EXERCISE FOR CEREBRAL PALSY
THE EXECP PROJECT

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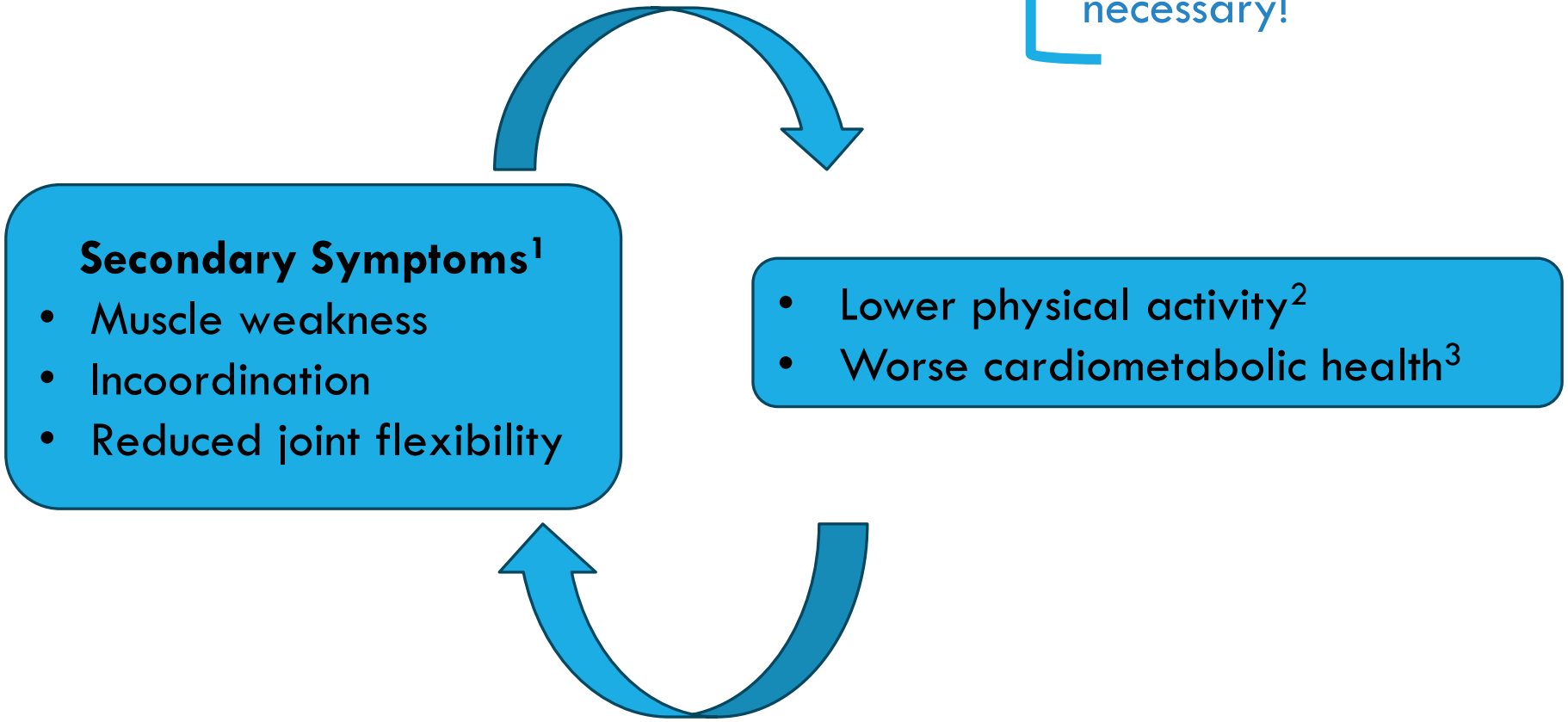
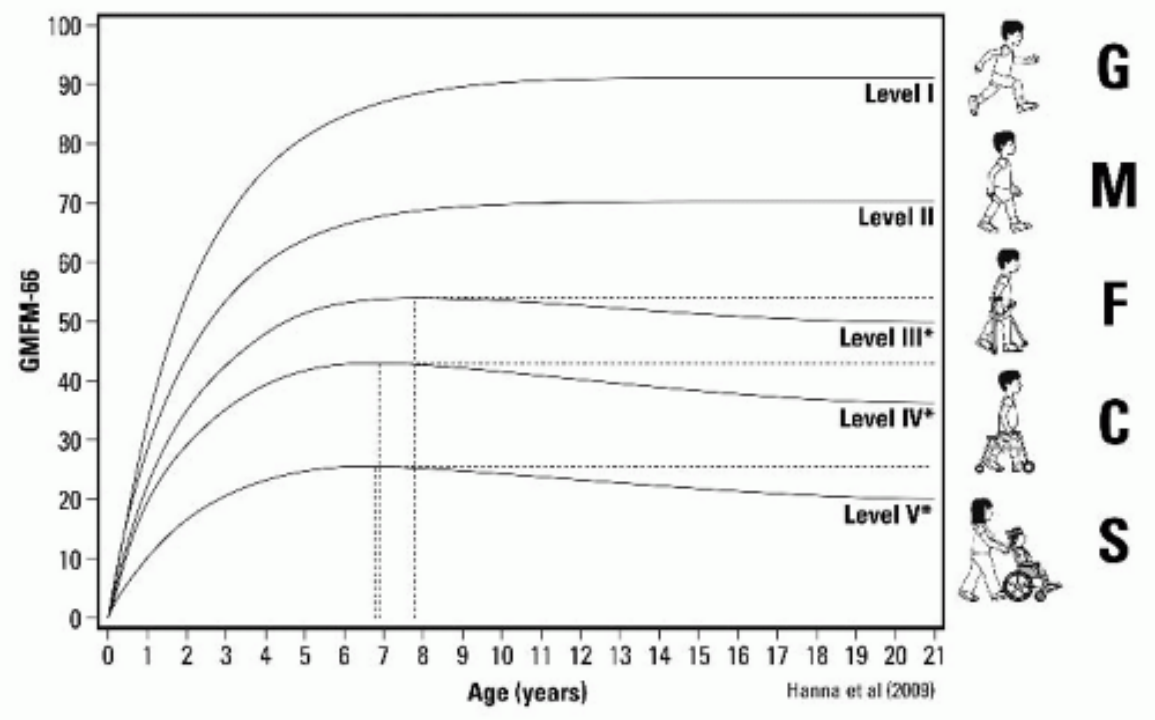
INTRODUCTION

Interventions able to stop this downward spiral of loss of function and inactivity are necessary!



FUNCTION DECLINE[4]



n = 657, 3455 observations. Hanna et al., (2008)

Bottos et al., (2001) – Contacted 72 adults with CP 33 ± 9 years (range:19-65) after they stopped attending the pediatric clinic (max age 18).

- Independent walkers at 18 yrs = 29. At follow-up 13 lost walking independency (45%)!

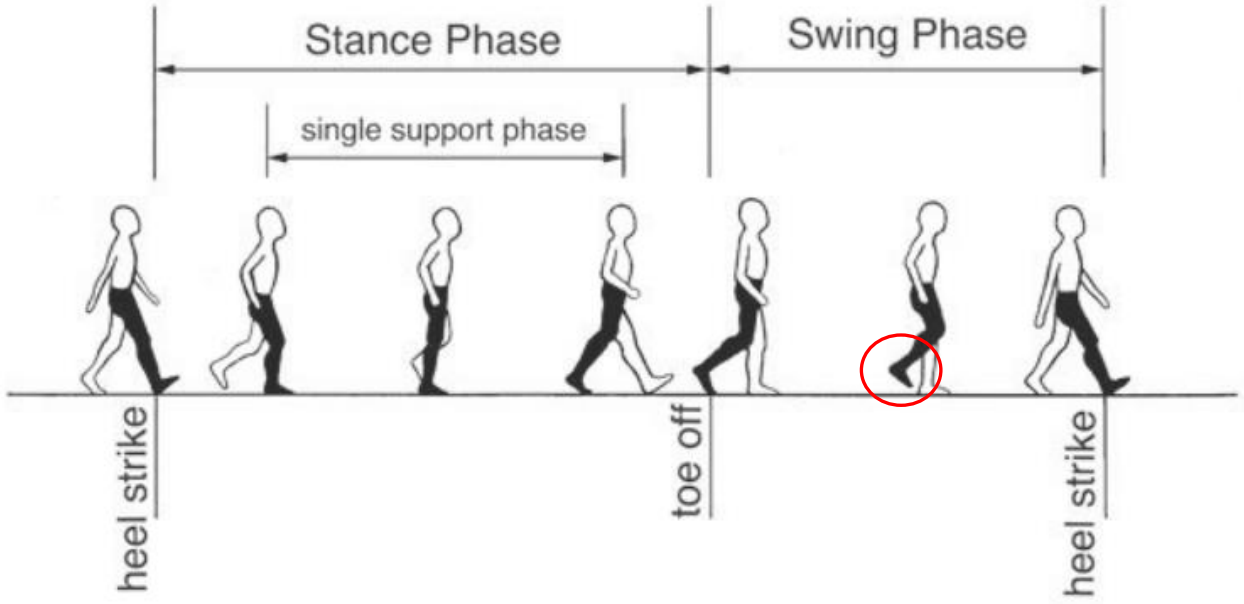
Jahnsen et al., (2003) – Mailed questionnaire Norway. 402 adults with CP 34 ± 11 years (range:18-72).

- 97 (27%): increased walking ability before 25 yrs.
- 102 (28%): no change in walking ability
- 106 (44%): decreased walking ability before 35 yrs.

GROSS MOTOR FUNCTION

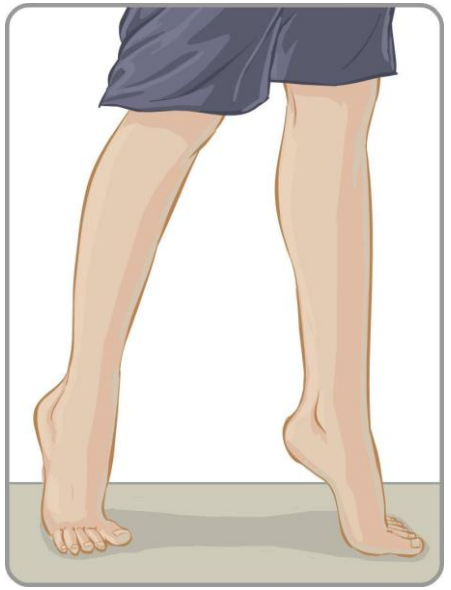
- Activation of agonist and synergist muscles.
- Concomitant inhibition of antagonist muscles.
- Muscle mass.
- Joint flexibility – in CP mostly muscle extensibility.
- Overall motor coordination to execute multi-joint actions such as walking and squatting.
- Aerobic and anaerobic capacities (limits volume, not a single action).

IDENTIFYING THE LIMITING FACTOR



Insufficient ankle dorsiflexion during the swing phase

- Decreased TA voluntary activation (spastic paresis)?
- Increased passive plantarflexors stiffness?
- Increased active plantarflexors stiffness (spastic co-contraction)?
- Motor coordination?



Toe walking

- Insufficient range of motion (i.e., contracture)?
- (In)Voluntary activation?

STRENGTH TRAINING

- Widely researched!
- Effective in increasing muscle strength[5] if established training guidelines[6] are followed.
- Conflicting evidence about changes in motor function, why?!

Single joint exercises
Single muscle exercises
Lack of specificity
Inadequate training load
Strength was not the limiting factor!

An appropriate intervention should train all relevant muscles with naturalistic patterns of neural activation!

GILLET ET AL., (2015, 2018)[7] – FAST CP

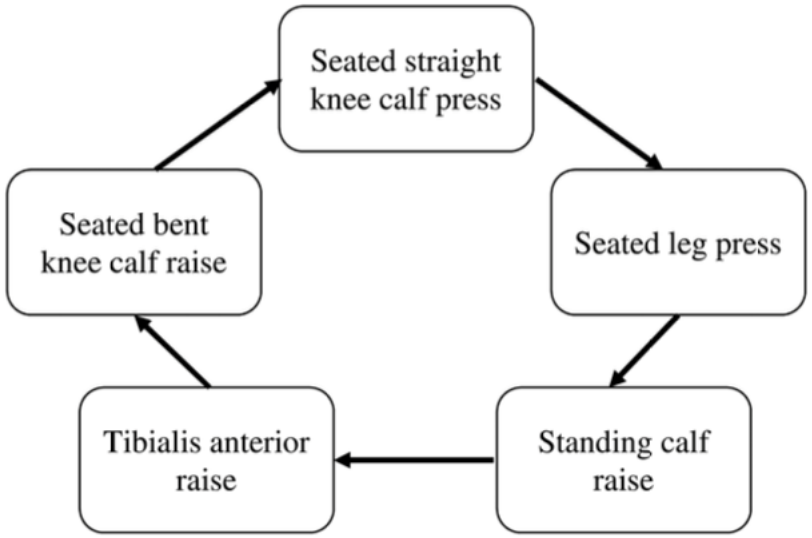
Sample

Spastic CP, GMFCS I, II.

Mean age: 21, range: 15–27

N = 8 + 8

Strength Circuit training



Supervised training: 1–3 participants

Table 3 Training progression of resistance exercises to be performed in the FAST CP programme

Week	Speed of movement (s)	Load	Sets	Repetitions	Rest (s)
1–2	Concentric: 2 Eccentric: 2	60% 12 RM	3	12	90
3–4	Concentric: 2 Eccentric: 2	80% 12 RM	3	12	90
5–6	Concentric: 1 Eccentric: 2	100% 10 RM	3	8	90
7–8	Concentric: 1 Eccentric: 2	100% 8 RM	3	8	90
9–10	Concentric: X Eccentric: 2	100% 6 RM	4	6	120
11–12	Concentric: X Eccentric: 2	100% 6 RM	4	6	120

Amount of weight that can be moved through the available range of motion a designated number of times to fatigue. Load will be adjusted in 0.25 kg increments to maintain defined repetition number.
CP, cerebral palsy; FAST, functional anaerobic and strength training; RM, repetition maximum; X explosive concentric movement.

GILLET ET AL., (2015, 2018)[7] – FAST CP

Anaerobic training

- Step up
- Bean bag run
- Lateral step-ups
- 5 m sprints
- Up and down stairs
- 4 cone run

Improvements

Muscle volume: Soleus, medial and lateral gastrocnemius
Isometric plantarflexion strength
6 minutes walking test
Muscle power sprint test
10x5 m agility test

No changes

Isometric dorsiflexion strength → 1 DF vs. 4 PF!
Stairs up and down
Muscle power sprint test
10x5 m agility test

OTHER PROTOCOLS[7]

McPhail et al., (1995): Isokinetic (90 deg/s) training for knee flexors and extensors.

3x per week, 8 weeks. 3x5 MVC → ↑muscle strength and GMFM.

Dodd et al., (2003): Heel raises, half squat, step up. Home trained!

3x per week, 6 weeks. 3 x 8-10 reps → ↑ muscle strength and GMFM.

** Although we know that there are various limiting factors, only Gillet et al., (2015) tried to address more than one!

FLEXIBILITY TRAINING[8]

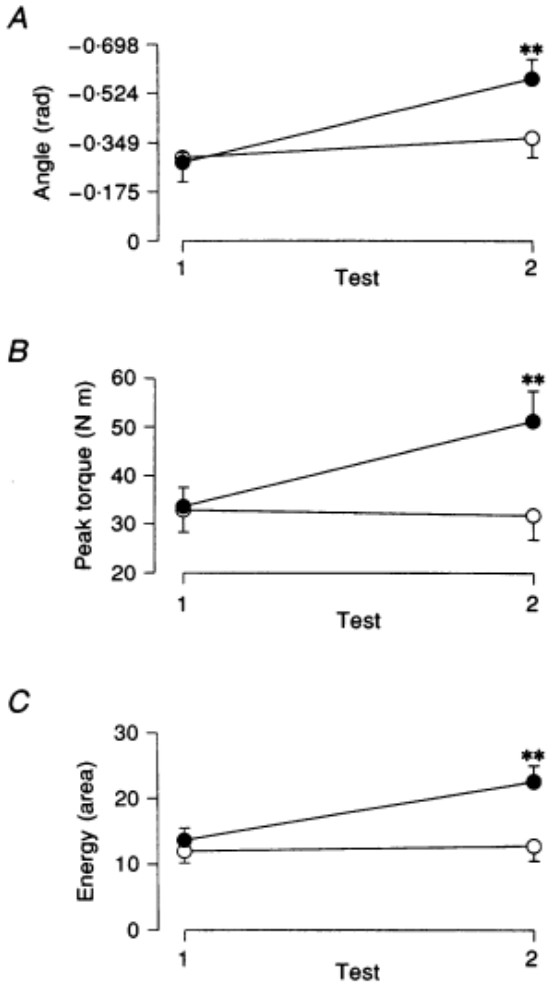
- Broadly used in CP, unclear efficacy
- Low scientific evidence: short duration (3 months) and often unreliable assessment methods
- Structural changes vs. tolerance to stretch[8]: can the CP muscle adapt?!
- Clinical + sports training vs. current research evidence

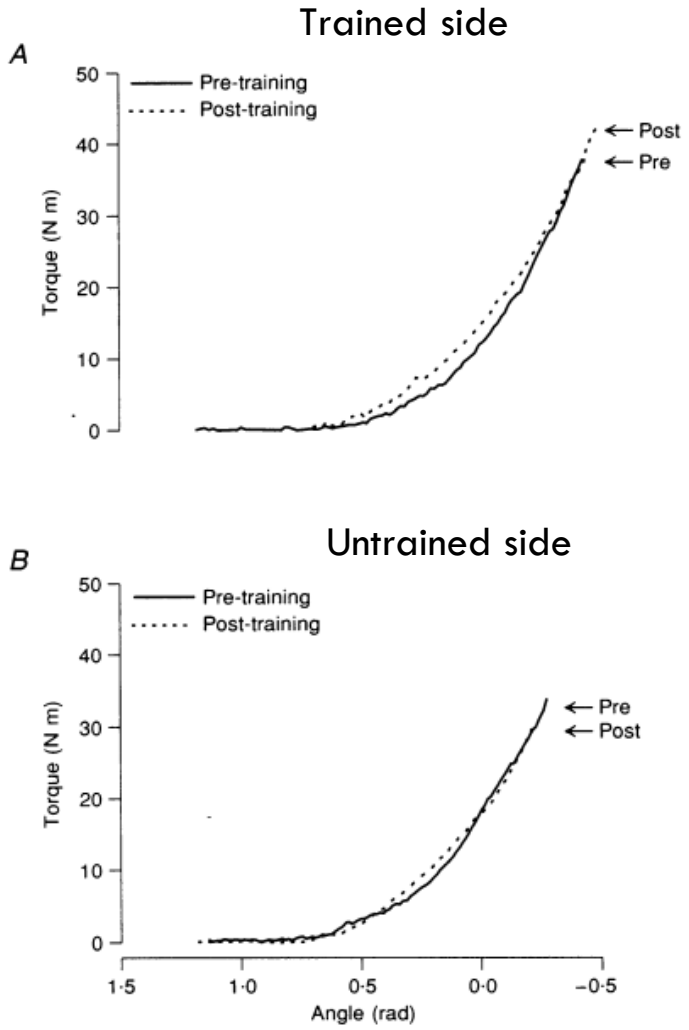
> The chronic effects of stretching must be understood! Preventing limited range of motion and contractures is vital!

MAGNUSSON ET AL., (1997)[9]

n = 7.
Passive-static stretching: 20 days, twice a day.
5 sets of 45 s stretches, 15-30 s of rest.
Intensity = " Stretch feeling".

Conclusion: No morphological adaptations occurred; the changes were seen were due to stretch tolerance!





BOAKES ET AL., (2006)[9]

16 yr old girl – Femoral lengthening of 4 cm.

"Dramatic increase in fascicle length and in vivo sarcomere length decreased slightly reveals an increase in serial sarcomeres from 25,000 to 58,650".

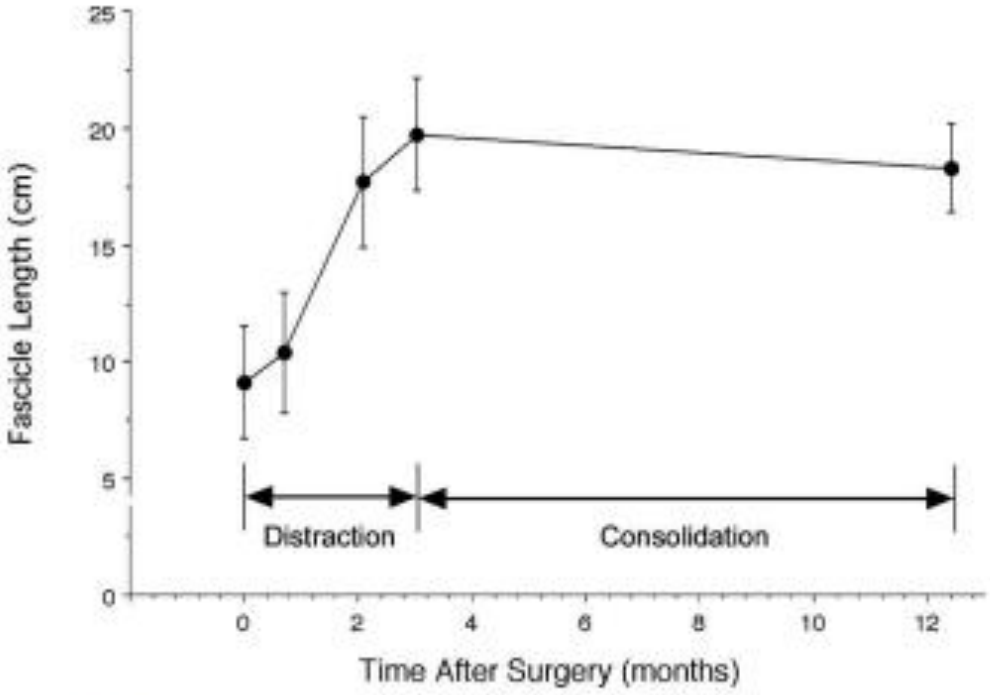


Fig 2. A graph shows the relationship between fascicle length measured by ultrasound and time after surgical placement of the ISKD® frame during distraction and consolidation. Fascicle length increased rapidly by approximately 100% during the distraction phase.

TABLE 1. Vastus Lateralis Muscle Cell Properties

Date	Age (months)	Biopsy Timing	Modulus (kPa)*	Slack Sarcomere Length (μm)*
April 1, 2005	209	Before lengthening	31.9 ± 4.3	2.39 ± 0.28
November 30, 2005	217	After lengthening	34.2 ± 5.2	2.26 ± 0.06

*Results shown as mean and standard deviation (n = 5)

GAULT-COLAS ET AL., (2024)[9]

44 yr woman, stroke. Guided self rehabilitation contract for 4 years.

Mean daily practice:

20 min high-intensity passive-static stretch per muscle!

81 min of stretching per day!

Active-static stretch with maximum effort using antagonist muscles.

Maximal voluntary activation of the antagonist muscle (active-static stretch)

GAIT TRAINING[10]

Few studies, small samples, results are promising!

- Safe, feasible and likely effective in improving walking ability
- Inclined treadmill strategy
- Walking is automatic and boring, augmented reality may be a good solution.
- Assistive devices (e.g., exoskeletons).

Gait training has the potential to enhance motor coordination, joint mechanics and aerobic capacity!

WILLERSLEV-OLSEN ET AL., (2014):

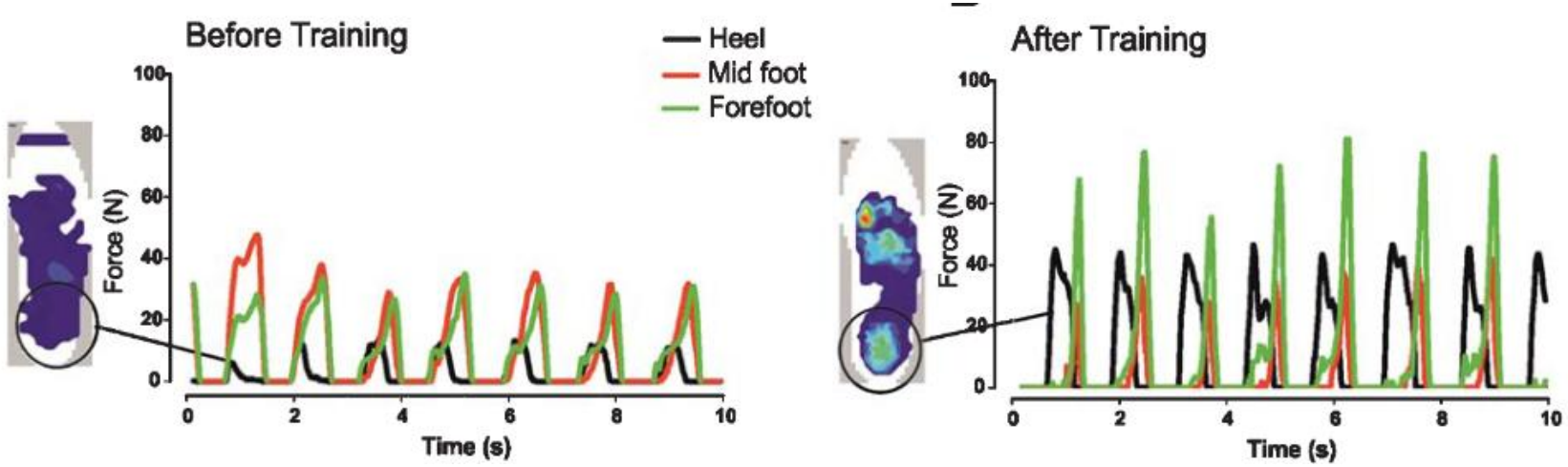
17 children with CP (4–14 years).

4 weeks of home-based inclined treadmill training, 30 minutes per day.

↓triceps surae passive stiffness,

↑toe lift in the end of the swing phase,

↑heel strike.



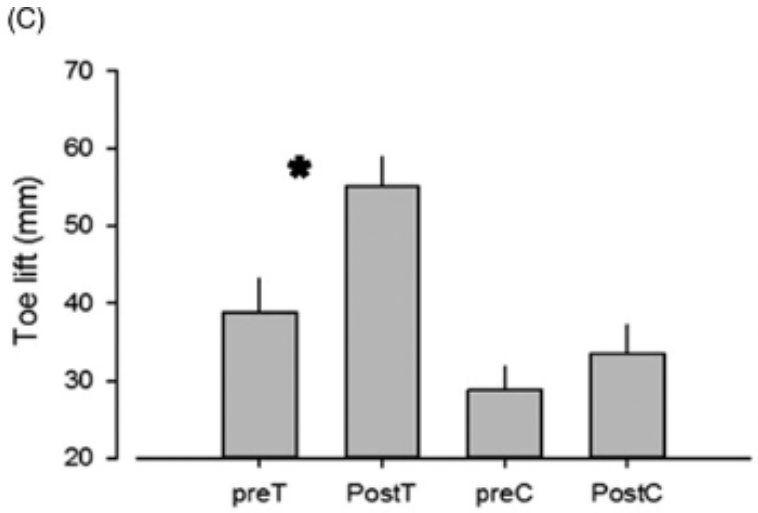
LORENTZEN ET AL., (2017)

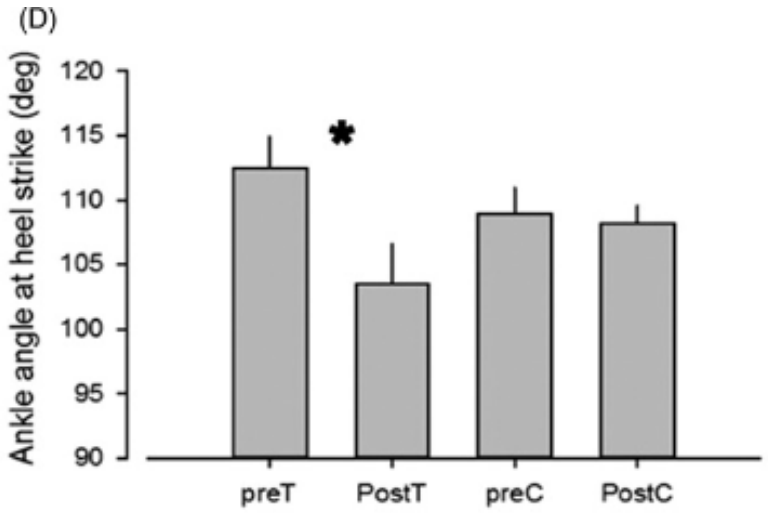
RCT: 32 adults with CP (38 yrs ± 12), 16 in the training group. 6 weeks of home-based treadmill training, 30 minutes per day.

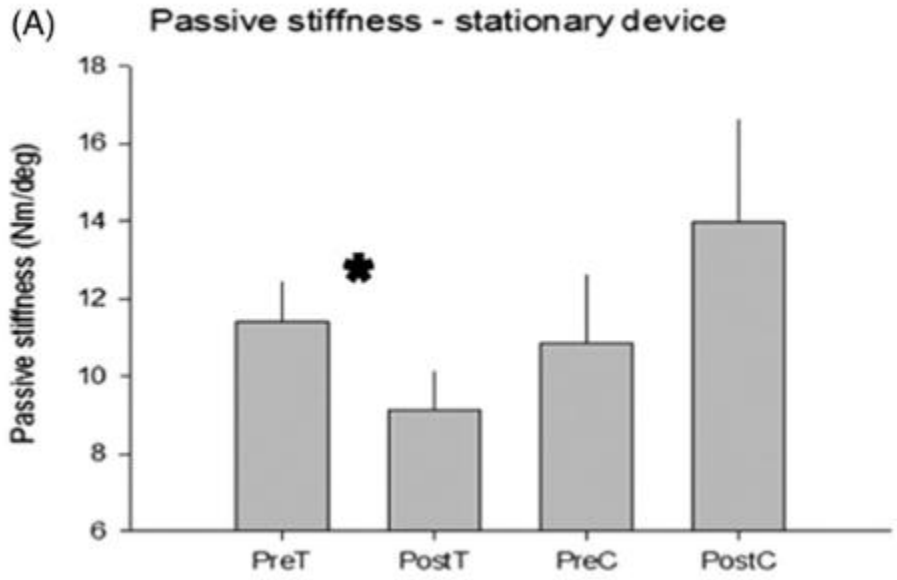
↓angle joint passive stiffness,

↑toe lift in the end of the swing phase,

↑heel strike.



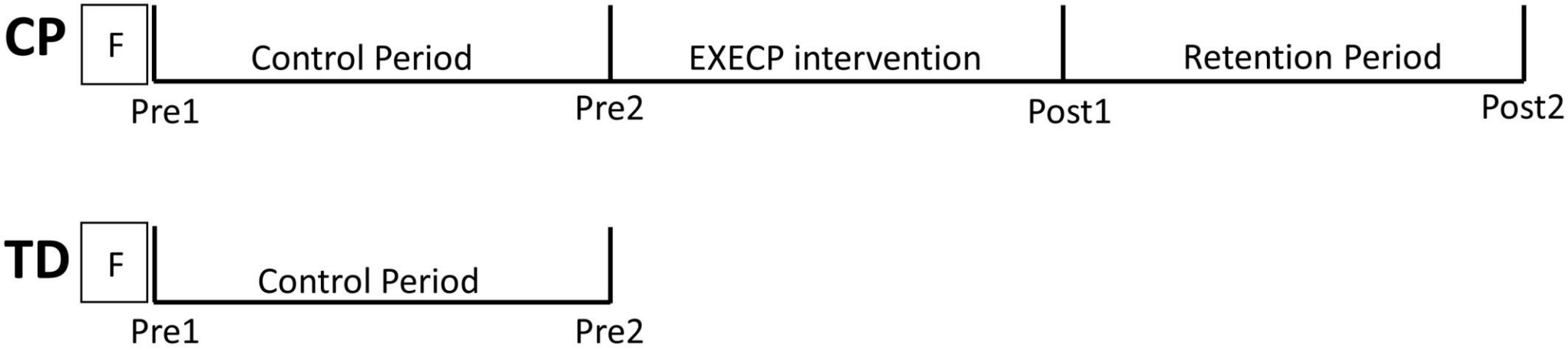




EXECP INTERVENTION[11]

- Strength, flexibility and gait training for children and young adults with spastic CP.
- Do the induced adaptations last three months?

  - 18 participants with CP
  - 17 sex- and age-matched typically developing controls



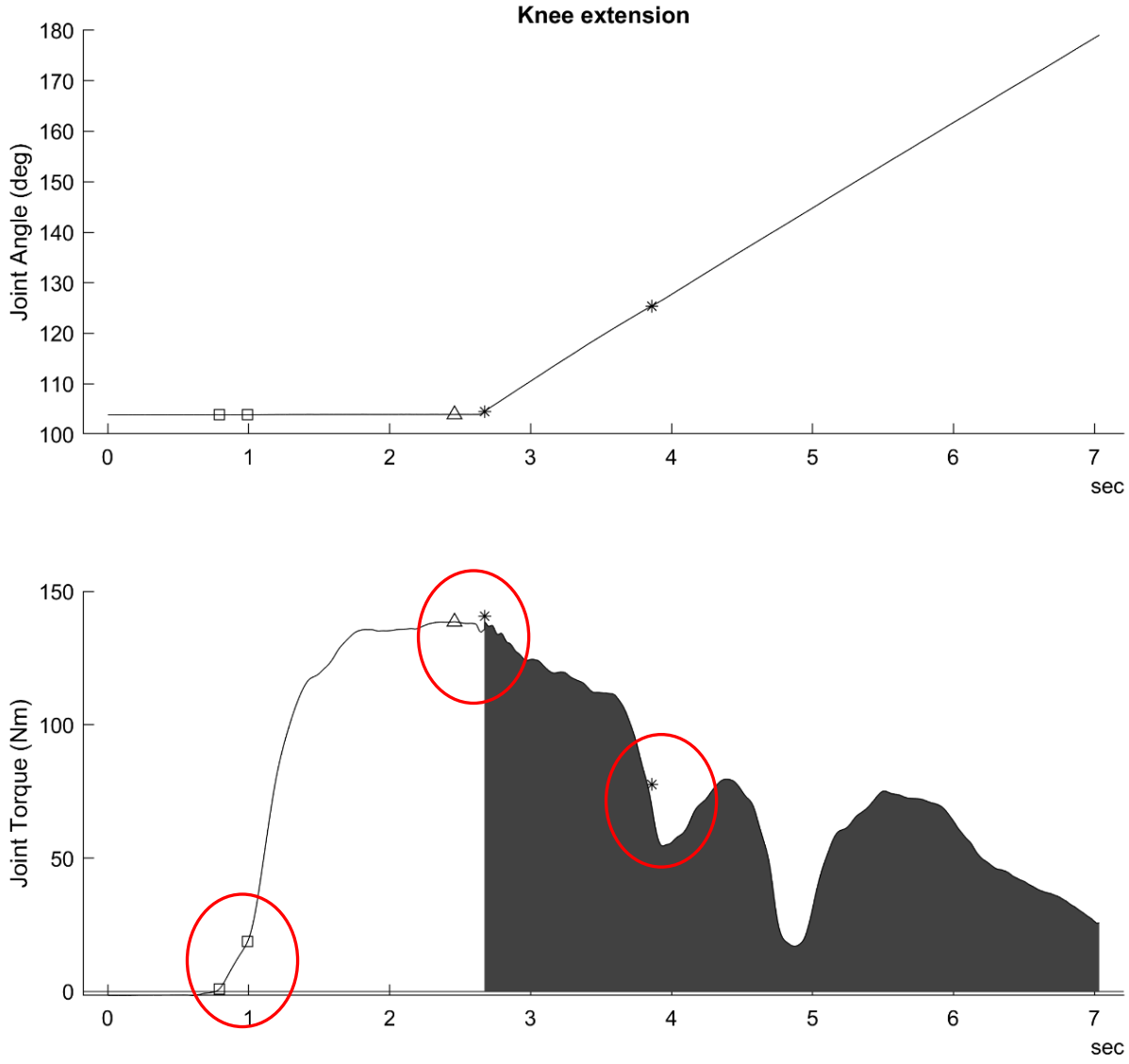
EXECP INTERVENTION

2 to 3 90-min training sessions per week, for 12 weeks.

- Gait (5–10 min) :
  quality over quantity!
- Strength (60–75 min):
  lower limbs and trunk muscles.
  5-7 exercises per session.
- Flexibility (0–20 min):
  muscles diagnosed short.

Details in Valadão et al., (2021)
https://execp.fi


HUOMIO!


Knee extension
Joint Angle (deg)
180
170
160
150
140
130
120
110
100
0
1
2
3
4
5
6
7
sec
Joint Torque (Nm)
150
100
50
0
0
1
2
3
4
5
6
7
sec

RESULTS
(AFTER THE INTERVENTION)

- Walking ability
- Motor Function
- Muscle Strength (thigh and trunk muscles)
- Flexibility (hip and knee joints)
- No changes for shank muscles
- No changes in cardiometabolic risk factors (blood pressure, BW, fat %, pulse wave vel)
- No side-effects

RESULTS
(AFTER 3 MONTHS)

- Thigh strength and hip flexors flexibility 
- Walking ability and knee flexors flexibility 
- Not tested: Trunk strength, GMFM, cardiometabolic markers

DISCUSSION

- The EXECP intervention was feasible, safe and effective!
- Detraining effects were seen 3 months after cessation. Training must be a life-long decision, just like brushing the teeth!
- The intervention was not able to attenuate cardiometabolic risk factors. Aerobic exercise is required!

THANK YOU!

Feel free to contact me at pedro.valadao@jyu.fi

Detailed information in video and text are available for anyone wanting to try it at:

Protocol article: Valadão et al., (2021)
www.youtube.com/@EXECP-kv4io
execp.fi
osf.io/4kbjh/

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