TYPICAL AND ATYPICAL DEVELOPMENT OF POSTURAL CONTROL
Mijna Hadders-Algra, MD, PhD

Institute of Developmental Neurology
Beatrix Children’s Hospital
University Medical Center Groningen
The Netherlands
www.developmentalneurology.com
m.hadders-algra@umcg.nl

POSTURAL CONTROL IS VERY COMPLEX
• Phylogeny: upper limbs increasingly less involved in postural control → two limb based postural control → high demands on neural control
• Protracted course of human postural development
• Complex control system easily affected in developmental motor disorders

GENERATION OF POSTURAL ADJUSTMENTS
• During external perturbations.
• During self-generated voluntary movements.
**DEVELOPMENT OF VARIATION IN RESPONSES DURING FORWARD TRANSLATIONS**

5-6 MONTHS

- Slow
- Fast

7-8 MONTHS

- Slow
- Fast

9-10 MONTHS

- Slow
- Fast

**SUMMARY PERTURBATION STUDIES (1)**

- Direction-specificity present early after term age → probably innate origin
- Early life: variable repertoire of direction-specific postural adjustments: primary variability
SUMMARY PERTURBATION STUDIES (2)

- From 3 months onwards: selection of specific adjustments which fit situation best; selection based on trial and error based experience
- From 9-10 months emergence of EMG amplitude modulation; ability affected by trial and error based experience

US BRAIN LESION AND NEUROLOGICAL CONDITION AT PRE-SCHOOL AGE

Hadders-Algra et al. Brain 1999

PATERN VARIATION DURING FAST FW TRANSLATIONS

PATERN VARIATION INDEX (PVI) DURING FAST FW TRANSLATIONS

STUDY GROUPS

- 13 preterm children (<1500g) with ultrasound lesions of the periventricular white matter (PWM); n = 10, periventricular cyst formation (W3), n = 3, large, intense echodensities extending into the deep layers of the white matter (W4), gestational age of birth: 25-34 weeks (median: 28), age at assessment: 1.5-4.5 years.
- 13 preterm children without brain lesions: matched to group A concerning GA, SGA, sex and age at assessment.
- 13 healthy full-term children: matched to group A concerning sex and age at assessment.
Results

- All children direction specific postural adjustments, except child with spastic tetraplegia.
- PWM-group significantly less variation in responses during FW-translations than PT-N (p<0.01) and FT-group (p<0.05).
- PWM-group > 2 years significantly shorter latencies to postural responses than other children > 2 years.
- Preterm children (PWM and PT-N) higher sensitivity to platform velocity than FT-children.
- In contrast to FT-children, preterm children (PWM and PT-N) unable to modulate EMG-amplitude with respect to initial pelvis position during FW-translations.

Conclusions

- PWM-lesions and preterm birth have a different adverse effect on postural adjustments.
- PWM-lesions are associated with:
  * a limited repertoire of postural response variation
  * shortened latencies to the onset of the responses, indicating reduced processing time.
- Preterm birth is associated with:
  * an inability to modulate EMG-amplitude with respect to initial sitting position
  * an increased sensitivity to platform velocity, i.e. muscle stretch.
  ➔ This implies a shift of postural control, which is guided by feedforward processes based on prior experience, to a form of postural control, which is dominated by feedback mechanisms.

GENERATION OF POSTURAL ADJUSTMENTS

- During external perturbations.
- During self-generated voluntary movements.

POSTURAL ADJUSTMENTS DURING REACHING IN INFANCY

(De Graaf-Peters et al. EBR, 2007; Van Balen et al. EBR, 2012)

- Around 4 mo: ± 40% of reaches accompanied by direction-specificity, at 18 mo ± 60%, and at 2 years reaches virtually always accompanied by direction specificity
- Primary variability: varied use of repertoire of direction specific adjustments
- Selection emerges between 4 and 6 mo
- Recruitment order: variation, with gradual change in preference from top-down to bottom-up
- Amplitude modulation emerges at 9-10 mo
**Postural muscle activity during reaching in children aged 2-10 years**

- Typically developing
- Mild spastic hemiplegia
- Severe bilateral spastic CP

*Van der Heide et al. DMCN 2004*

**Latencies to postural muscle activation**

- TD 2-4 yrs
- SH 2-4 yrs
- Bi-CP 2-4 yrs
- TD 5-7 yrs
- SH 5-7 yrs
- Bi-CP 5-7 yrs
- TD 8-11 yrs
- SH 8-11 yrs
- Bi-CP 8-11 yrs

*Van der Heide et al. DMCN 2004*

**EMG-amplitude modulation**

- head trunk pelvis elbow upper arm max velo
- TD 2-4 yr
- 5-7 yr
- 8-11 yr
- Hemi CP 2-4 yr
- 5-7 yr
- 8-11 yr
- Bilat CP 2-4 yr
- 5-7 yr
- 8-11 yr

*Van der Heide et al. DMCN 2004*
POSTURAL CONTROL IN CHILDREN WITH CP DURING REACHING (2)

- Stereotyped top-down recruitment
- Absent or reduced ability to adapt the degree of muscle contraction to condition
- Reduced capacity to modulate postural muscle activity related to PEDI scores, i.e. activities of daily life
- Indications that foot and/or back support facilitated capacity to modulate postural activity

POSTURAL CONTROL IN CHILDREN WITH CP PRACTICAL IMPLICATIONS (1)

- Children with severe forms of CP
  - i.e. not able to sit independently by the age of 4 years
  - basic level of postural control lacking
- MANAGEMENT: should focus on provision of adequate postural support

POSTURAL CONTROL IN CHILDREN WITH CP PRACTICAL IMPLICATIONS (2)

- Children with less severe forms of CP
  1. Limited repertoire of postural strategies
     MANAGEMENT: accept atypical postural strategies
  2. Problems in adaptation of postural activity to specific situation

POSTURAL CONTROL IN CHILDREN WITH CP PRACTICAL IMPLICATIONS (3)

- Strategies to cope with problems in adaptation:
  - stereotyped top-down recruitment (focus on stabilization head in space)
  - antagonistic co-activation in case of serious disturbance of balance
  - Strategies should not be ‘treated away’
- Adaptation can be improved by active training
- Adaptation can be facilitated by proper support

THANKS TO COLLABORATORS

**GRONINGEN**
- Victorine De Graaf-Peters
- Linze Jaap Dijkstra
- Bert Otten
- Lieve Van Balen
- Ingrid Van der Fits
- Jolanda Van der Heide

**STOCKHOLM**
- Eva Brogren Carlberg
- Hans Forssberg
- Åsa Hedberg

**OSLO**
- Bjørg Fallang

MORE INFORMATION?

www.developmentalneurology.com

m.hadders-algra@umcg.nl