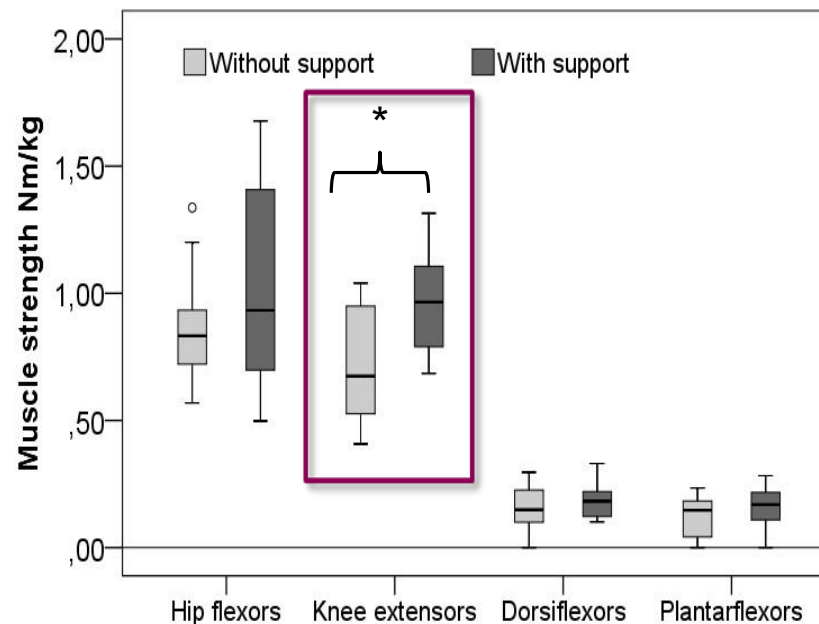


Two seated positions: on a chair and on a stool



## Results – Muscle strength Nm/kg (median)

- CP-SwoS and CP-SwS: No difference in hip and ankle muscles
- CP-SwS vs CP-SwoS: Stronger knee extensors ( $p=0.038$ )
- No difference between seated conditions



( $p < 0.05$ )

## Conclusions

Children standing with support were not weaker compared to those standing without support

Muscle strength does not explain:

- the requirement for support for standing
- the more crouched knee flexion in the children standing with support

How vision, somatosensory deficits and/or difficulties with perception of gravity influence standing need to be further investigated!

## Aim

Explore the influence of visual stimuli on standing posture while blindfolded and during an attention demanding task in children with various standing abilities with or without support

Lidbeck *et al.* *BMC Neurology* (2016) 16:151  
DOI 10.1186/s12883-016-0676-2

BMC Neurology

RESEARCH ARTICLE

Open Access



# The role of visual stimuli on standing posture in children with bilateral cerebral palsy

Cecilia Lidbeck<sup>1\*</sup>, Åsa Bartonek<sup>1</sup>, Priti Yadav<sup>2,3</sup>, Kristina Tedroff<sup>1</sup>, Per Åstrand<sup>1</sup>, Kerstin Hellgren<sup>4</sup>  
and Elena M. Gutierrez-Farewik<sup>1,2,3</sup>

## Method

### Participants

36 children with BSCP

- 19 CP-SwoS
- 17 CP-SwS

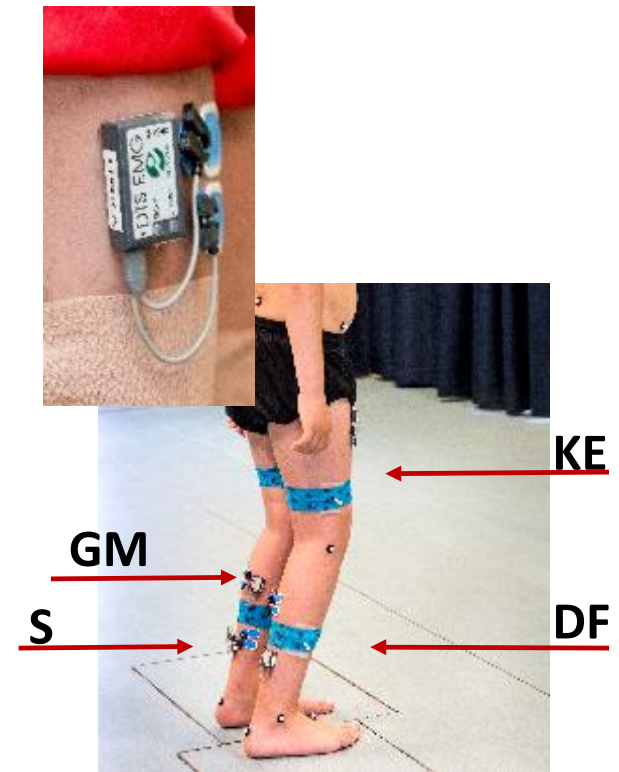
27 TD children

**3D-motion analysis:** Standing posture

**Surface Electromyography** (Noraxon®, USA): Muscle activity

Four lower limb muscle groups:

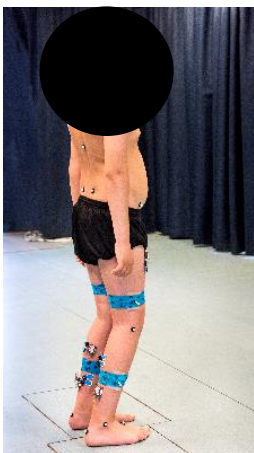
- knee extensors (KE)
- dorsiflexors (DF)
- plantarflexors: gastrocnemius (GM), soleus (S)



## Method

Quiet standing: 30 s./condition

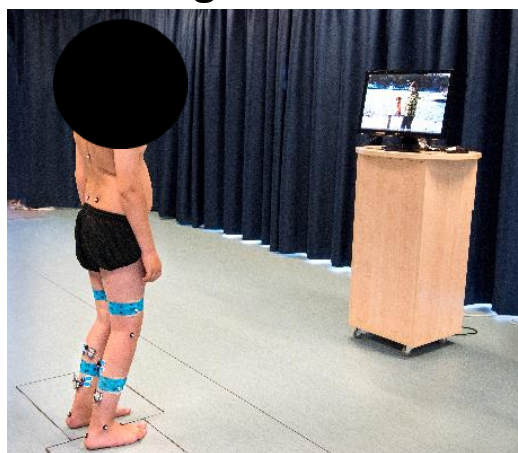
No-task



Blindfolded



Watching a video



- Body position
- Body movements
- Muscle activity

**Visual function** - examined by an ophthalmologist

- neuro-ophthalmological impairments in 28/32
- no difference in ophthalmological status between the groups
- Visual acuity sufficient to see the film

## Results: No-task condition (mean)

TD children: erect and still position

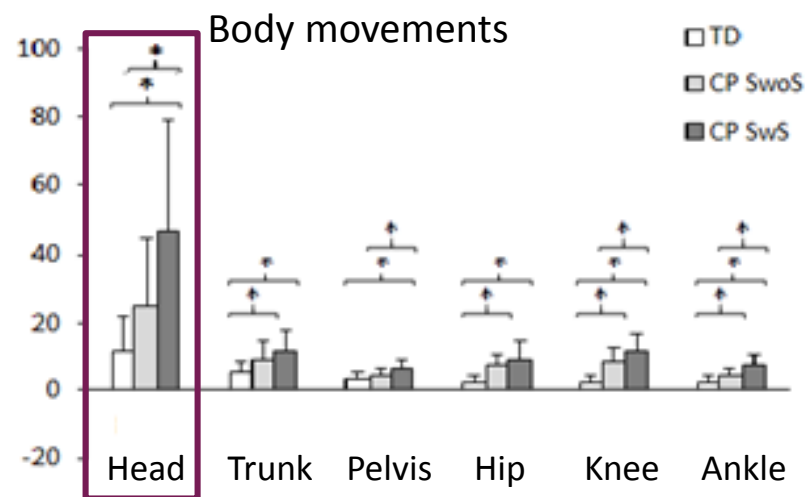
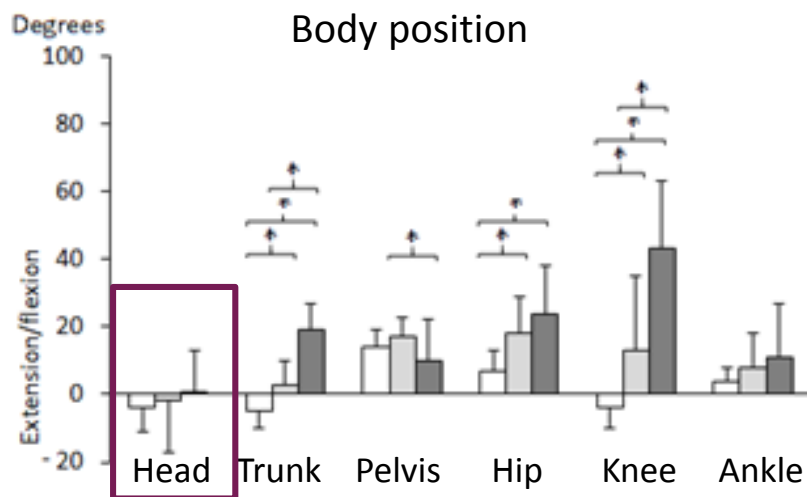
Children with CP vs TD children: flexed position with more body movements, more obvious in CP-SwS

### Head movements

TD: almost still

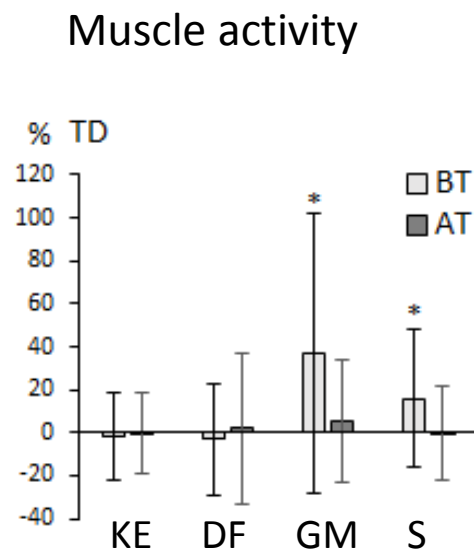
CP-SwoS: 25°

CP-SwS: ~50°



## Results: Standing conditions TD children (mean)

	Blindfolded (BT)	Watching the movie (AT)
Body position:	increased head extension 3°	no change
Body movements:	no change	no change
Muscle activity:	increased in calf 35 %	no change



BT



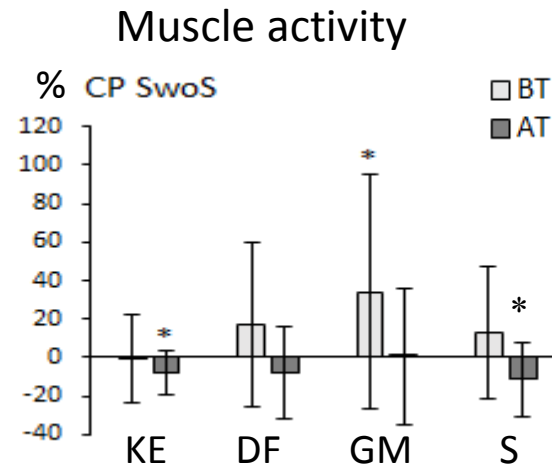
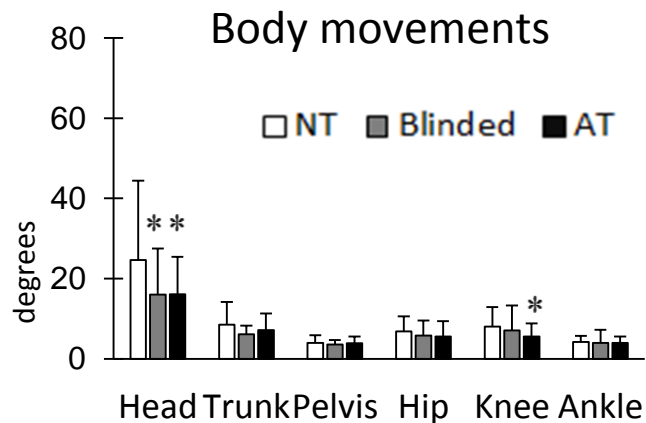
## Results: Standing conditions CP-SwoS (mean)

### Blindfolded (BT)

Body position: no change  
 Body movement: more still head 10°  
 Muscle activity: increased in calf 35%

### Watching the movie (AT)

no change  
 more still head 10° and knee 2°  
 decreased in knee and calf 10%



## Results: Standing conditions CP- SwS (mean)

### Blindfolded (BT)

Body position: increased flexion hip, knee 5°

Body movements: no change

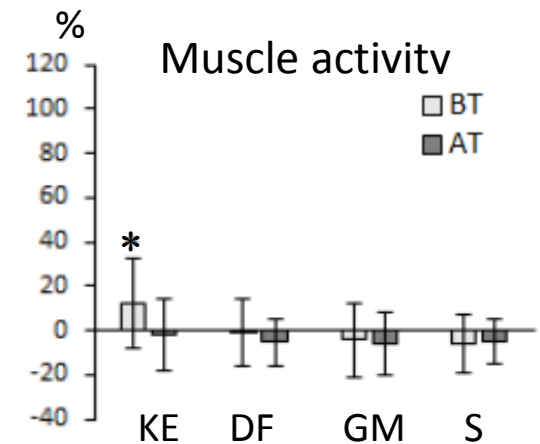
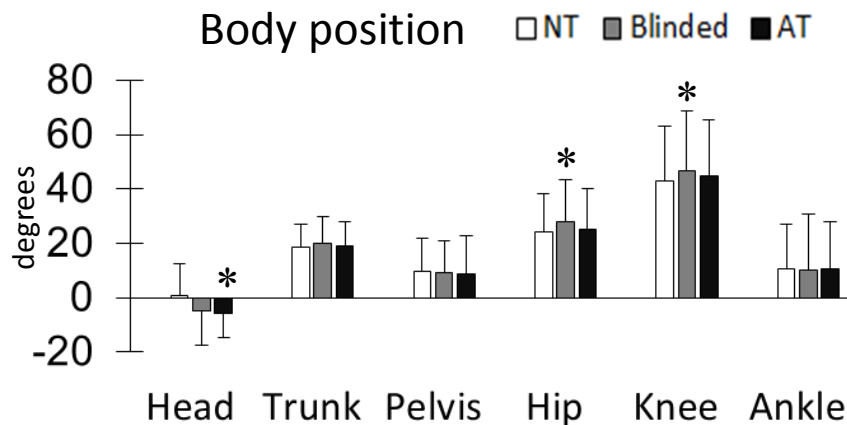
Muscle activity: increased in knee 10%

### Watching the movie (AT)

head extended 5°

more still head 20°

no change



## Conclusions

- Without vision the children CP-SwS had difficulties to maintain posture:
  - crouched position increased
- Visual stimulus changed posture in both groups of children with CP:
  - CP-SwoS stood more still and with less lower limb muscle activity
  - CP-SwS stood with more upright and still head position
- *How impairments in the sensory systems and difficulties with perception of gravity influence standing need to be further investigated!*

## Aim

To explore motor function in other positions than standing, such as lying, sitting, and kneeling in relation to standing ability

## **Gross motor function and standing ability in children with bilateral spastic cerebral palsy**

*Cecilia Lidbeck & Åsa Bartonek*

## Methods

### Participants

36 children with BSCP

- CP-SwoS: 19 (GMFCS I:5, II:12, III:2)
- CP-SwS: 17 (GMFCS II:1, III:13, IV: 3)

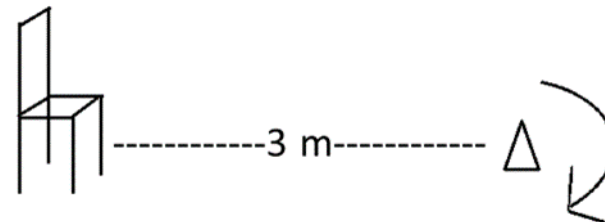


### Gross Motor Function Measure (GMFM-66 & GMFM-88)

Motor activities in lying/rolling, sitting, crawling/kneeling, standing and walking/running/jumping

### Timed Up and Go (TUG) test:

Functional mobility in walking



*Study IV*

## Results: GMFM (median)

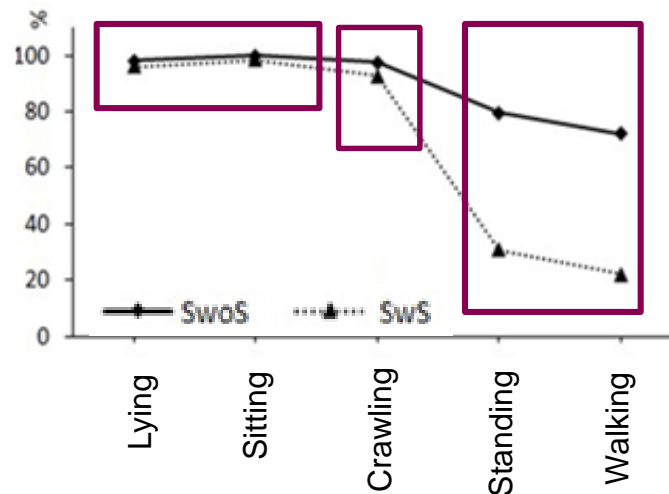
	CP-SwoS	CP-SwS	<i>p</i>
GMFM - 66 score:	70	54	<0.001
Total GMFM-88 score (%):	88	70	<0.001

( $p < 0.05$ )

## Study IV

### Results: GMFM % (median)

	CP-SwoS	CP-SwS	<i>p</i>
A) Lying & Rolling:	100	96	0.271
B) Sitting:	100	96	0.285
C) Crawling & Kneeling:	98	93	0.035
D) Standing:	80	31	<0.001
E) Walking & Running:	72	22	<0.001



(*p* < 0.05)

## Results: GMFM-88 Crawling & Kneeling

	CP-SwoS	CP-SwS	<i>p</i>
C) Crawling & Kneeling %:	98	93	0.035

Total: 14 items

Item 48: High kneeling 10 sec

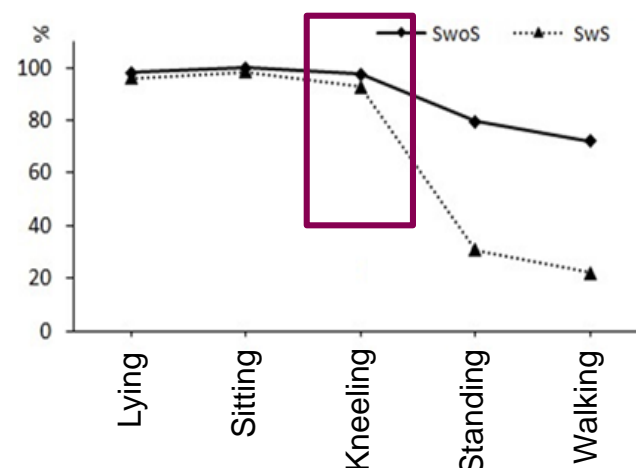
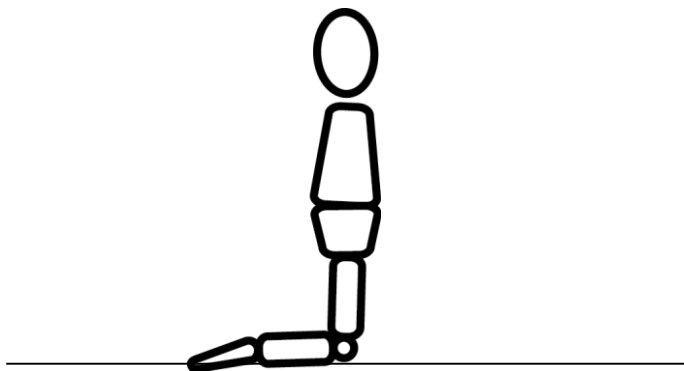
Item 51: Walks forward on knees 10 steps

19/19 (100%)

14/17 (82%)

16/19 (84%)

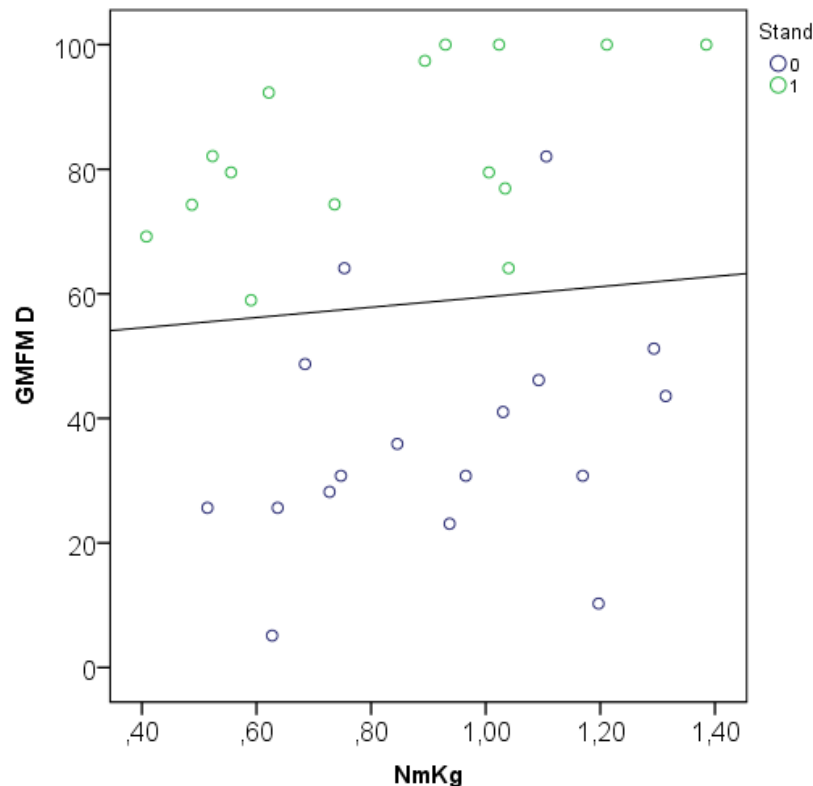
10/17 (59%)



( $p < 0.05$ )

## Results

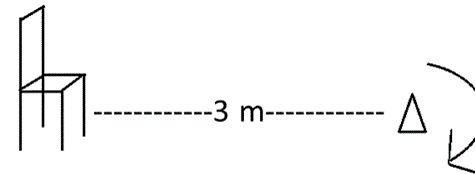
No correlation between knee extensor muscle strength (Nm/kg) and GMFM dimension D (%):  $r = 0.093$ ,  $p = 0.612$



## Study IV

# Results - Timed Up and Go (TUG) test (median, range)

TUG: in 32/36 children with CP



	TD (22/27)	CP-SwoS 19/19	CP-SwS 13/17	<i>p</i>
TUG test (sec):	8.2 (6.5, 10.6)	11.1 (7.4, 28.6)	25.6 (11.0-70.0)	<0.001
Mobility device (nr):		2	12	

## Conclusions

- Children CP-SwoS and CP-SwS performed motor tasks:
  - equally in Lying and Sitting
  - differently in Standing and Walkingconfirming that capacity to perform motor tasks depends on position
- Motor tasks in Crawling & Kneeling were performed similarly despite challenging tasks such as standing and walking on the knees
- *The question arises whether these findings refer to somatosensory disturbances and difficulties with spatial orientation?*

# Summary of the thesis

- Investigation of standing posture verified a crouched body position with increased body movements – most obviously in the children who required support to stand
- Muscle strength measurements indicated equally strong lower limb muscles despite various standing abilities
- Without vision and during the attention demanding task various solutions were seen ranging from difficulties to maintain posture, to more still body positions, and change of lower limb muscle activity
- Motor function measurements indicated that the children who stood with support were capable to perform motor activities in Crawling & Kneeling despite difficulties in standing

Challenge remains to develop methods to measure factors contributing to the multifactorial process of postural orientation during standing

*Thank you for your attention!*

