Quantitative techniques for assessment of upper extremity movement dysfunction

Measurement of muscle stiffness in wrist and finger flexors

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The brain damage in CP is not progressive, but symptoms change

- No contractures when the child is born
- Different growth rate of bone and muscle, and early signs of contracture (Herskind et al. 2015, Gough and Shortland 2012)
- Increased whole muscle passive stiffness in the calf has been described as early as three years of age (Willerslev-Olsen et al. 2013)

Contracture formation in CP is progressive and results in altered/deteriorated

- range of motion
- movement direction as the joint axis changes
- precision
- forces across the joint and bone growth zones
  $\rightarrow$ bone and joint deformation
Progressive contracture formation also with **no increased tone** (Ashworth 0)

Hägglund, Wagner 2011
pROM of ankle in 355 children with CP (CPUP)

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de Bruin et al 2014

- More collagen in the extracellular matrix surrounding larger muscle fiber bundles
- Potential for increased stiffness of the muscle
Forearm flexor muscles in children with cerebral palsy are weak, thin and stiff

Ferdinand von Walden 1, Kian Jalaleddini 2, Björn Evertsson 3,4, Johanna Friberg 1,4, Francisco J. Valero-Cuevas 2,6, Eva Pontén 1

CP (n=9) 6 boys/3 girls scheduled for upper limb surgery
TD (n=15) 10 boys/5 girls

Grip strength (10s isometric contraction) significantly lower in CP

Ramp-and-hold perturbation of 50° with a low velocity (5°/s)
The hand is moving from 0 to 10 s
Data was recorded for another 2 s (time 10–12 s)
Muscle passive stiffness was increased 2-fold in CP
CP 4.65 ± 3.42 vs.
TD 1.96 ± 0.62, p<0.05

Viscosity didn’t differ significantly

Cross-sectional area of flexor carpi radialis (FCR)
in cm² in TD and CP.
p < 0.05.

Did not correlate to passive stiffness or viscosity in CP or in TD children
Muscle size correlated to age ($R^2=0.58$, $p<0.01$) in TD children/adolescents but not in CP.

Muscle size correlated to body weight ($R^2=0.92$, $p<0.0001$) in TD but not in CP.
Muscle size correlated to strength ($R^2=0.58$, $p<0.01$) in TD and in CP ($R^2=0.60$, $p<0.05$)

**Conclusion**

- Wrist flexor muscles in CP are twice as stiff as in TD children/adolescents even though the muscles have a smaller cross-sectional area.
- Grip strength is both in CP and TD related to muscle cross-sectional area of the wrist stabilizing flexor carpi radialis muscle.
- The FCR cross-sectional area in CP is not correlated to body weight or age → suggesting that the diminished growth is related to the extent of the brain damage.
Future perspectives

- Stiffness in even a few muscles can add obstacles to smooth and efficient movements (Valero-Cuevas et al. 2015)
- Stiffness measurements could help in planning tendon transfer surgery or tendon lengthening surgery
- Stiffness measurement devices, with slow perturbation not eliciting spasticity, should be developed for more joints
- Ultrasound measurements of echogenicity and stiffness should be developed for surgical planning
- The long term relationship between intramuscular tendon release (open or percutaneous) and stiffness + strength should be evaluated and compared with control.

References:


Willerslev-Olsen, M., Lorentzen, J., Sinkjaer, T., and Nielsen, J.B. (2013). Passive muscle properties are altered in children with cerebral palsy before the age of 3 years and are difficult to distinguish clinically from spasticity. Dev Med Child Neurol 55(7), 617-623


