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

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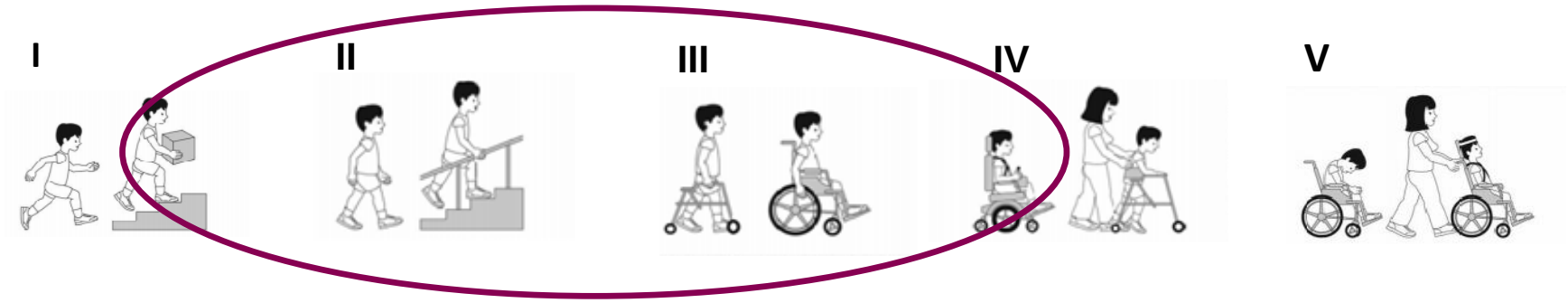
Cerebral palsy (CP)

- 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 **M**otor **F**unction **C**lassification **S**ystem - **GMFCS**



(Palisano et al. 1997)

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

Subtypes	Distribution	Classification
Spastic	Unilateral	
	Bilateral	Ambulation
Dyskinetic		Manual ability
Ataxic		

(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 *(Jacobsson et al. 2000)*
- Proprioceptive deficits have been related to instability in standing *(Damiano et al. 2013)*
- Perceptual impairments with disturbed interactions between the sensory systems may complicate posture modulation *(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

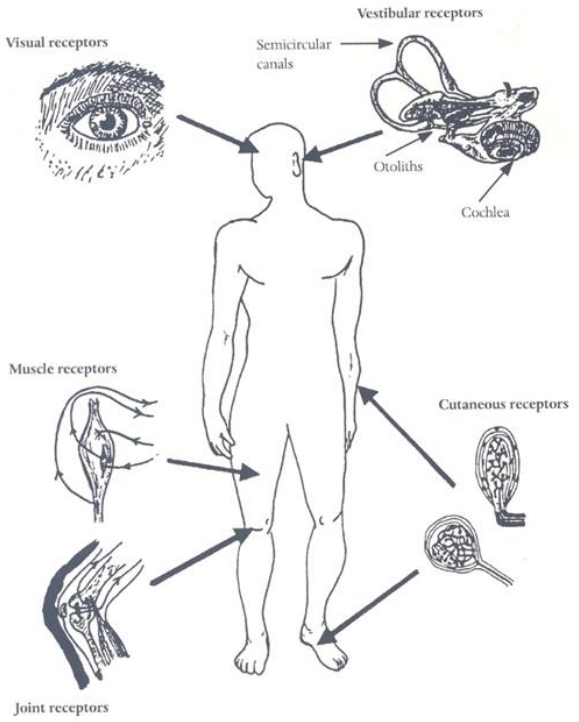
(Shumway-Cook et al. 2012, Horak et al. 1996, Maisson et al. 2004)

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?

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

Overview

Study I. Investigating postural orientation i.e. body position & body movements during quiet standing

Study II. Exploring lower limb muscle strength with respect to standing ability with or without support

Study III. Exploring the influence of visual stimuli on standing posture

Study IV. Exploring motor function in other positions than standing, such as lying, sitting and kneeling

Participants in total

55 children with CP

- 25 standing **with** support (CP-S**w**S)
- 30 standing **without** support (CP-S**wo**S)

CP-S**w**S CP-S**wo**S

Reference group:
46 typically developing (TD) children

Inclusion criteria

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

Study I

Pediatric Physical Therapy 2014

Aim

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

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

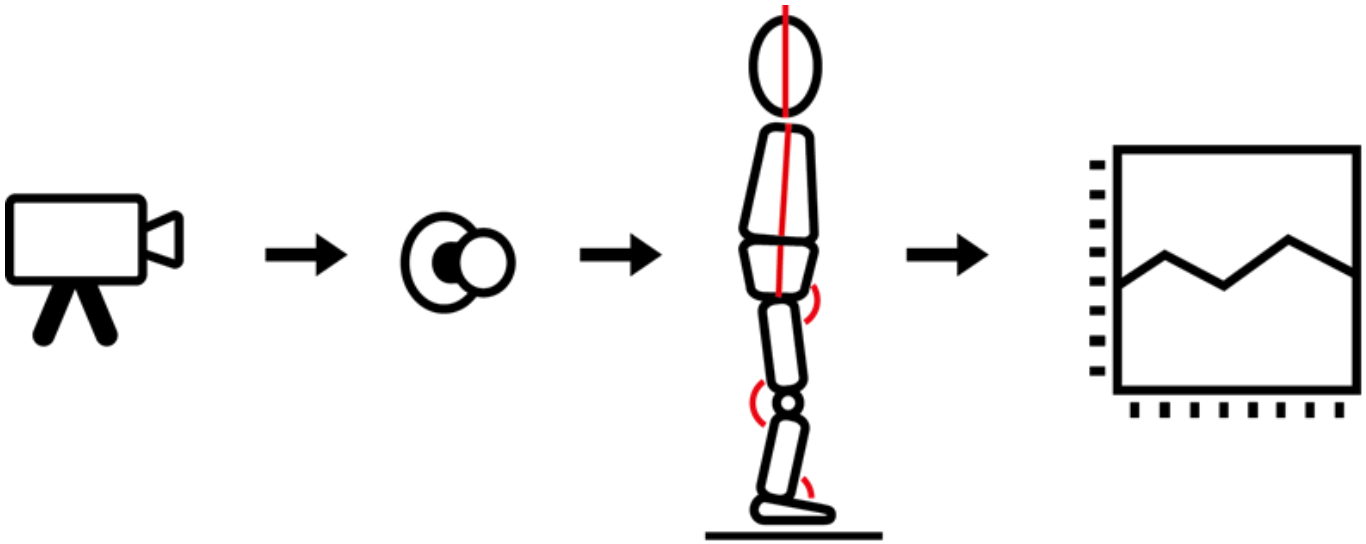
19 TD children

3-D motion analysis: Standing posture

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

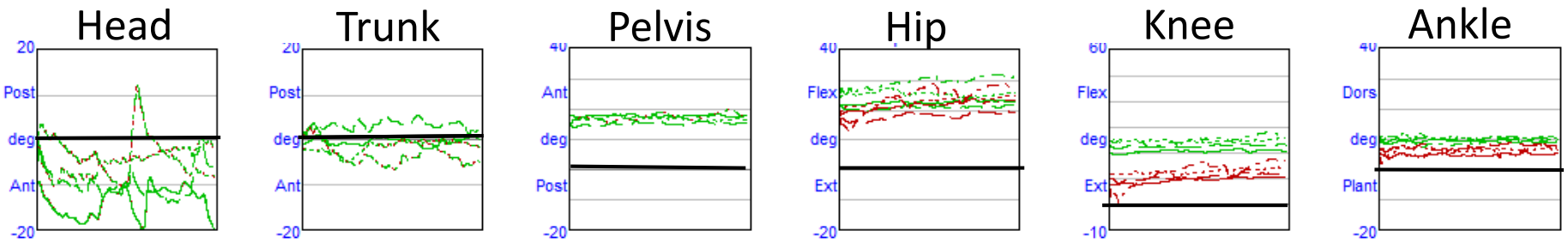
3-D Motion Analysis (Vicon® Oxford, UK) (Force plates, Kistler® Switzerland)

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



Graphical illustration of 3-D Motion Analysis

(three trials in one child)



— = neutral position

— = right limb

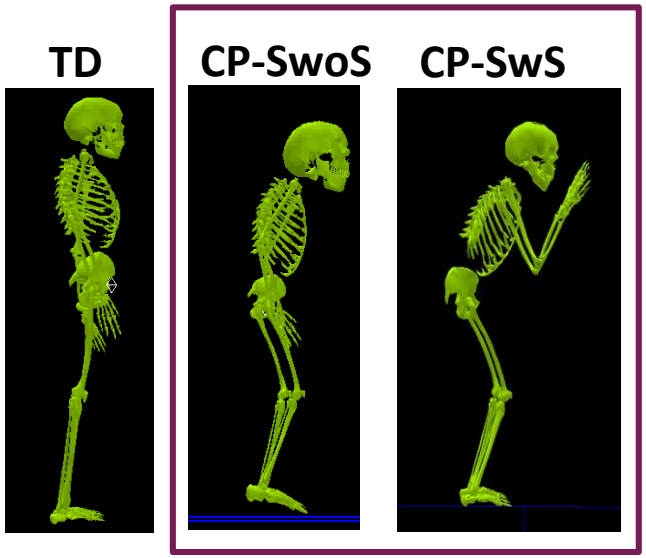
— = left limb

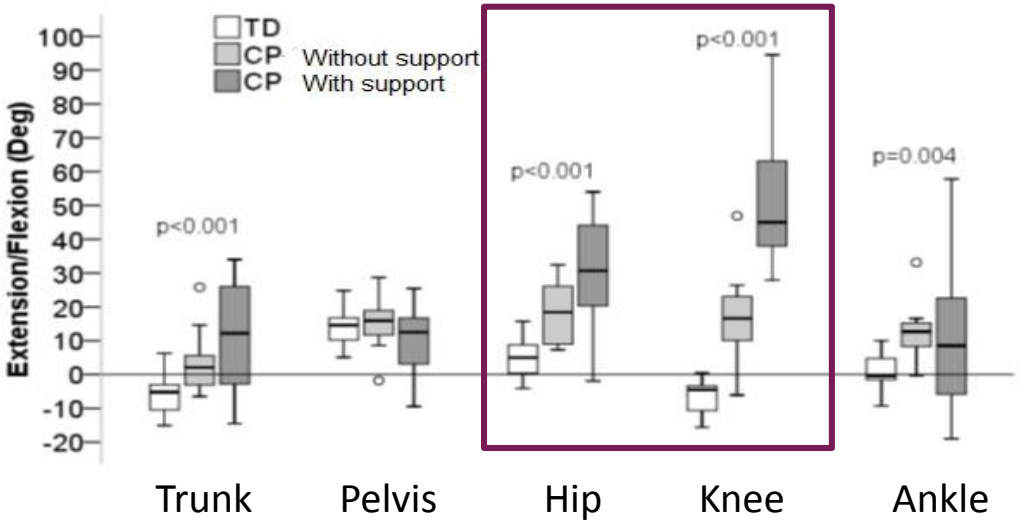
Study I

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°)

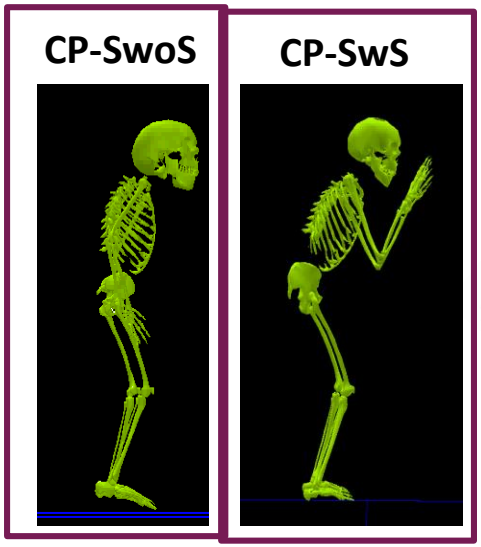


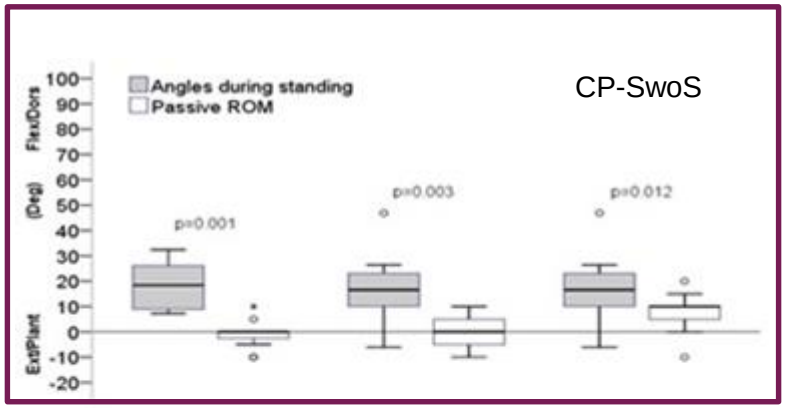


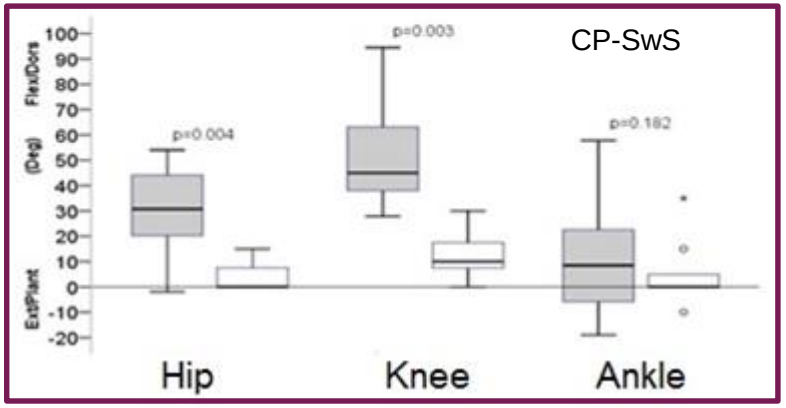
p<0.05

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°





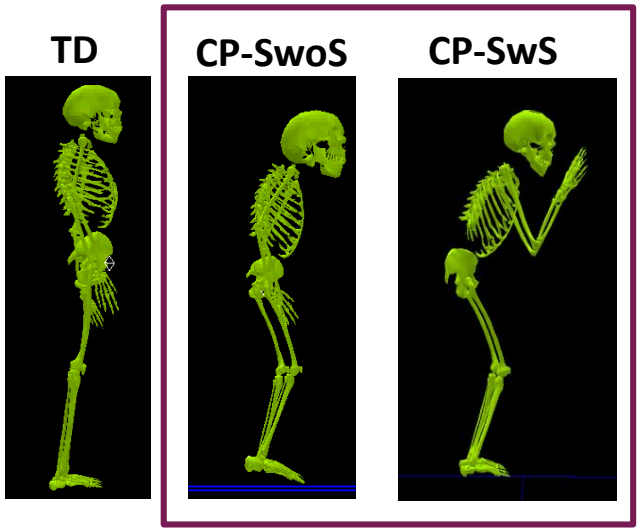


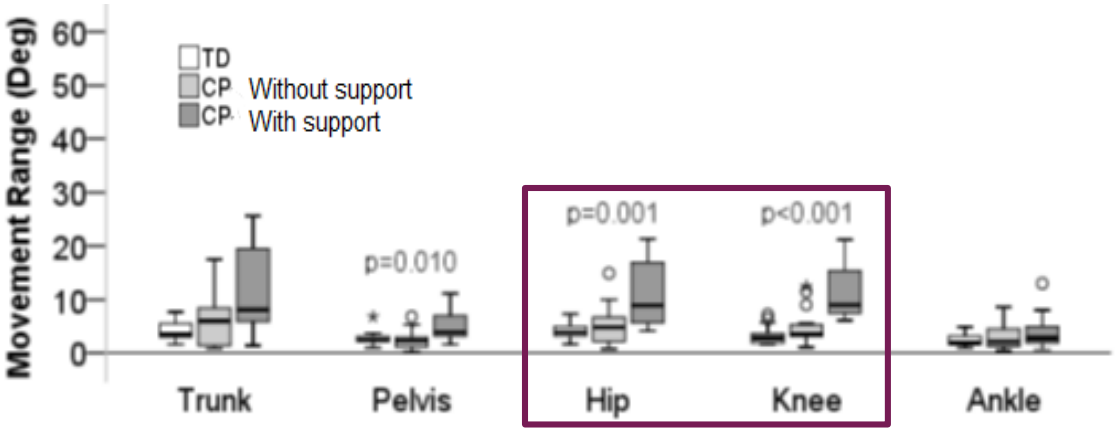
p<0.05

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

BMC Neurology

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

Methods

Participants

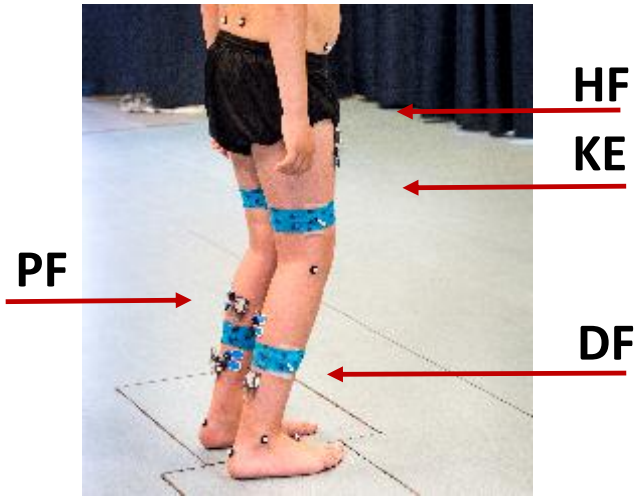
25 children with BSCP

- 11 CP-SwoS
- 14 CP-SwS

Hand-held dynamometer (HHD) (Chatillon®)

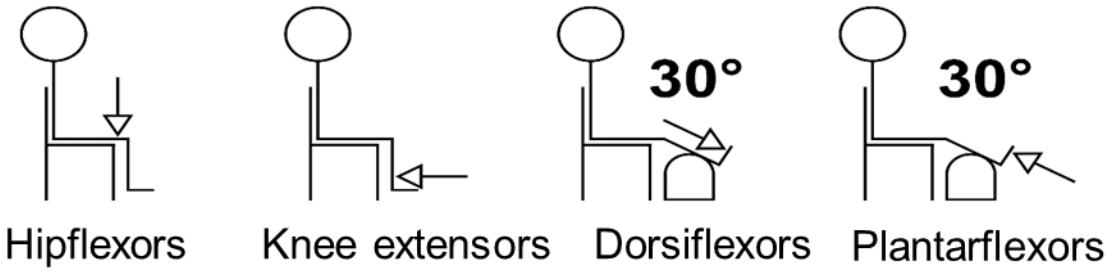
Isometric muscle strength

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



Methods

Testing positions:

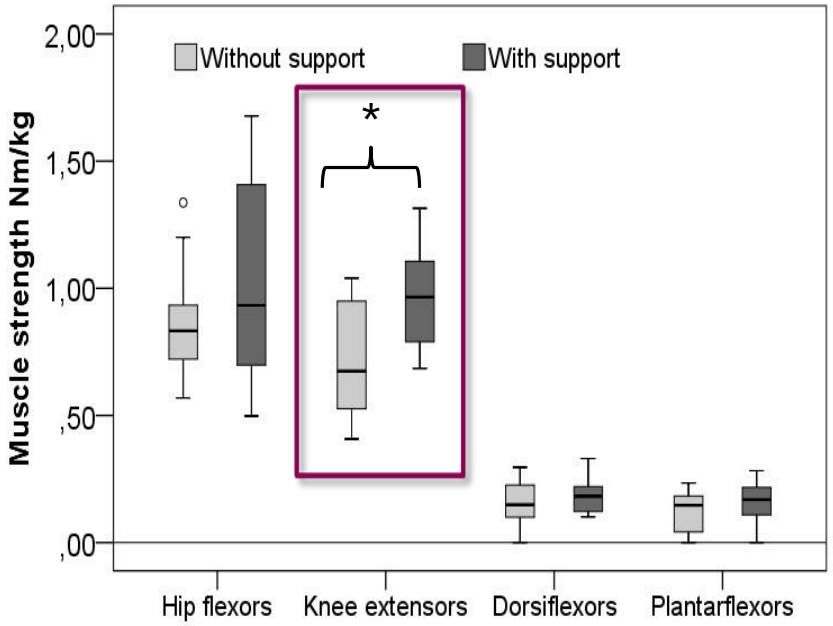


Two seated positions: on a chair and on a stool

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[1*], Åsa Bartonek[1], Priti Yadav[2,3], Kristina Tedroff[1], Per Åstrand[1], Kerstin Hellgren[4] and Elena M. Gutierrez-Farewik[1,2,3]

Method

Participants

36 children with BSCP

- 19 CP-SwoS
- 17 CP-SwS

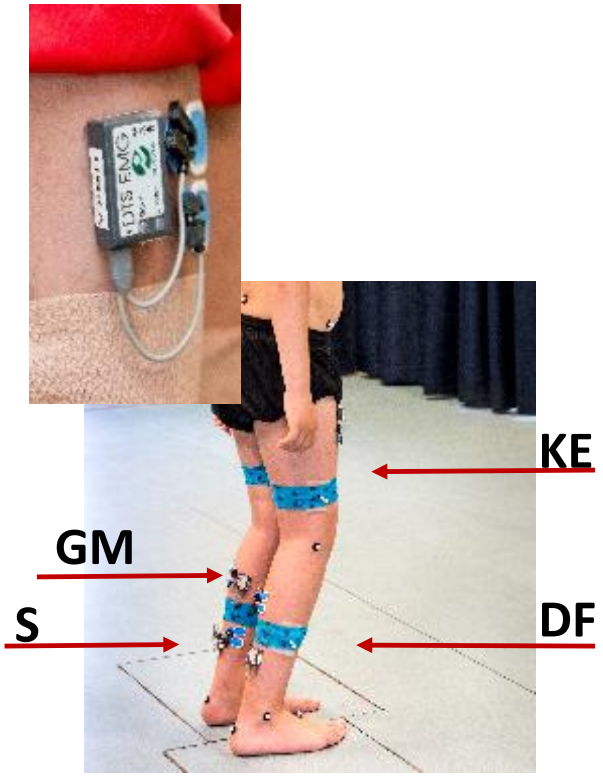
27 TD children

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

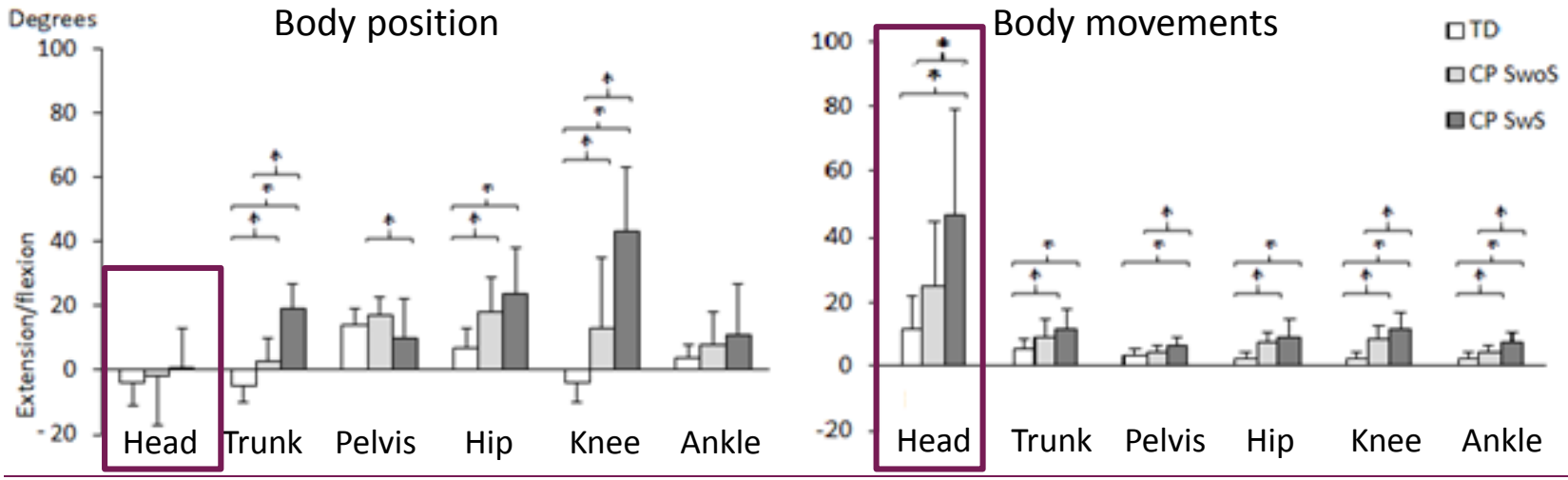
Children with CP vs TD children: flexed position with more body movements, more obvious in CP-SwS

Head movements

TD: almost still

CP-SwoS: 25°

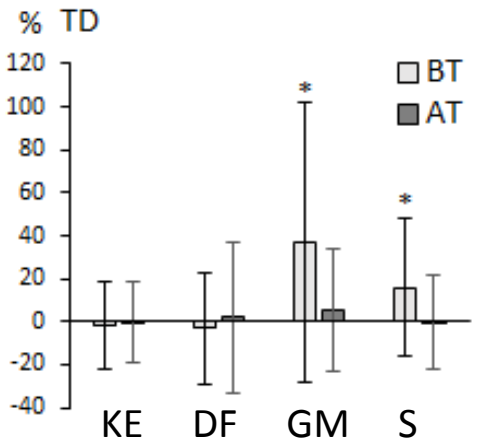
CP-SwS: ~50°



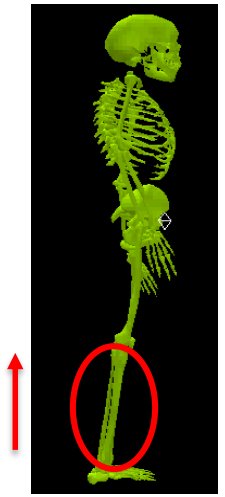
Results: Standing conditions TD children (mean)

	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

Muscle activity

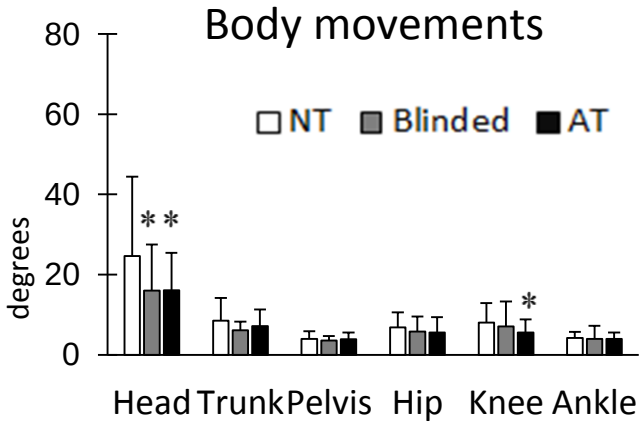


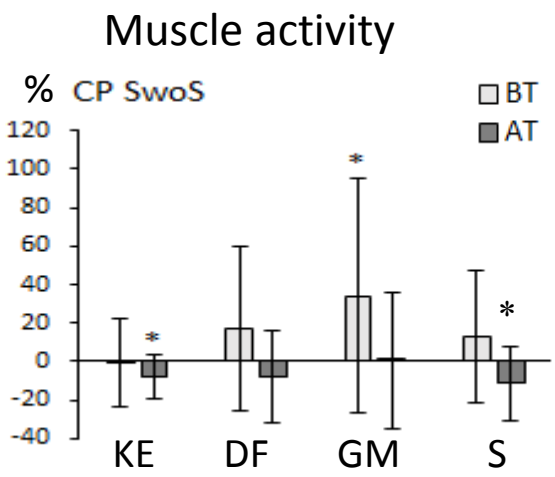
BT



Results: Standing conditions CP-SwoS (mean)

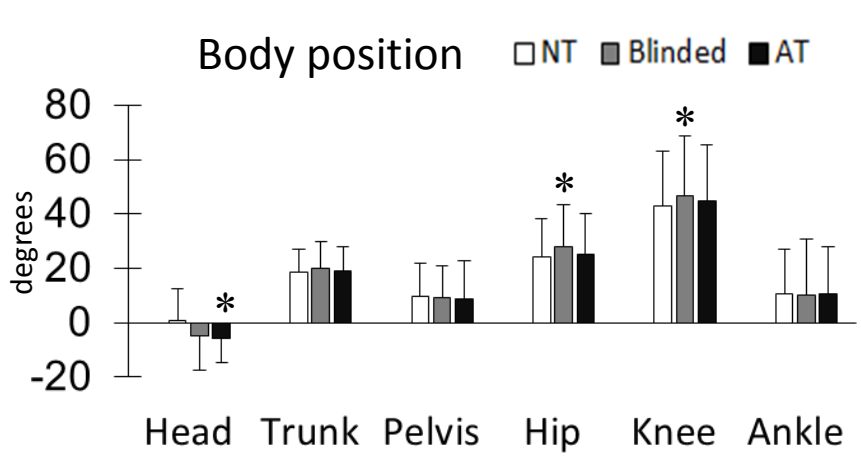
	Blindfolded (BT)	Watching the movie (AT)
Body position:	no change	no change
Body movement:	more still head 10°	more still head 10° and knee 2°
Muscle activity:	increased in calf 35%	decreased in knee and calf 10%

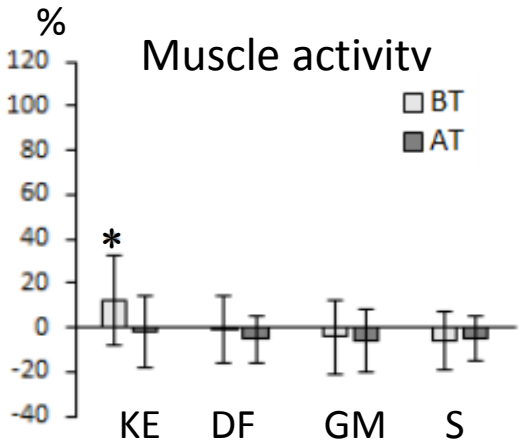




Results: Standing conditions CP- SwS (mean)

	Blindfolded (BT)	Watching the movie (AT)
Body position:	increased flexion hip, knee 5°	head extended 5°
Body movements:	no change	more still head 20°
Muscle activity:	increased in knee 10%	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

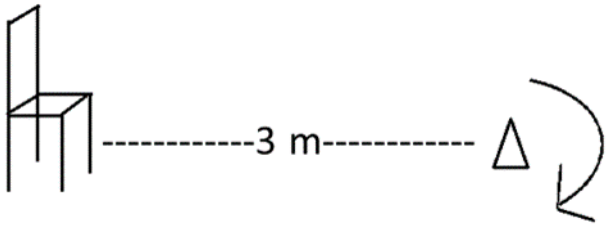
- CP-SwoS: 19 (GMFCS I:5, II:12, III:2)
- CP-SwS: 17 (GMFCS II:1, III:13, IV: 3)

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)

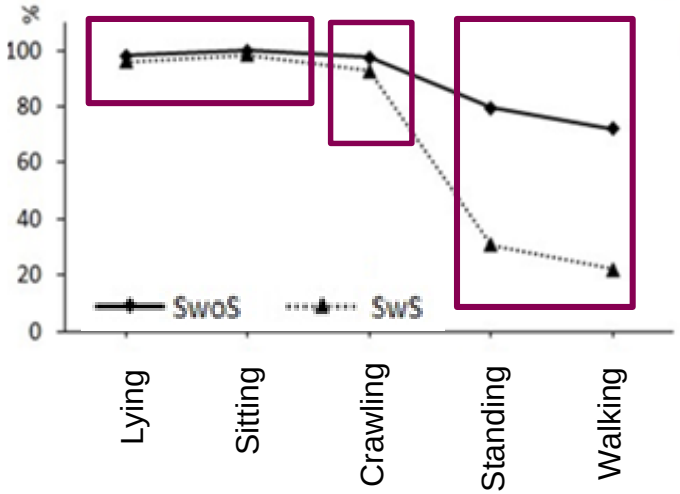
	CP-SwoS	CP-SwS	*p*
GMFM - 66 score:	70	54	<0.001
Total GMFM-88 score (%):	88	70	<0.001

(p< 0.05)

Study IV

Results: GMFM % (median)

	CP-SwoS	CP-SwS	*p*
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)

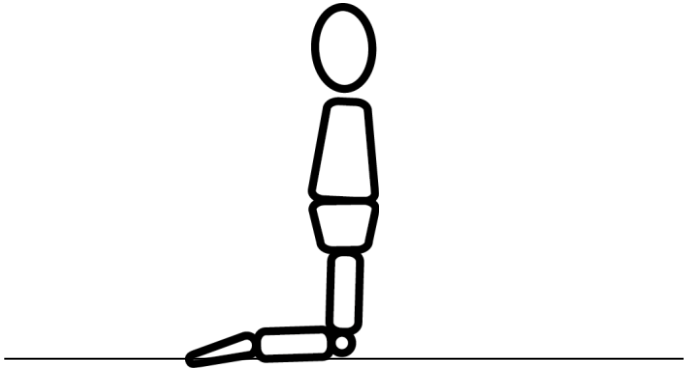
Study IV

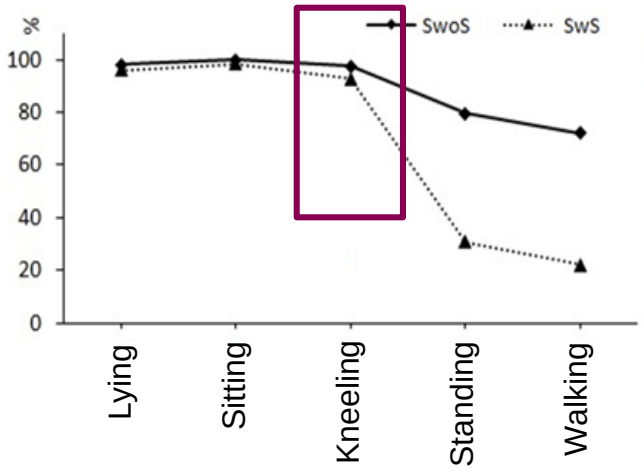
Results: GMFM-88 Crawling & Kneeling

	CP-SwoS	CP-SwS	*p*
C) Crawling & Kneeling %:	98	93	0.035

Total: 14 items

Item 48: High kneeling 10 sec	19/19 (100%)	14/17 (82%)
Item 51: Walks forward on knees 10 steps	16/19 (84%)	10/17 (59%)

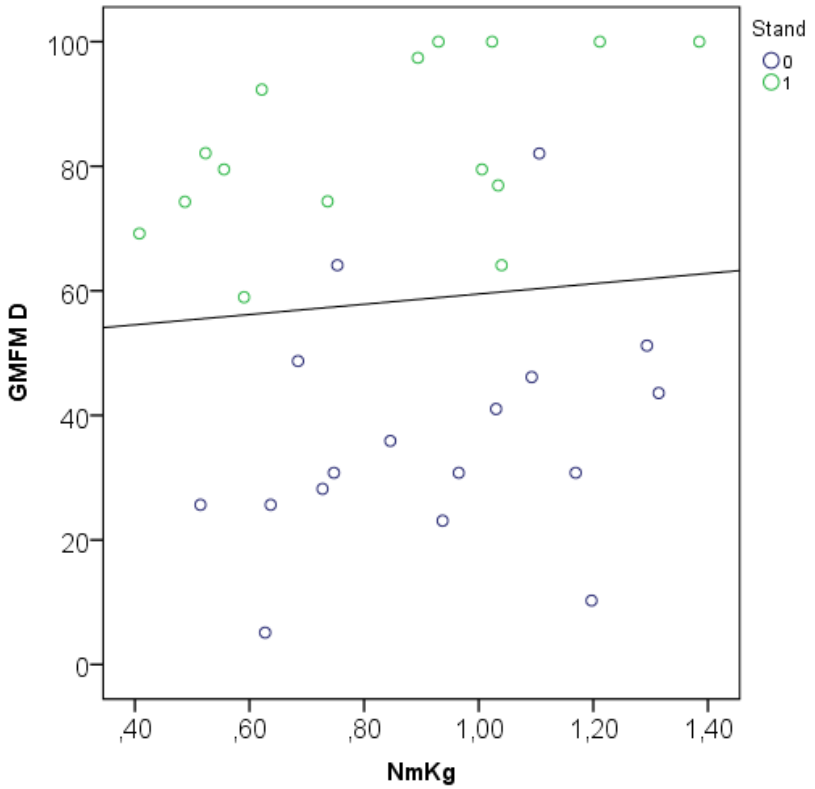




(p< 0.05)

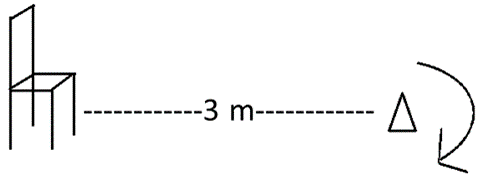
Results

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



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	*p*
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 Walking

confirming 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!