Evidence based techniques for pediatric rehabilitation

Stretching and Strengthening exercises

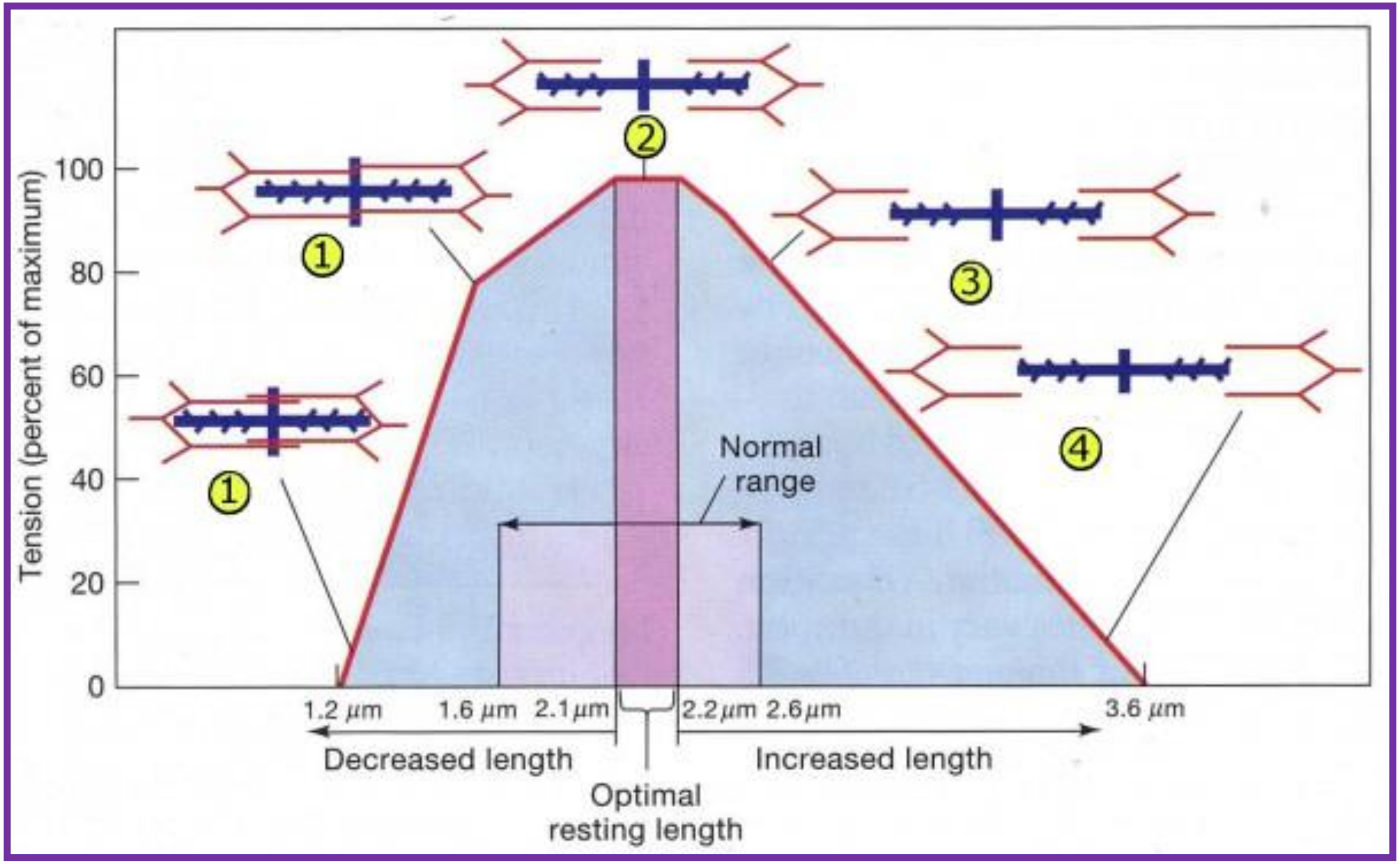
가톨릭의대
재활의학교실
장대현

Definition

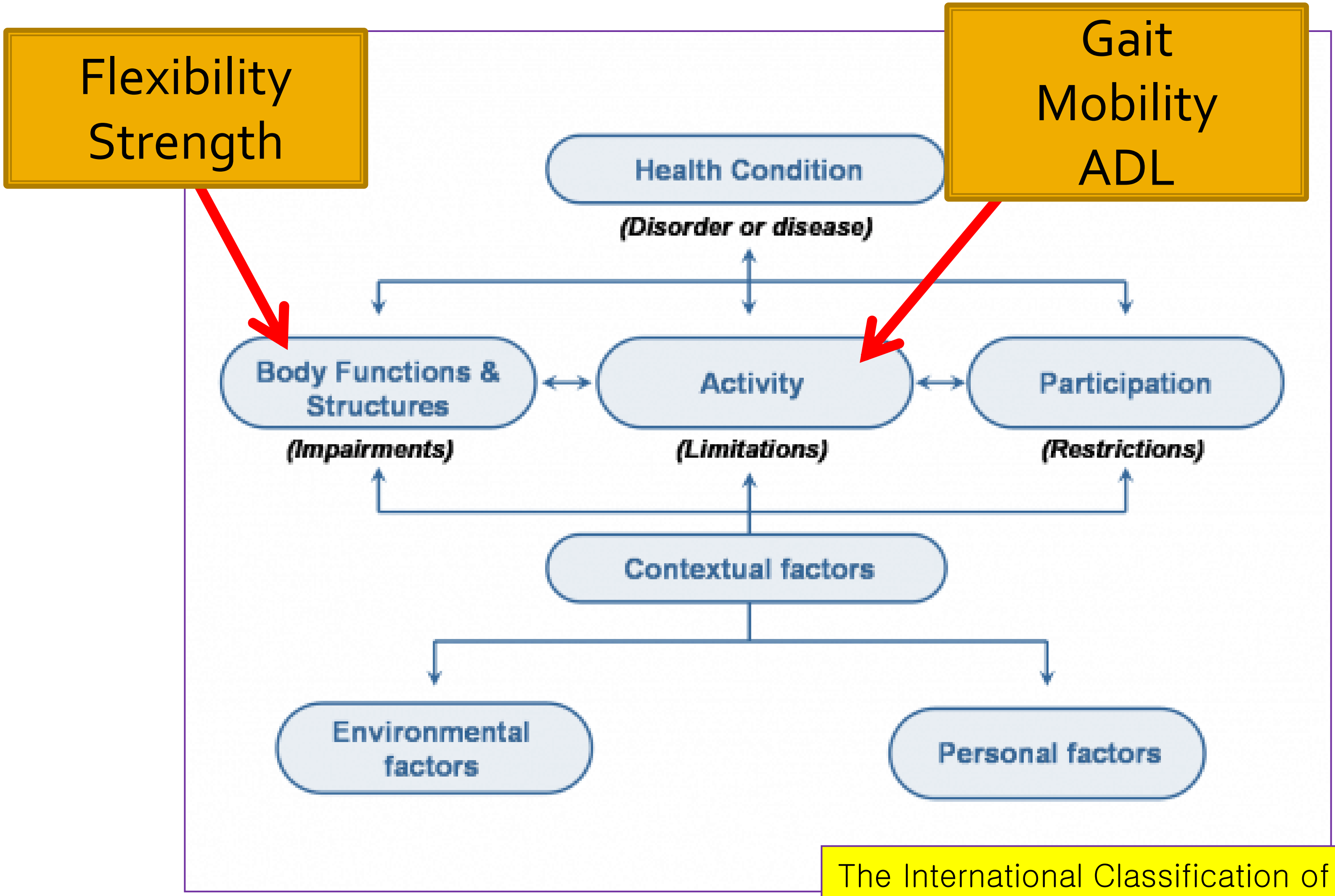
- Stretching
  - Flexibility exercise
  - Lengthen pathologically shortened soft tissue

- Strengthening
  - Strength is the maximal force a muscle can generate.
  - Power is the product of strength (speed of movement).
  - Muscular endurance is the capacity to sustain repeated muscle actions.

Length-tension relationship of the muscle



Evidences of stretching and strengthening



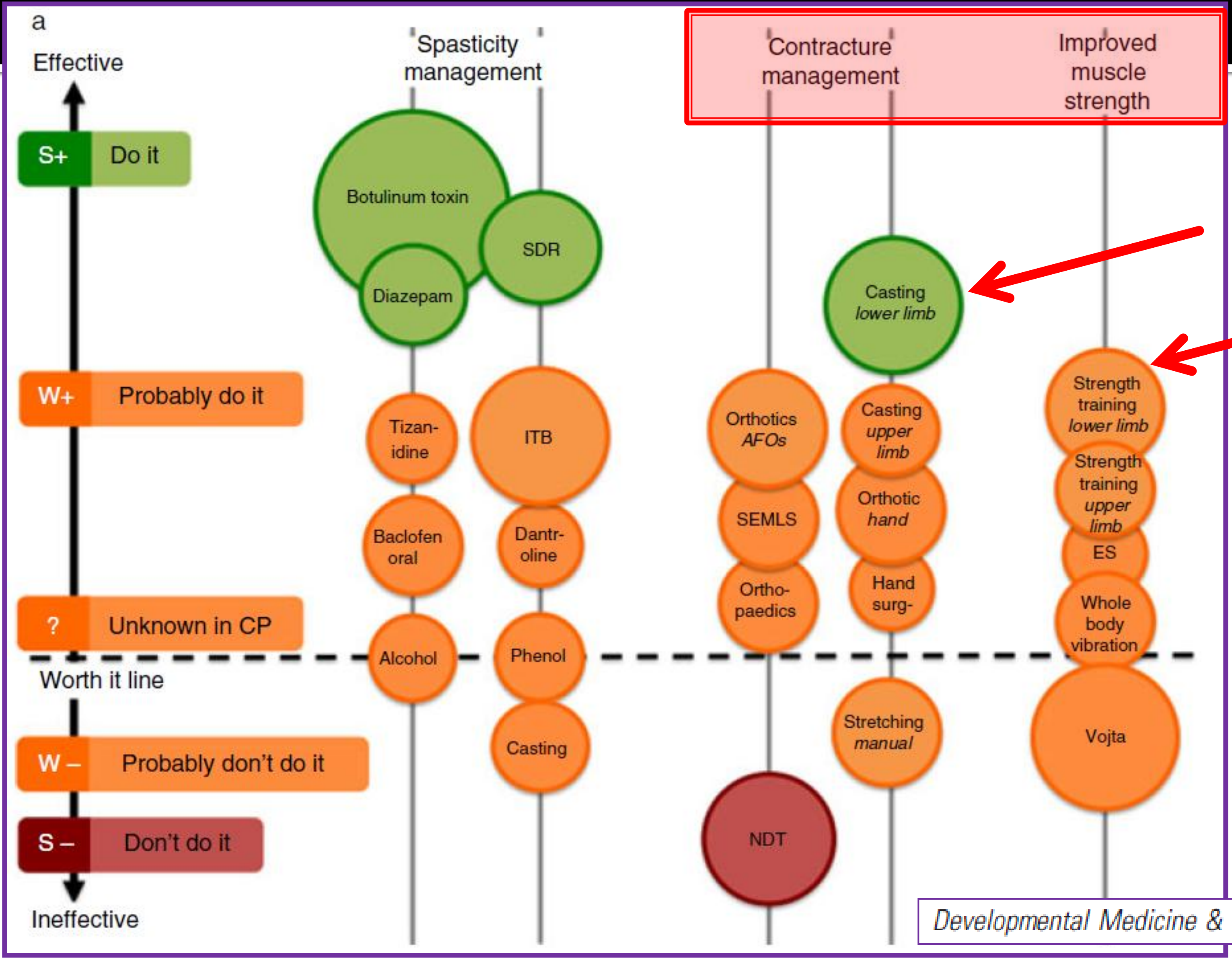
The International Classification of Functioning, Disability and Health (ICF)

Evidences of stretching and strengthening

- Pediatric rehabilitation
  - Cerebral palsy
  - Neuromuscular disease (Myopathy, SMA, CMT etc.)
  - Genetic disease (Down syn, PWS etc.)

Cerebral palsy

A systematic review of interventions for children with cerebral palsy: state of the evidence



Developmental Medicine & Child Neurology 2013

Strengthening exercise in CP

- Variety of methods
  - Progressive resistance exercise
  - Isometric exercise
  - Isokinetic exercise
  - Functional exercise
  - Weight-bearing exercise
- Training intensity?
- Training period?

Muscle strength training to improve gait function in children with cerebral

Table III: Results from Gross Motor Function Measure (GMFM) and time–distance gait parameters (n= 16)

	Before training, median (range)	*After training, median (range)*	*Wilcoxon signed rank p*
GMFM	84.8 (66.7–100)	90 (67.4–100)	0.003
Velocity, m/sec	1.2 (1–1.5)	1.25 (0.9–1.6)	0.859
Stride, m	1.1 (0.9–1.4)	1.15 (0.9–1.5)	0.059
Cadence, steps/min	132 (108–151)	130.5 (104–149)	0.016

		After training period, ...ge)	*Comparison All n=32*
		61.5)	<0.001
		1.3)	<0.001
		9.3)	<0.001
		05.5)	0.001
		8.6)	0.955
		07.9)	0.001
Ankle dorsiflexors, Nm	10.9 (0.6–20.5)	11.5 (0–25.7)	0.057
	46 (2-68.8)		
Ankle plantarflexors, Nm	30.4 (13–65.3)	33 (14.1–73.8)	0.132

-764

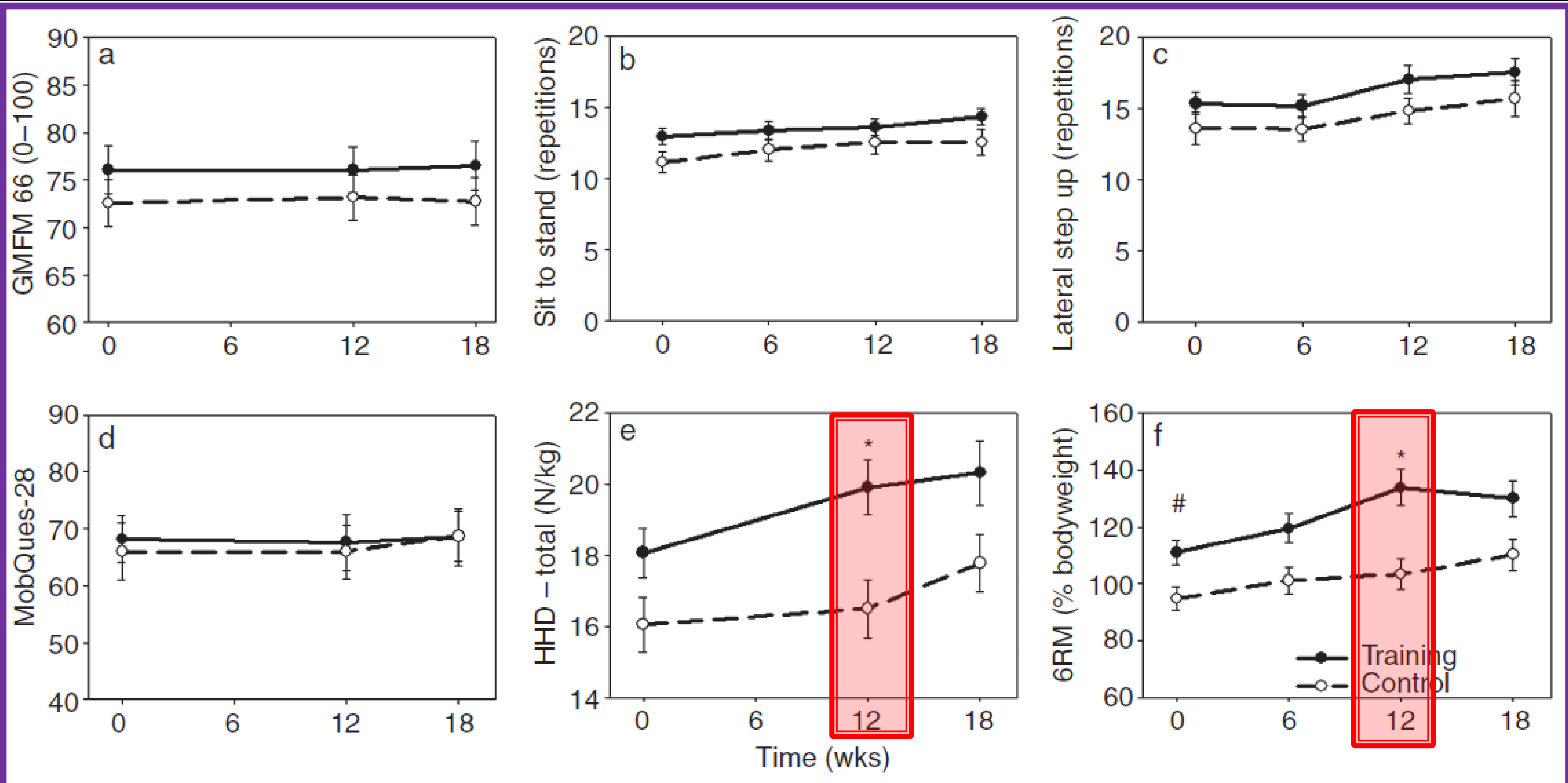
Therapeutic effects of strengthening exercise on gait function of cerebral palsy

Disability and Rehabilitation, 2008; 30(19): 1439–1444

	Pre training		Post training	
	Experimental	Control	Experimental	Control
Lateral step up	6.4 ± 4.1	6.6 ± 4.7	9.3 ± 4.8	8.5 ± 4.7
Squat to stand	11.6 ± 6	13.8 ± 5.6	13.2 ± 5.4	14.1 ± 5.8*
GMFMT	86.5 ± 13.3	85.2 ± 13.4	86.9 ± 13.4	85.4 ± 13.5
GMFMD	73.5 ± 25.7	74.5 ± 23.7	73.7 ± 26.6	74.6 ± 23.7*
GMFME	61.6 ± 34.1	61.4 ± 33.9	62.7 ± 34.1	61.4 ± 33.9*

Speed (cm/s)	54.7 ± 30.7	69.8 ± 43.0	74.6 ± 38.7	68.2 ± 42.9*
Stride length (cm)	62.5 ± 21.8	70.0 ± 32.1	80.0 ± 26.4	68.3 ± 24.6*
Cadence	106.8 ± 37.1	107.9 ± 48.4	109.7 ± 26	101.1 ± 47.4
Single support (%)	35.8 ± 10.0	38.2 ± 9.2	39.3 ± 11.0	36.5 ± 12.1
Double support (%)	22.0 ± 11.9	23.7 ± 17.6	15.8 ± 12.9	27.0 ± 22.7*

Effectiveness of functional progressive resistance exercise strength training on muscle strength and mobility in children with cerebral palsy: a randomized controlled trial



Developmental Medicine & Child Neurology 2010, 52: e107–e113

Increases in muscle volume after plantarflexor strength training in children with spastic cerebral palsy

Table I: Median values (range) for functional measures at different points in the strengthening programme. Timed Up and Go scores expressed as mean (SD)

	Baseline	Week 5	Week 10	Follow-up
Functional Mobility Scale	17 (4–18)	17 (8–18)	17 (8–18)	17 (5–18)
Gillette Functional Assessment Questionnaire	9 (2–10)	9 (2–10)	9 (7–10)	9 (8–10)
Timed Up and Go, s	5.6 (0.7)	5.5 (0.9)	5.63 (0.7)	5.37 (0.8)
Heel raises, *n*	1 (0–30)	4.5 (0–50)[a]	10 (0–50)[b]	9.5 (0–60)[c]

Table III: Mean (SD) gait parameters at different points in the strengthening programme

	Baseline	Week 5	Week 10	Follow-up
Knee flexion single support, °	14.3 (6.1)	16.1 (4.8)	13.4 (6.3)	14.5 (6.2)
Maximum ankle dorsiflexion, second half stance °	11.7 (10.7)	12.6 (10.2)	12.0 (9.2)	10.7 (11.1)
Cadence, steps/min	117.9 (20.9)	120.1 (17.1)	119.6 (14.8)	121.8 (10.1)
Walking speed, m/s	1.03 (0.3)	1.08 (0.3)	1.06 (0.2)	1.12 (0.2)
Time spent in single support, %	38.7 (3.4)	39.0 (3.2)	38.8 (2.6)	39.4 (2.2)
Participants, *n*	13	13	13	10

Developmental Medicine & Child Neurology 2009, 51: 429–435

Pediatric endurance and limb strengthening for children with cerebral palsy (PEDALS) – a randomized controlled trial protocol for a stationary cycling intervention

Neurorehabilitation and Neural Repair
27(9) 816–827

- Spastic dip
- 7-18 years
- 60명
- 12 weeks (3 times/wk)

Table 3.
Gait Speed and Gross Motor Function Outcomes[a]

Measure	Cycling Group	Control Group	P^b
600-Yard Walk-Run Test speed (m/min)	n=27	n=28	
Baseline	85.0 (69.7 to 100.4)	81.6 (65.9 to 97.4)	
Postintervention	90.6 (75.4 to 105.7)	84.1 (67.6 to 100.7)	
Change[c]	5.6 (1.6 to 9.5)	2.5 (−1.1 to 6.0)	.24
P	.008[d]	.16	
30sWT speed (m/min)	n=29	n=29	
Baseline	66.9 (58.6 to 75.1)	58.7 (51.0 to 66.5)	.
Postintervention	68.0 (60.4 to 75.7)	62.1 (54.4 to 69.8)	
Change	1.2 (−3.9 to 6.2)	3.4 (−1.7 to 8.4)	.52
P	.64	.18	
GMFM-66	n=29	n=29	
Baseline	69.6 (65.4 to 73.8)	68.8 (64.5 to 73.0)	
Postintervention	70.8 (66.6 to 74.9)	69.3 (65.4 to 73.3)	
Change	1.2 (0.5 to 1.8)	0.5 (−0.2 to 1.3)	.23
P	.002[d]	.12	

Meta-analysis of the effect of strengthening interventions in individuals with cerebral palsy

Outcomes	Sub-outcomes	*k*	−95%CI	ES
Activity	GMFM	13	0.260	0.565
	Other gross motor measures	5	0.286	0.787
	Sit to stand	3	0.535	1.175
	Stair climbing	5	0.220	0.552
	Others	4	0.224	1.858
	Subtotal	30	0.474	0.668
Gait	Endurance	1	−0.994	0.139
	Kinematic	23	1.209	1.671
	Kinetic	12	0.586	0.916
	Spatial parameter	11	0.452	0.900
	Speed	12	0.166	0.475
	Subtotal	59	0.675	0.858
Strength	Ankle plantar flexor	3	−0.017	0.349
	Hip abductor	3	1.408	1.850
	Hip adductor	1	−0.404	0.568
	Hip extensor	3	−0.036	1.538
	Hip flexor	3	0.157	0.772
	Knee extensor	16	0.983	1.463
	Knee flexor	5	1.148	1.150

Research in Developmental Disabilities 35 (2014) 239–249

Strengthening exercise in CP

- Various strengthening exercise programs
  => evident to gain of strength

Specificity
Reversibility

Individuality?
Overload?

→

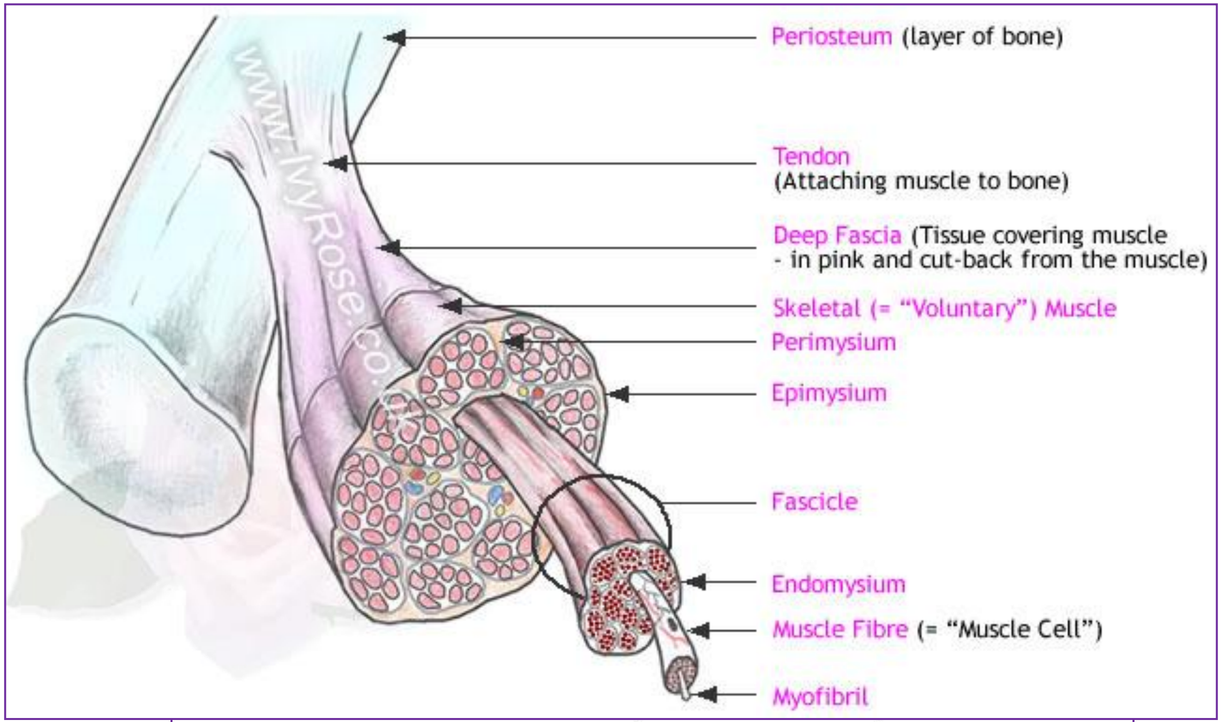
Functional gain?

Stretching exercise in CP

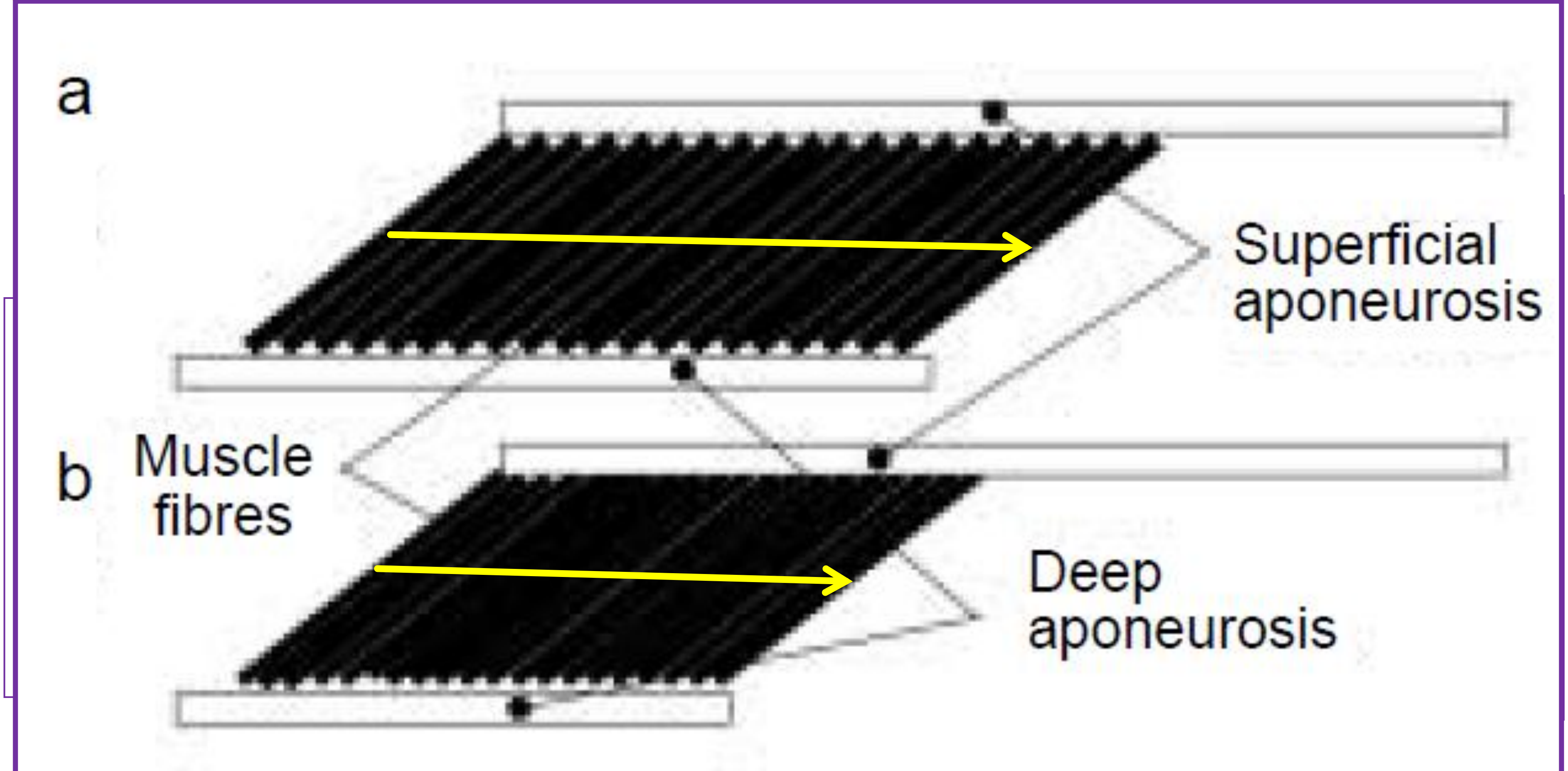
- Active stretching
- Passive stretching
- Therapeutic stretching (PNF etc.)
- Sustained passive stretching (cast, splint, standing table)

Mechanisms?

- Mechanisms of contracture in CP?
  - Muscle fascicle
  - Tendon
  - Fascia



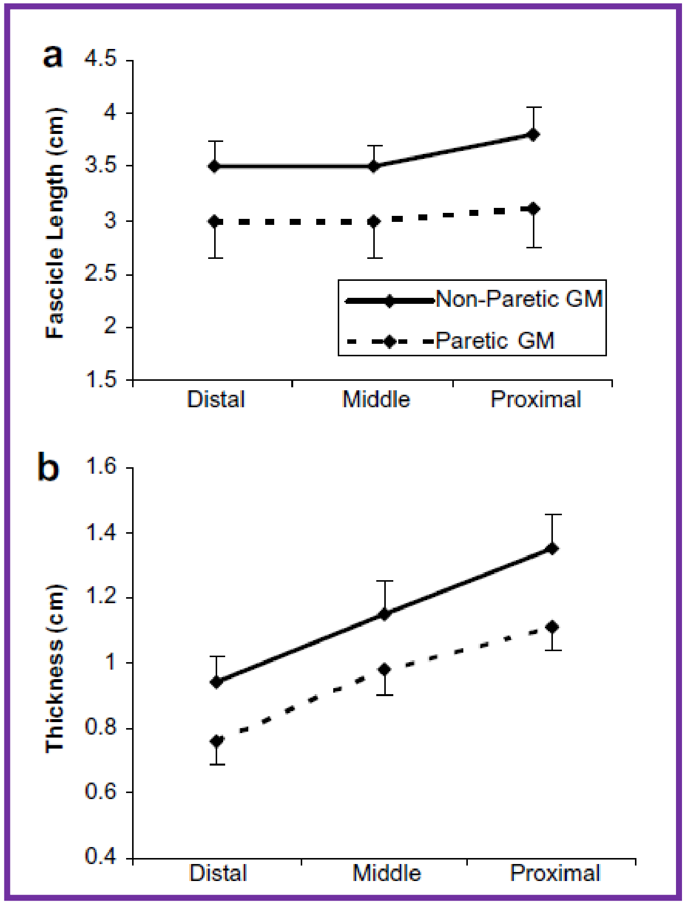
Architecture of the medial gastrocnemius in children with spastic diplegia

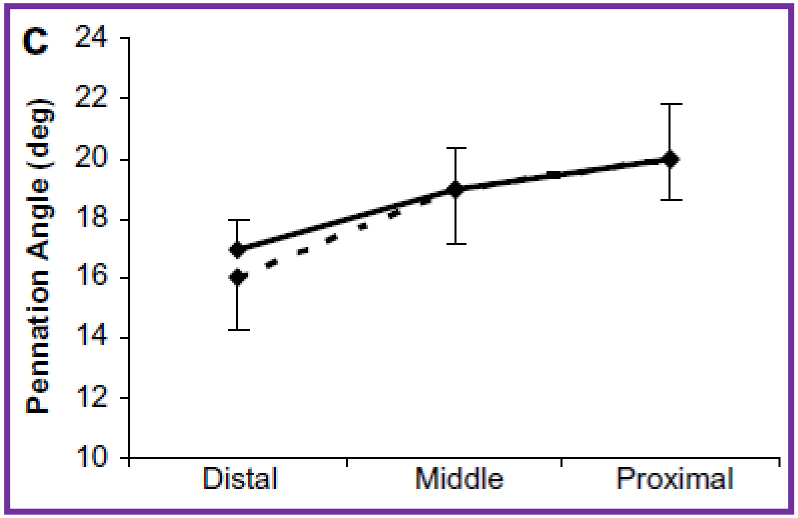


Developmental Medicine & Child Neurology 2002, 44: 158–163

Differences in gastrocnemius muscle architecture between the paretic and non-paretic legs in children with hemiplegic cerebral palsy

- CP spastic hemi (n=8)





Clinical Biomechanics 22 (2007) 718–724

Does acute passive stretching increase muscle length in children with cerebral palsy?

Clinical Biomechanics 28 (2013) 1061–1067

Stretching with Children with Cerebral Palsy: What Do We Know and Where Are We Going?

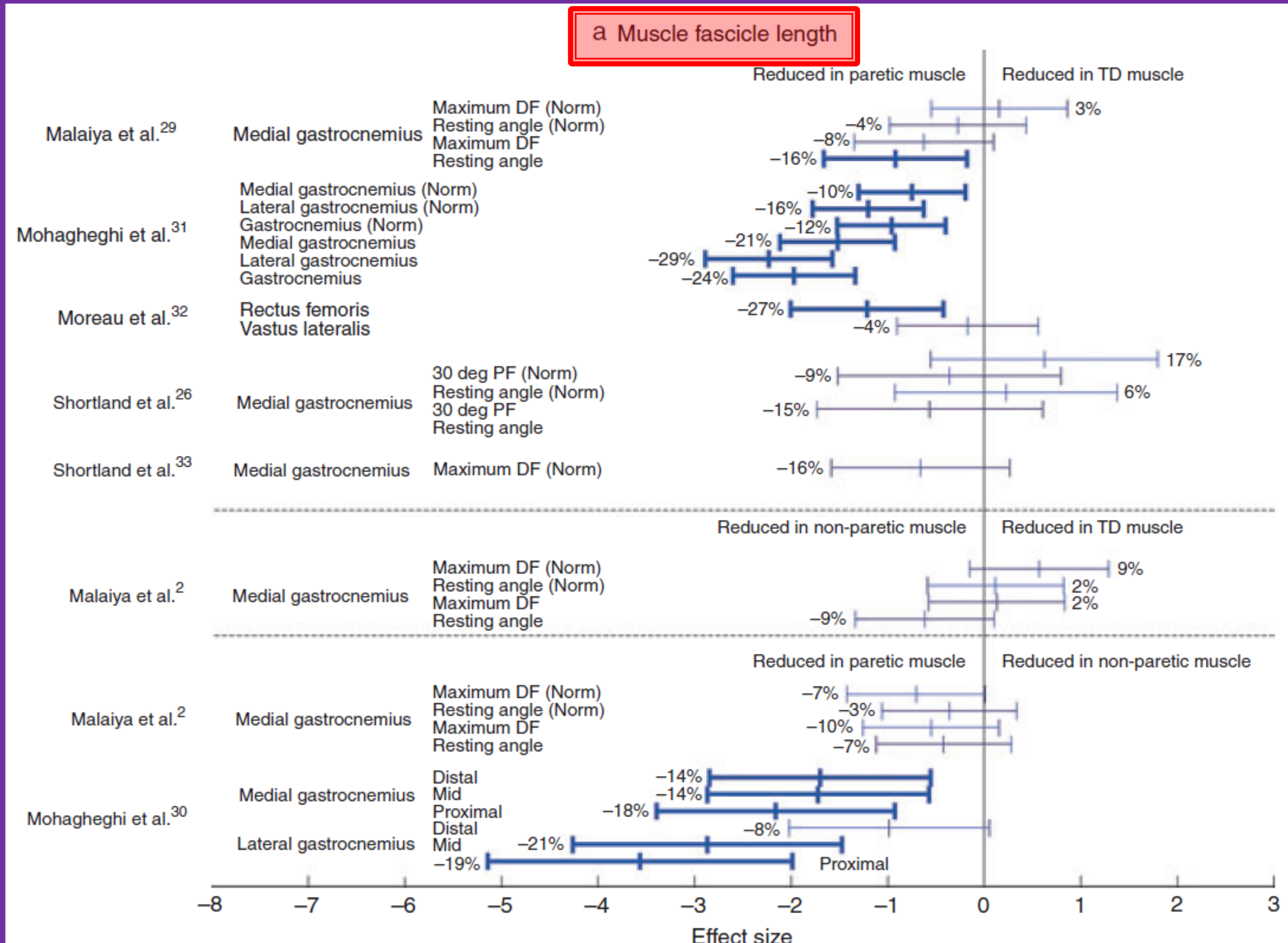
Pediatr Phys Ther 2008 20(2) 173–8

'To stretch or not to stretch in children with cerebral palsy'

Developmental Medicine & Child Neurology 2007, 49: 797–800

Gross muscle morphology and structure in spastic cerebral palsy: a systematic review

Developmental Medicine & Child Neurology 2010, 52: 794–804



Effect size

Clinical research?

The effectiveness of passive stretching in children with cerebral palsy

Table II: Summary of study characteristics

Study	*Research design*	*Nr of participants*	
		Treatment group	*Control group*
Fragala et al. (2003)[20]	Multiple single-subject ABAB design	7	7[a]
Lespargot et al. (1994)[19]	Before-and-after design	10	20
McPherson et al. (1984)[21]	Multiple single-subject design	4	4[a]
Miedaner and Renander (1987)[16]	Multiple single-subject with randomized cross-over design	13	13[a]
O'Dwyer et al. (1994)[14]	Randomized controlled trial	8	7
Richards et al. (1991)[17]	Randomized controlled trial	8	11
Tremblay et al. (1990)[18]	Randomized controlled trial	11	10

Developmental Medicine & Child Neurology 2006, 48: 855–862

A systematic review of
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- 19 origi

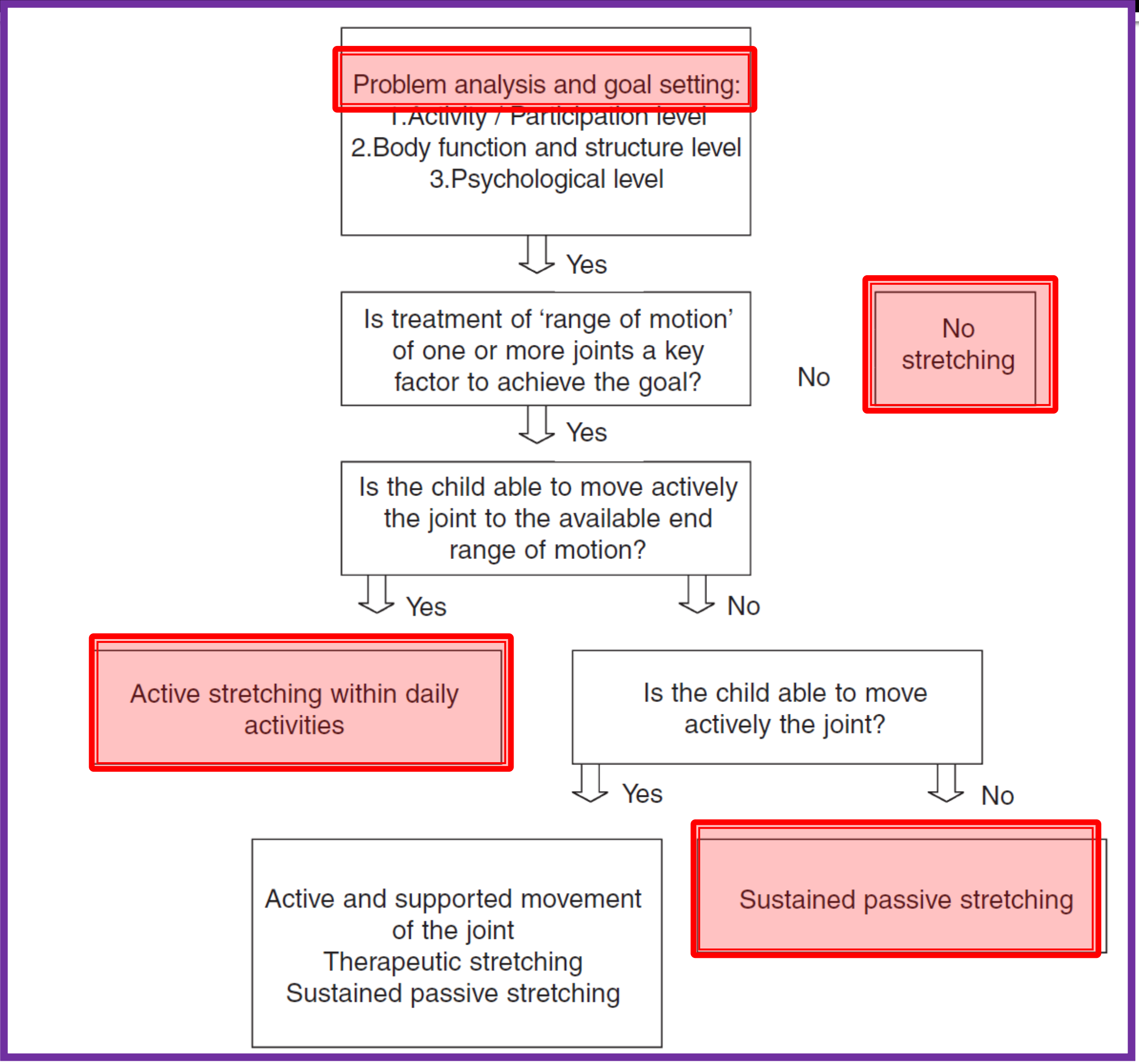
Casting plus BTX-A vs BTX-A-only					12mo
Bottos et al. 2003[21]	Tricep				*ns*
II-W (3/7)	Gross motor fu				*ns*
Small RCT					*ns*
					ns
					ns
					ns
	Right				*ns*
	Left				*ns*
					ns
	Stride length			BTX-A	
	Cadence	Gait analysis	*ns*	*ns*	*ns*
	Speed of progression	Gait analysis	*ns*	0.04 C+ BTX-A	*ns*
	Sagittal ankle angle at initial contact	Gait analysis	*ns*	*ns*	*ns*
	Ankle df during stance	Gait analysis	*ns*	*ns*	*ns*
Ackman et al. (2005)[20c]	Gait velocity	Vicon 3D gait analysis			*ns*
II-S (6/7)	Stride length	Vicon 3D gait analysis			*ns*
Small RCT	Ankle df at initial contact	Vicon 3D gait analysis			*ns*
	Peak df in stance	Vicon 3D gait analysis			*ns*
	Peak df in swing	Vicon 3D gait analysis			*ns*
	Triceps surae spasticity	MAS			*ns*
		Tardieu			*ns*
	Passive ankle df	Goniometry			*ns*
	Active ankle df	Goniometry			*ns*
	Ankle df strength	Manual muscle test			*ns*
	Ankle pf strength	Manual muscle test			*ns*
	Ankle power generation	Unilateral heel rises			*ns*
Casting then BTX-A vs BTX-A then casting study					
Desloovere et al. (2001)[23]	Walking velocity	Gait analysis			*ns*
II-M (5/7)					
Small RCT					

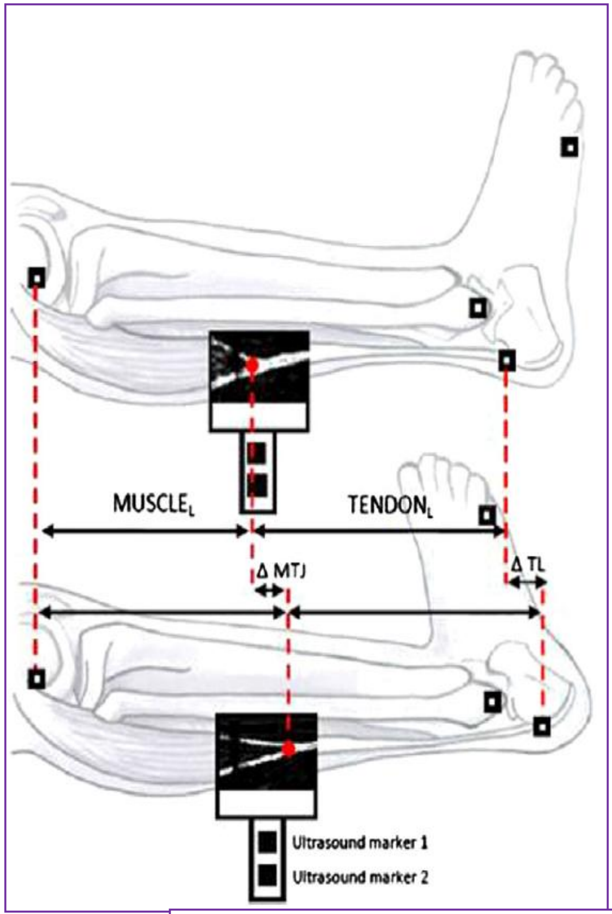
Serial casting in cerebral palsy: panacea, placebo, or peril?

Developmental Medicine & Child Neurology 2007, 49: 725–725

Developmental Medicine & Child Neurology 2007, 49: 781–790

Experienced based





Clinical Biomechanics 28 (2013) 1061–1067

Stretching exercise in CP

- Mechanism?
- Clinical research (RCT)?
- Experience/basic science/natural history based approach

Neuromuscular disease
(Myopathy, SMA, CMT etc.)

Duchenne Muscular Dystrophy

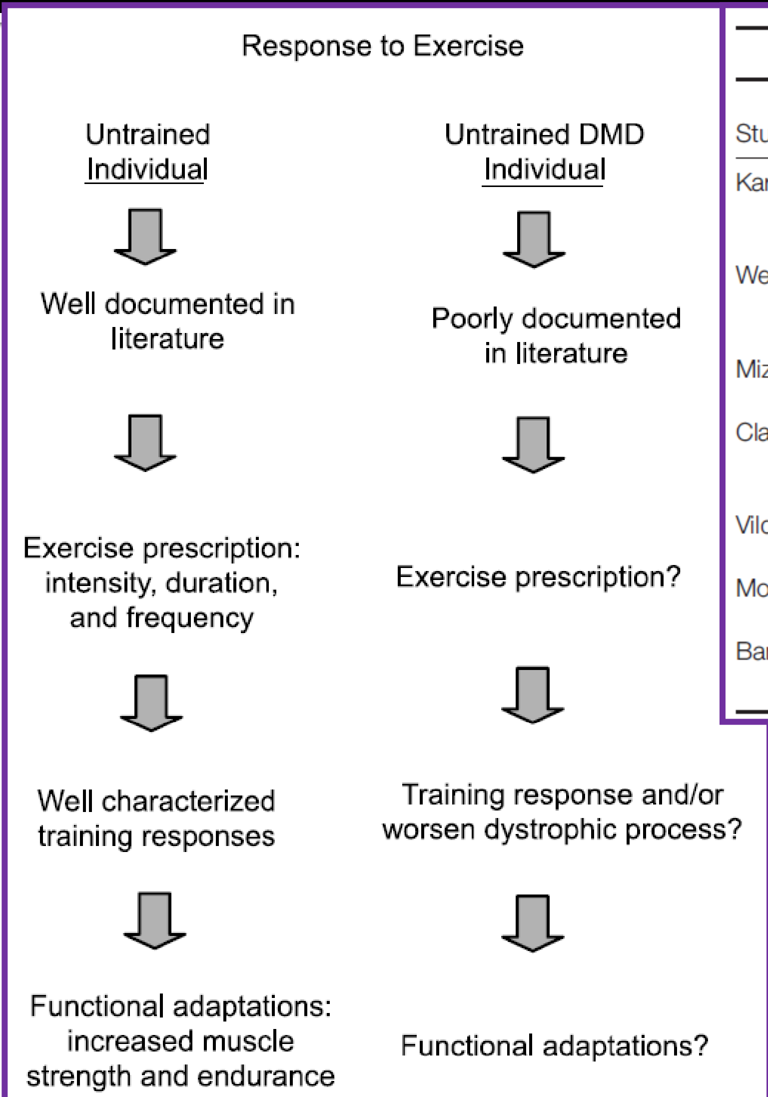


Table 1. Studies that suggest exercise is contraindicated in DMD.[3

Study reference	Study title	M that pot
Karpati et al. (1986)[182]	Small-caliber skeletal muscle fibers do not suffer deleterious consequences of dystrophic gene expression	
Weller et al. (1990)[183]	Dystrophin-deficient *mdx* muscle fibers are preferentially vulnerable to necrosis induced by experimental lengthening contractions	
Mizuno (1992)[184]	Prevention of myonecrosis in *mdx* mice: effect of immobilization by the local tetanus method	
Clarke et al. (1993)[73]	Loss of cytoplasmic basic fibroblast growth factor from physiologically wounded myofibers…	
Vilquin et al. (1998)[185]	Evidence of *mdx* mouse skeletal muscle fragility in vivo by eccentric running exercise	
Mokhtarian et al. (1999)[186]	Hindlimb immobilization applied to 21-day-old *mdx* mice…	
Bansal et al. (2003)[187]	Defective membrane repair in dysferlin-deficient muscular dystrophy	

ACSM, 2007

Spinal muscular atrophy

What kind of exercise is best?

Some physical therapy experts have raised questions about whether it's wise to put too much demand on a gradually decreasing number of motor neurons, which have to do the work that would normally be done by many more such cells. Research is needed to determine whether this theoretical issue should actually be considered in designing an exercise plan. Some experts believe it's impossible to overdo it, while others believe exercising to exhaustion can "burn out" remaining motor neurons before their time. It seems sensible to exercise with discretion and stop before reaching the point of exhaustion.

MDA USA

SMA

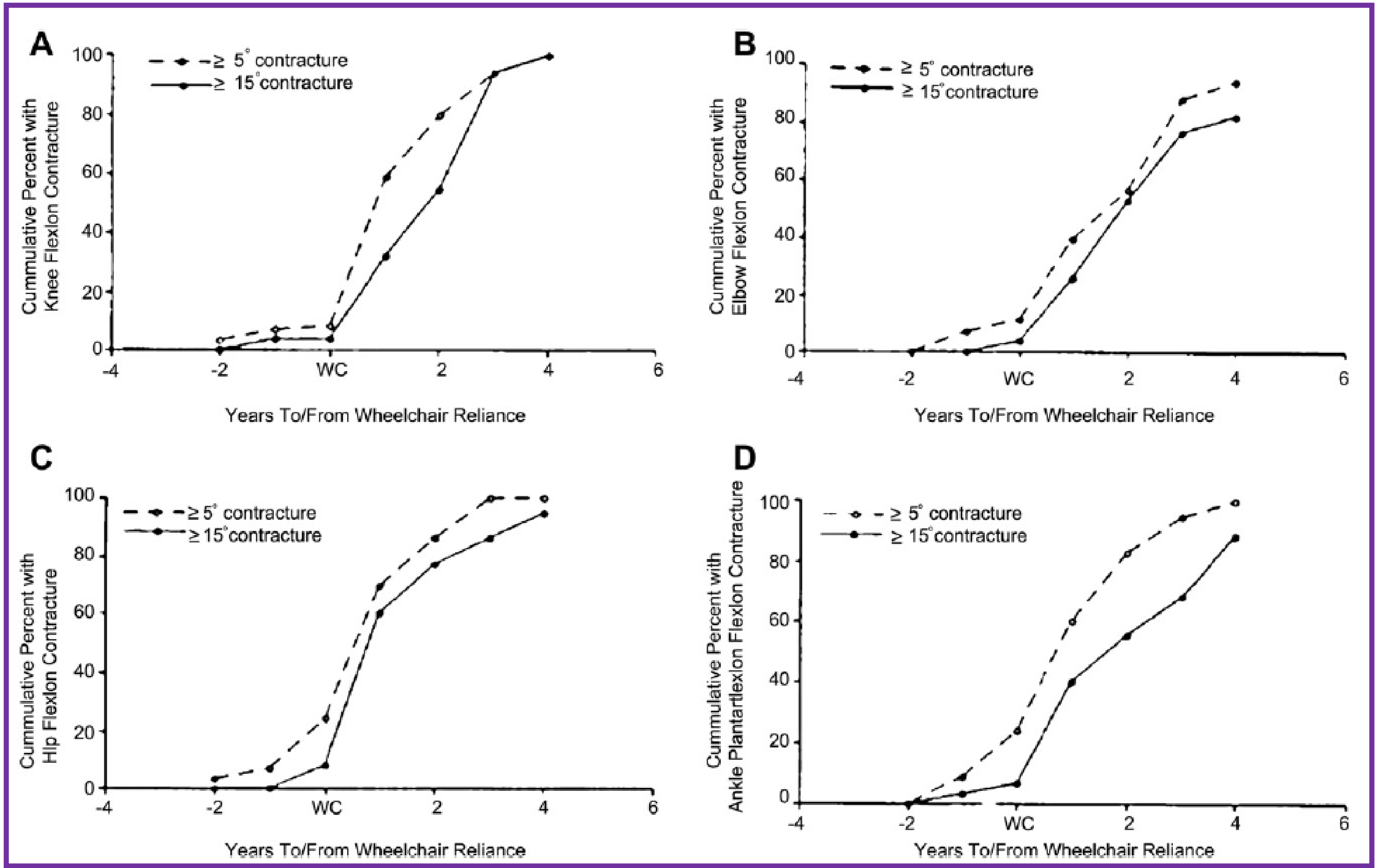
Measured Motions	Percentage of Participants	Max Range Loss (deg)	Contracture Index	Age Distribution
	ROM Limitations			
Knee extension	89 (24)	48±24	4.27	1.6, 21.5 (12±6)
Ankle dorsiflexion	52 (14)	25±20	1.30	1.6, 21.5 (12±7)
Hip extension	48 (13)	40±20	2.16	4.0, 21.5 (13±6)
Shoulder flexion	30 (8)	31±22	0.93	7.3, 21.5 (17±8)
Shoulder abduction	30 (8)	51±42	1.53	7.3, 21.5 (17±6)
Elbow extension	30 (8)	33±27	0.99	7.4, 21.5 (15±5)
Hip abduction	30 (8)	17±8	0.51	7.3, 22.2 (16±6)
Forearm supination	26 (7)	70±41	1.82	4.3, 22.2 (15±7)
Hip flexion	15 (4)	18±6	0.27	7.3, 21.5 (16±7)
Ankle plantarflexion	15 (4)	26±18	0.39	1.9, 21.5 (13±9)

Table 3: Descriptive Statistics of ROM Limitations for SMA Type II (n=27)

Neuromuscular Disorders 22 (2012) 1069–1074

Arch Phys Med Rehabil Vol 85, October 2004

DMD



Phys Med Rehabil Clin N Am 23 (2012) 675–687

Analysis 5.2. Comparison 5 Night splinting versus control in Charcot-Marie-Tooth disease, Outcome 2 Change in eversion range of motion (deg).

Review: Rehabilitation interventions for foot drop in neuromuscular disease

Comparison: 5 Night splinting versus control in Charcot-Marie-Tooth disease

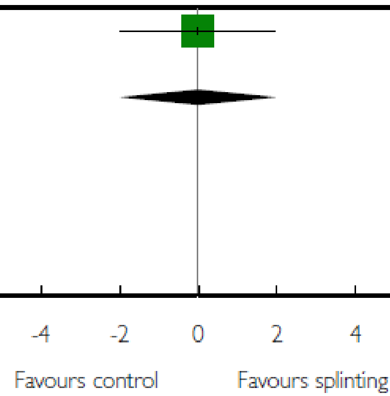
Outcome: 2 Change in eversion range of motion (deg)

Study or subgroup	Splinting N	Splinting Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
Refshauge 2006	13	1 (3)	13	1 (2)		100.0 %	0.0 [-1.96, 1.96]
Total (95% CI)	**13**		**13**			**100.0 %**	**0.0 [-1.96, 1.96]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.0 (P = 1.0)

Test for subgroup differences: Not applicable



EXERCISE AND DUCHENNE MUSCULAR DYSTROPHY: TOWARD EVIDENCE-BASED EXERCISE PRESCRIPTION

Muscle Nerve 43: 464–478, 2011

CONCLUSIONS

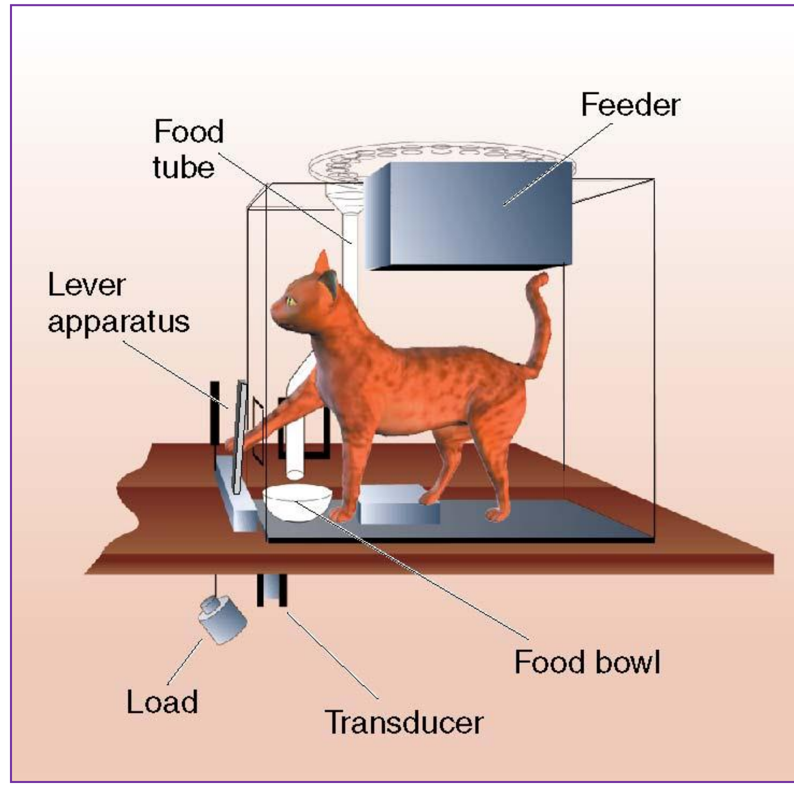
A sense of urgency permeates research into the pathophysiological mechanisms underlying DMD. Improved understanding of the pathophysiology is critical, and the incorporation of exercise into experimental designs could help to mechanistically define the pathophysiology. At present, informed exercise prescription for DMD patients is challenging due to lack of inquiry and lack of evidence.

EXERCISE AND DUCHENNE MUSCULAR DYSTROPHY: WHERE WE HAVE BEEN AND WHERE WE NEED TO GO

MUSCLE & NERVE May 2012

KEY UNANSWERED QUESTIONS

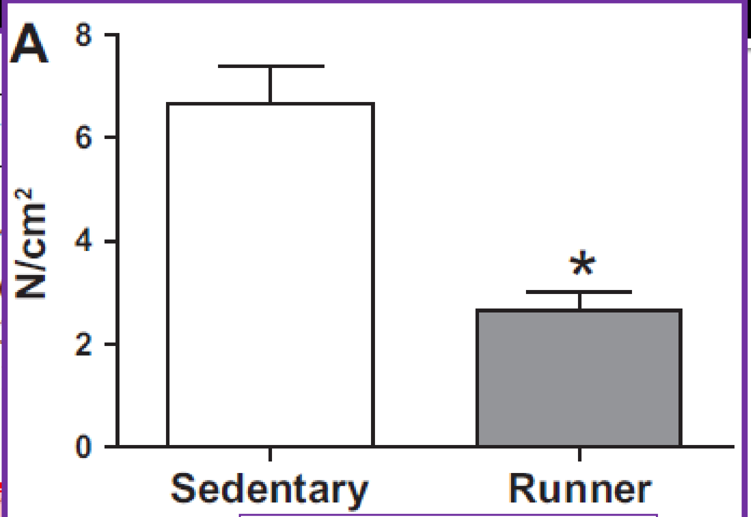
1. What is the appropriate amount and type of physical activity or exercise?
2. How long and how often should children be physically active? (What type, intensity, and duration of exercise and/or activity?)
3. What are the contributions of fatigue, and how should it be best defined and measured?
4. What is the role of muscle stretching? For example, will flexibility exercises assist/maintain flexibility and therefore increase ease of movement and decrease the resistance against which weak muscles contract? Would maintenance of flexibility decrease intramuscular fibrosis? Will flexibility prevent contractures and improve biomechanics for movement?
5. With appropriate exercise, can the progression of muscle atrophy and weakness be mitigated?


Feeder
Food tube
Lever apparatus
Food bowl
Load
Transducer

Long-term wheel running compromises diaphragm function but improves cardiac and plantarflexor function in the mdx mouse

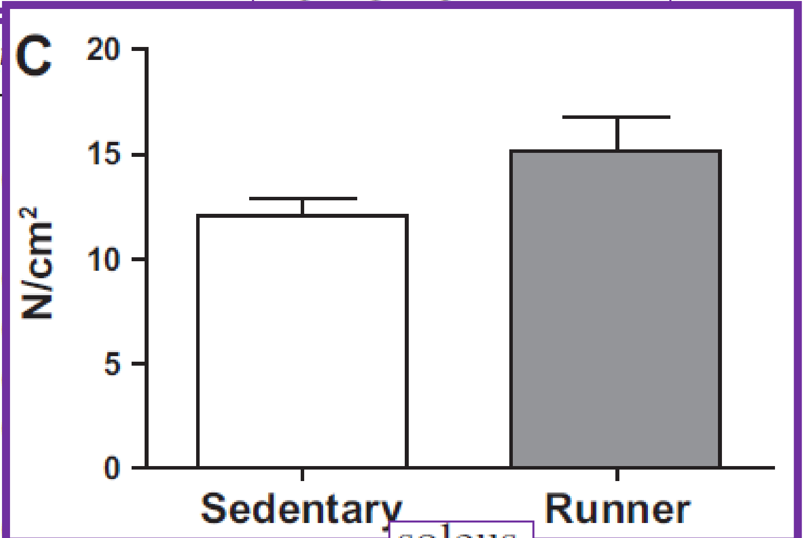
J Appl Physiol 115: 660–666, 2013.

	Sedentary
Body wt, g	
Initial	19.5 ± 0.
Final	32.4 ± 0.
EDL, mg and mg/g	15.3 ± 0.
Tibialis anterior, mg and mg/g	78.6 ± 2.
Quadriceps, mg and mg/g	293 ± 4
Gastrocnemius, mg and mg/g	160 ± 5
Soleus, mg and mg/g	16.2 ± 0.



diaphragm specific tension

	Sedentary (
Heart mass, mg	147 ±
Relative heart mass, mg/g body wt	4.5 ±
Heart rate, beats/min	349 ±
Interventricular septum (diastole), mm	0.96 ±
LV internal diameter (diastole), mm	3.3 ±
LV free wall (diastole), mm	1.0 ±
LV internal diameter (systole), mm	2.3 ±
Fractional shortening, %	33 ±
End-diastolic volume, ml	0.10 ±



soleus

Assisted Bicycle Training Delays Functional Deterioration in Boys With Duchenne Muscular Dystrophy: The Randomized Controlled Trial "No Use Is Disuse"

Neurorehabilitation and Neural Repair
27(9) 816–827

Time (weeks)

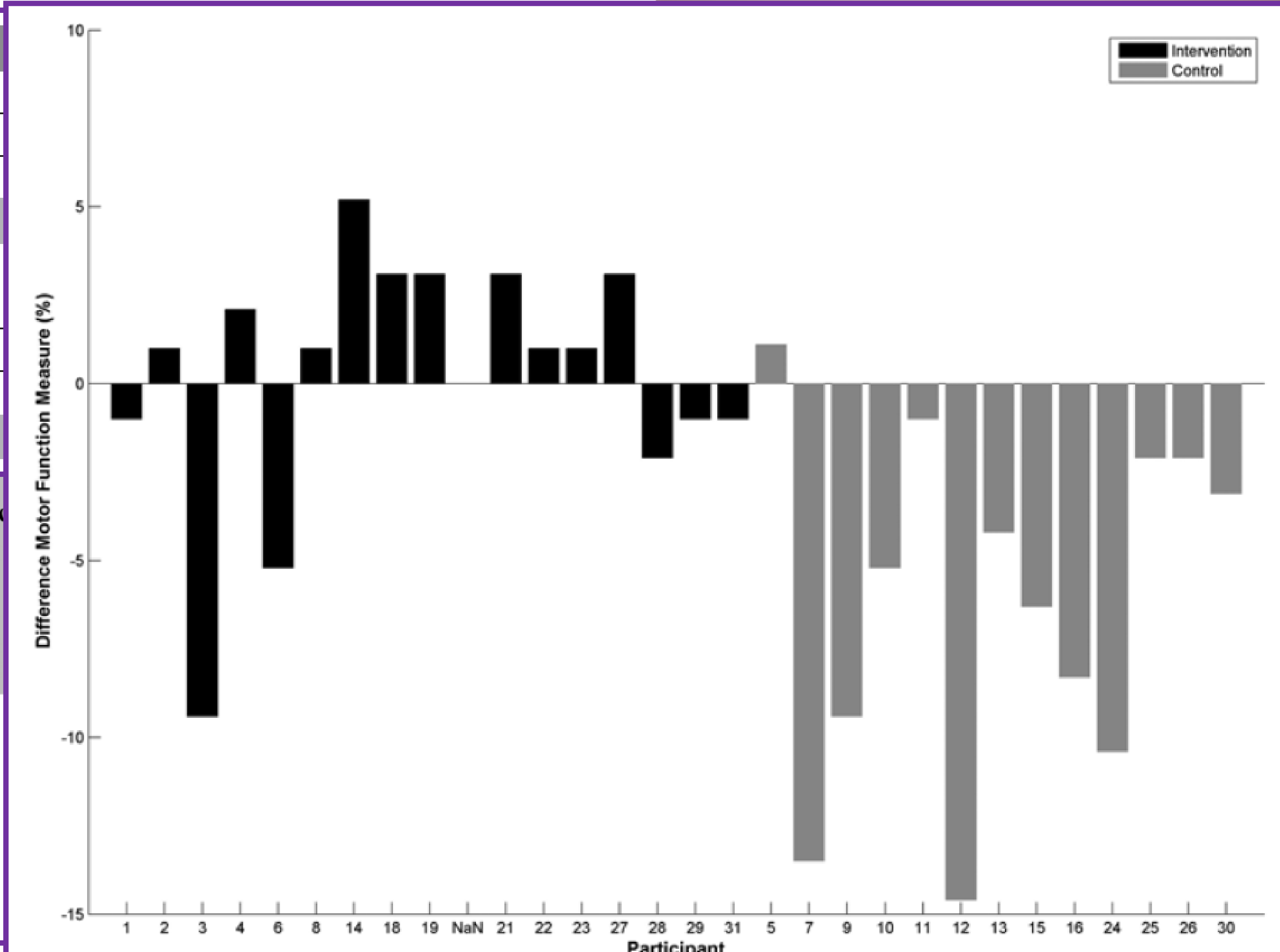
Intervention group

Measurement

Control group

Measurement

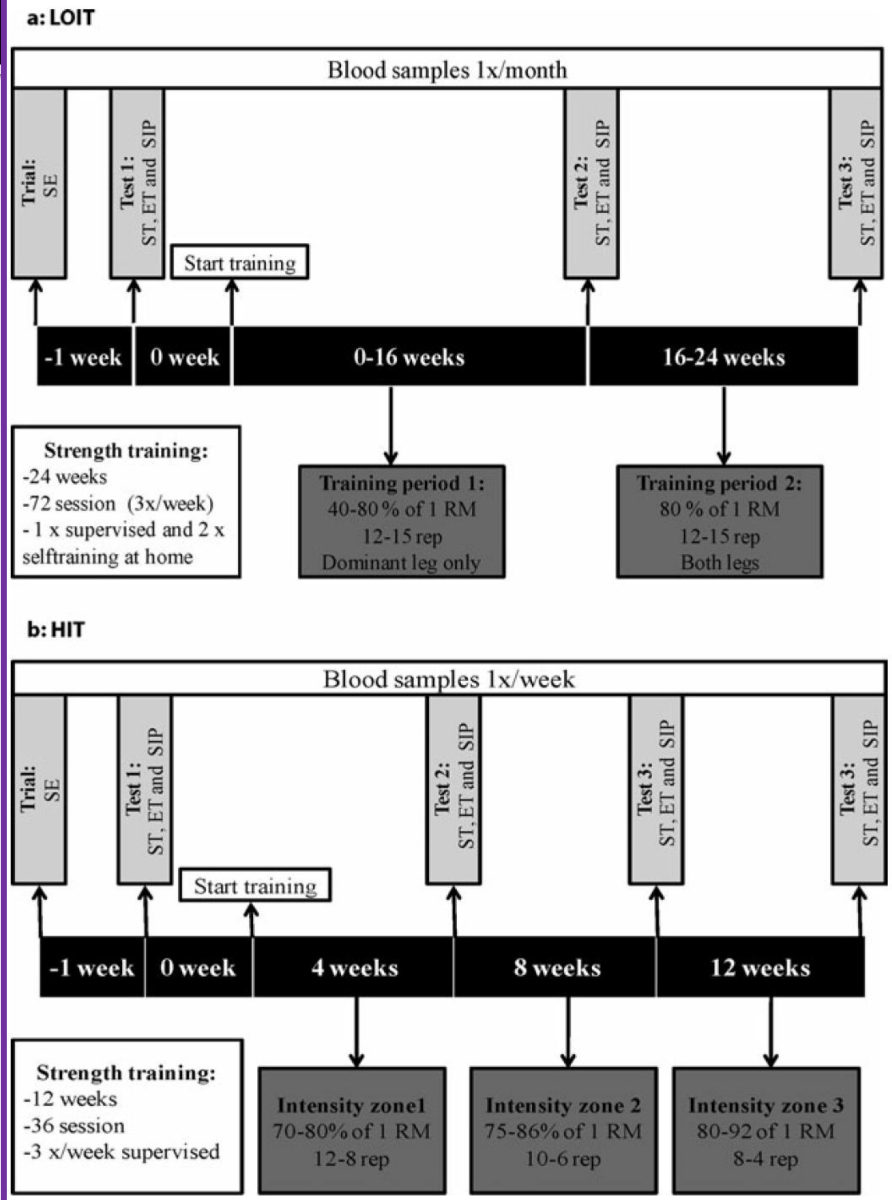
Low-intensity physic
training
Co-interventions



RESISTANCE TRAINING IN PATIENTS WITH LIMB-GIRDLE AND BECKER MUSCULAR DYSTROPHIES

Muscle Nerve 47: 163–169, 2013

	Age (years)	Mutation
(a) LOIT		
LGMD2A		
Patient 1	48	A798E/A798E
Patient 2	43	21bp del/NF
LGMD2I		
Patient 3	25	L276I/L276I
Patient 4	68	L276I/L276I
Patient 5	44	L276I/L276I
Patient 6	24	L276I/L276I
BMD		
Patient 7	23	del exon 37–43
Patient 8	21	del exon 45–47
(b) HIT		
LGMD2A		
Patient 1*	43	R289W/1981delA
Patient 2	44	R437G/R437G
Patient 3	48	R461C/R461C
Patient 4†	36	R572P/NF
LGMD2I		
Patient 5	50	L276I/L276I
BMD		
Patient 6	20	del exon 4–16



Efficacy of Muscle Exercise in Patients with Muscular Dystrophy: A Systematic Review Showing a Missed Opportunity to Improve Outcomes

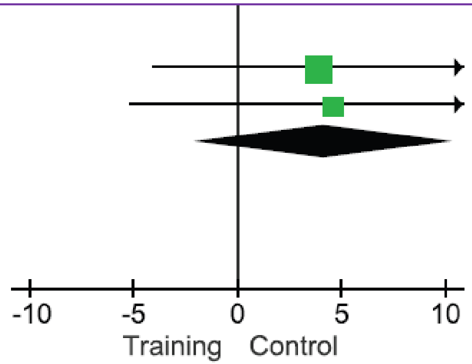
Strength training and aerobic exercise training for muscle disease (Review)

The Cochrane Library 2013, Issue 7

1.1.3 MyD and FSHD								
Lindeman 1995	5.3	12.9	14	1.4	8.2	14	60.2%	3.90 [-4.11, 11.91]
Tollback 1999	8.4	8.62	5	3.8	7.19	5	39.8%	4.60 [-5.24, 14.44]
Subtotal (95% CI)			**19**			**19**	**100.0%**	**4.18 [-2.03, 10.39]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.01$, df = 1 (P = 0.91); $I^2 = 0\%$

Test for overall effect: Z = 1.32 (P = 0.19)



Recommendations for exercises in DMD/other myopathy

Lancet Neurol 2010; 9: 177–89

- Submaximum, aerobic exercise/activity is recommended
- Avoid an overexertion and overwork weakness
- High resistance strength training & eccentric exercise are inappropriate

Consensus Statement for Standard of Care in Spinal Muscular Atrophy

Consensus on Pulmonary Care

Consensus on Gastrointestinal and Nutritional Care

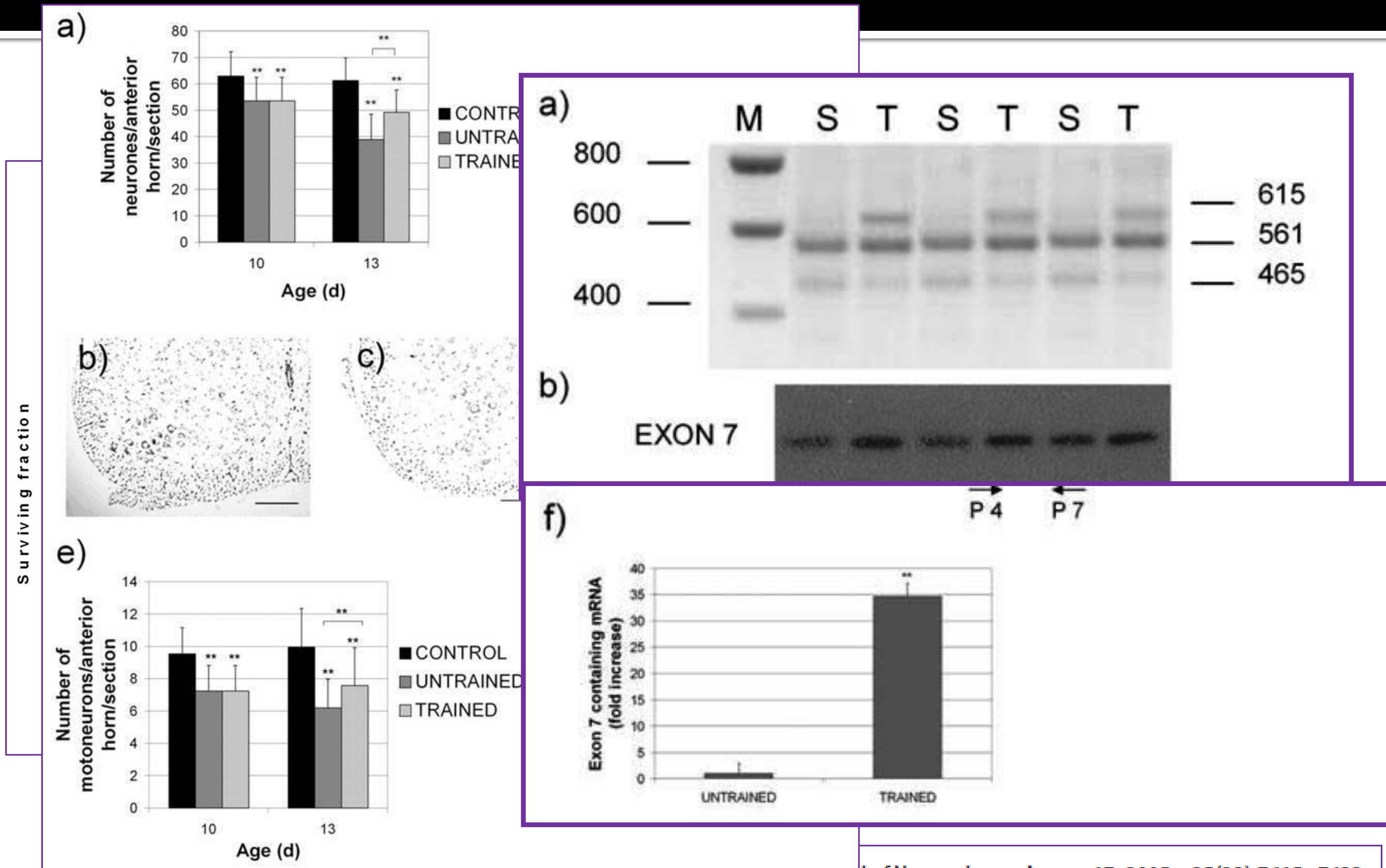
Consensus on Orthopedic Care and Rehabilitation

Interventions

No studies directly address physical therapy and occupational therapy as general therapies, although a case report

Journal of Child Neurology
Volume 22 Number 8
August 2007 1027-1049

Regular Exercise Prolongs Survival in a Type 2 Spinal Muscular Atrophy Model Mouse



The Journal of Neuroscience, August 17, 2005 • 25(33):7615–7622 •

Clinical

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Estimated Enrollment: 14
Study Start Date: November 2010
Estimated Study Completion Date: August 2014
Primary Completion Date: February 2013 (Final data collection date for primary outcome measure)

Arms	
Experimental: Exercise Muscle strengthening program using weights and resistance bands in combination with a home based cycle ergometry program. The home-based exercise program will be performed up to 5 times weekly.	Other: Exercise Muscle strength This home-base cycling and 30 m
No Intervention: Typical Activity Subjects in this group will be asked to maintain their typical daily activity. Those assigned to this arm will be given the opportunity to join the intervention arm seven months after their screening visit.	

Eligibility

Ages Eligible for Study: 8 Years to 50 Years
Genders Eligible for Study: Both
Accepts Healthy Volunteers: Yes

Criteria

Inclusion Criteria:

1. Weakness and hypotonia consistent with the clinical diagnosis of SMA type 3, i.e. having achieved the abilit
2. Laboratory documentation of homozygous absence of SMN1 exon 7
3. ability to walk at least 25 meters without assistance
4. Aged 8 to 50 years at the time of enrollment
5. Ability to tread the stationary cycle ergometer
6. Written informed consent of patient (if ≥ 18 years of age) or parents/guardian (if < 18 years of age), and ass

Exclusion Criteria:

1. Inability to walk independently at least 25 meters

In summary (neuromuscular diseases)

- The evidence of stretching: lack
- Consensus and recommendations
  based by animal studies/basic science/experience
  - Submaximal strengthening

Genetic disease (Down syn.)

Benefits of physical exercise intervention on fitness of individuals with Down syndrome: a systematic review of randomized-controlled trials

Table 2 Details of the participants

Studies	Groups	Mean age (years)	Male : female
Abdel Rahman and Shaheen (2010)	Intervention ($n=13$)	4.2 (0.4)	5 : 8
	Control ($n=13$)	3.9 (1.2)	6 : 7
Carmeli *et al.* (2002)	Intervention ($n=16$)	63.5 (2.0)	10 : 6
	Control ($n=10$)	63.3 (4.8)	6 : 4
González-Agüero *et al.* (2011)	Intervention ($n=12$)	13.7 (2.6)	7 : 5
	Control ($n=13$)	15.4 (2.5)	8 : 5
Gupta *et al.* (2011)	Intervention ($n=12$)	13.0 (ND)	8 : 4
	Control ($n=11$)	13.5 (ND)	6 : 5
Lin and Wuang (2012)	Intervention ($n=46$)	15.6 (3.6)	25 : 21
	Control ($n=46$)	14.9 (3.9)	24 : 22
Rimmer *et al.* (2004)	Intervention ($n=30$)	38.6 (6.2)	16 : 14
	Control ($n=22$)	40.6 (6.5)	13 : 9
Shields and Taylor (2010)	Intervention ($n=11$)	15.9 (1.5)	8 : 3
	Control ($n=12$)	15.3 (1.7)	9 : 3
Shields *et al.* (2008)	Intervention ($n=9$)	25.8 (5.4)	7 : 2
	Control ($n=11$)	27.6 (9.5)	6 : 5
Ulrich *et al.* (2011)	Intervention ($n=19$)	12.0 (1.9)	9 : 10
	Control ($n=27$)	12.4 (2.2)	11 : 16
Varela *et al.* (2001)	Intervention ($n=8$)	22.0 (3.8)	8 : 0
	Control ($n=8$)	20.8 (2.3)	8 : 0

Strength and agility training in adolescents with Down syndrome: A randomized controlled trial☆

Research in Developmental Disabilities 33 (2012) 2236–2244

Muscle strength of lower extremities measures by experimental and pre-posttest condition.

	Pretest				Posttest				
	Exercise group		Control group		Exercise group		Control group		p^*
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	
Hip flexors	16.39	1.71	16.28	2.00	17.33	2.15	16.20	1.97	0.010
Hip extensors	13.43	1.97	12.89	2.15	14.07	1.24	13.02	2.04	0.018
Hip abductors	12.89	2.15	13.24	1.99	14.46	1.73	13.37	1.82	0.004
Knee flexors	14.67	1.56	14.85	1.58	16.27	1.81	15.02	1.45	0.029
Knee extensors	14.33	1.65	14.46	1.39	15.75	1.94	14.65	1.23	0.031
Ankle plantarflexor	12.87	1.77	13.00	1.74	14.04	1.28	13.30	1.46	0.011

Note: muscle strength is measure in pounds (lb). p^* level indicates significance between groups on post-intervention scores.

Agility									
Shuttle run	5.0	1.2	5.0	1.3	7.0	1.8	4.0	1.5	0.01
Stepping sideways	3.0	1.0	3.0	1.1	3.0	1.1	3.0	1.3	0.02
One-legged stationary jump	4.0	1.3	4.0	1.0	6.0	1.5	4.0	1.6	0.03
One-legged side hop	4.0	1.4	4.0	0.9	5.0	1.5	3.0	1.2	0.01
Two-legged side hop	3.0	0.8	3.0	0.8	4.0	1.0	3.0	1.2	0.02
Total agility score	11.0	6.3	11.0	5.9	16.0	6.6	10.0	6.8	0.01
Body strength									
Standing long jump	5.0	1.2	5.0	1.3	7.0	1.8	4.0	1.5	0.01
Push-ups	3.0	1.0	3.0	1.1	3.0	1.1	3.0	1.3	0.04
Sit-ups	4.0	1.3	4.0	1.0	6.0	1.5	4.0	1.6	0.04
Wall sit	4.0	1.4	4.0	0.9	5.0	1.5	3.0	1.2	0.05
V-up	3.0	0.8	3.0	0.8	4.0	1.0	3.0	1.2	0.02
Total strength score	11.0	6.3	11.0	5.9	16.0	6.6	10.0	6.8	0.02
Strength and Agility score	33.1	7.9	34.2	6.5	40.4	10.2	33.9	8.1	0.01

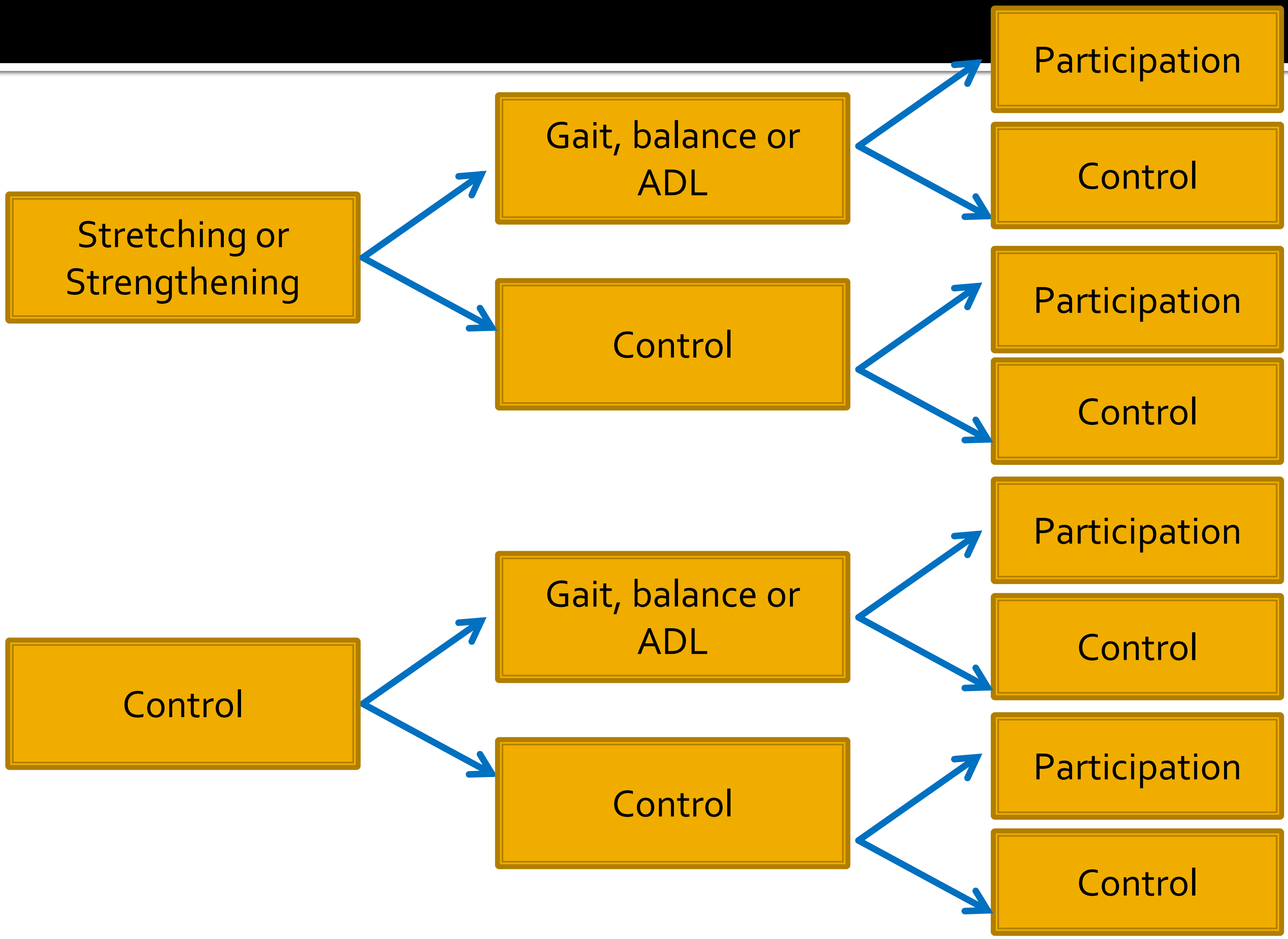
Wrap up the lecture

Wrap up

- Strengthening exercises
  - Improve strength
  - Safe and feasible
  - But, limited functional adaptation

- Stretching exercises
  - Less conclusive
  - Limited positive evidence

Evidence ?of Stretching or Strengthening



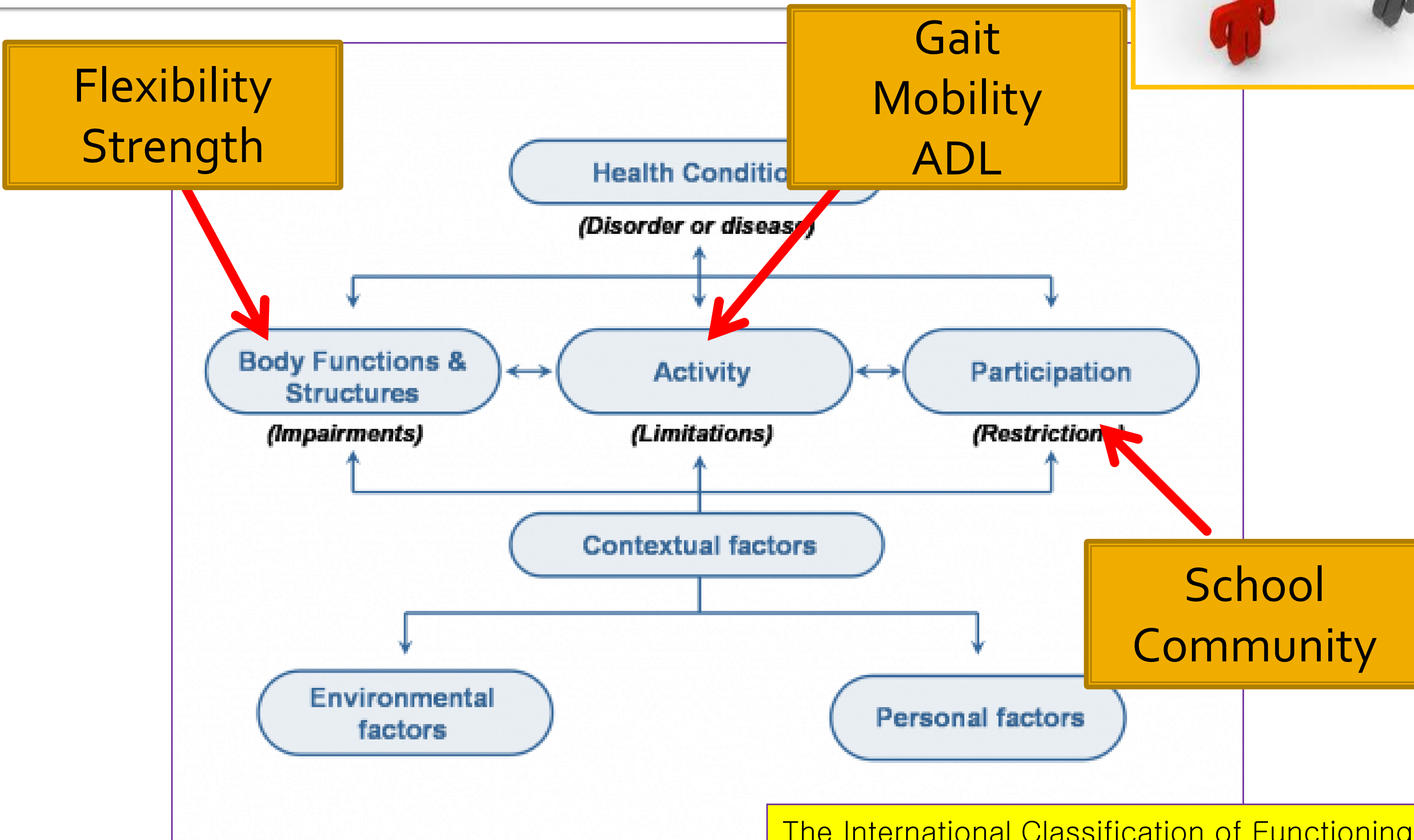
Wrap up

- Neuro-plasticity (Neuromodulation)
- Muscle plasticity (Increased ROM and strength)

=> Individualized/goal oriented task training

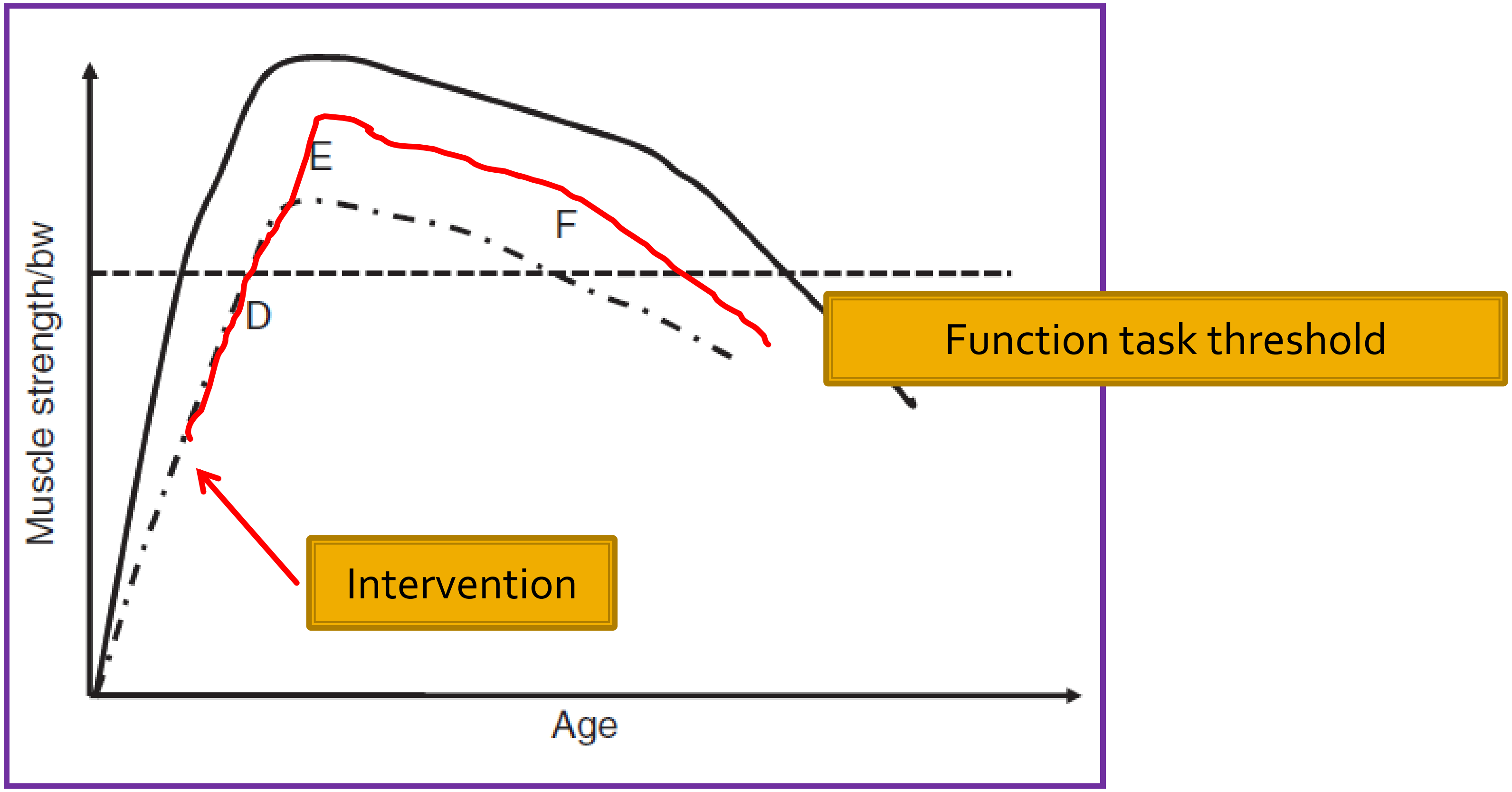
Pediatric rehabilitation

Evidences of stretching and strengthening



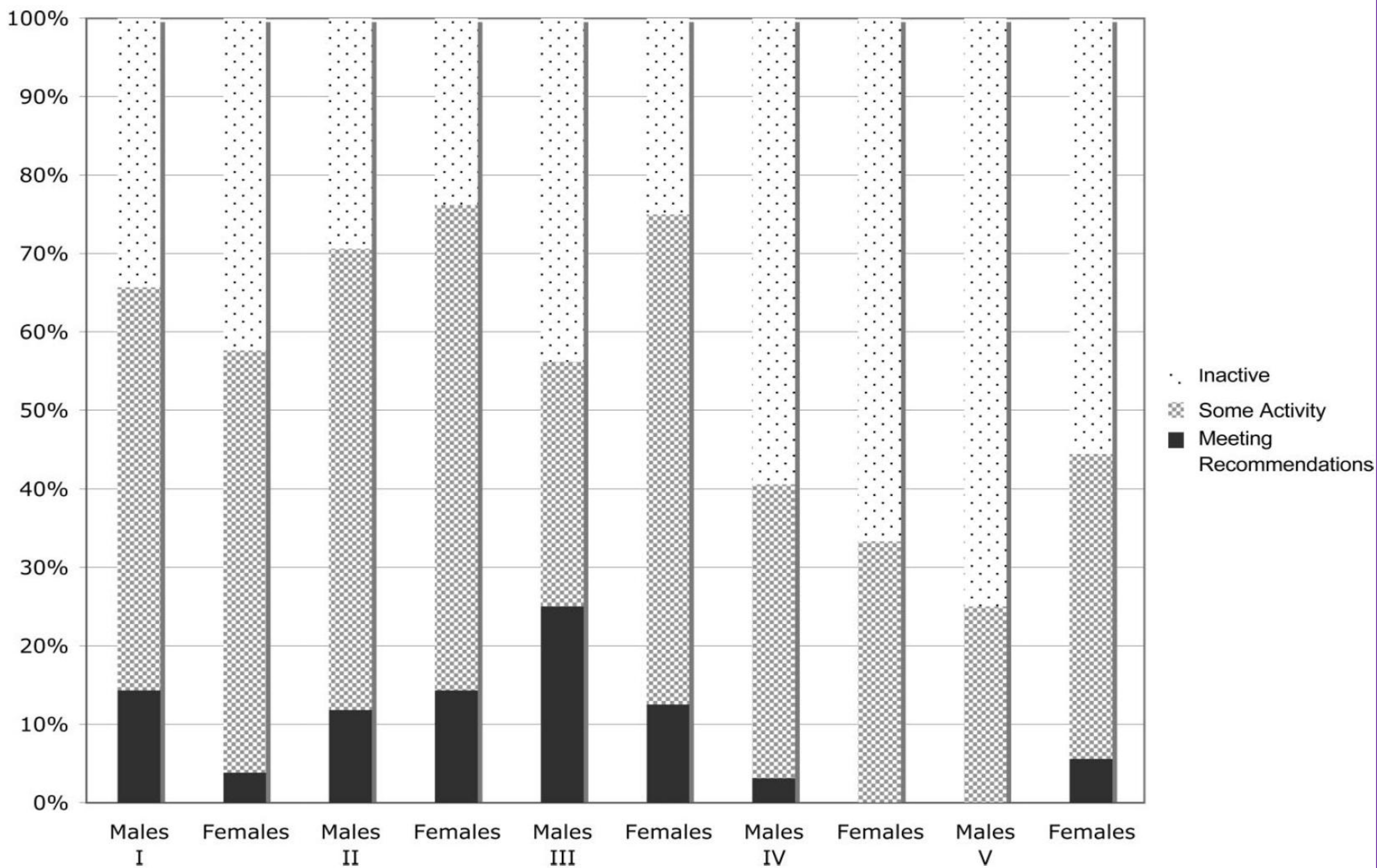
The International Classification of Functioning, Disability and Health (ICF)

Wrap up



Developmental Medicine & Child Neurology 2009, 51 (Suppl. 4): 59–63

Description of Exercise Participation of Adolescents With Cerebral Palsy Across a 4-Year Period



Wrap up

=> Exercise guideline in CP or other pediatric disable children

- School based exercise
- Home based exercise

- 감사합니다.