Aquatic Therapy in Neurology

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March, 19th, 2013
ECEBAT, Izmir, Turkey

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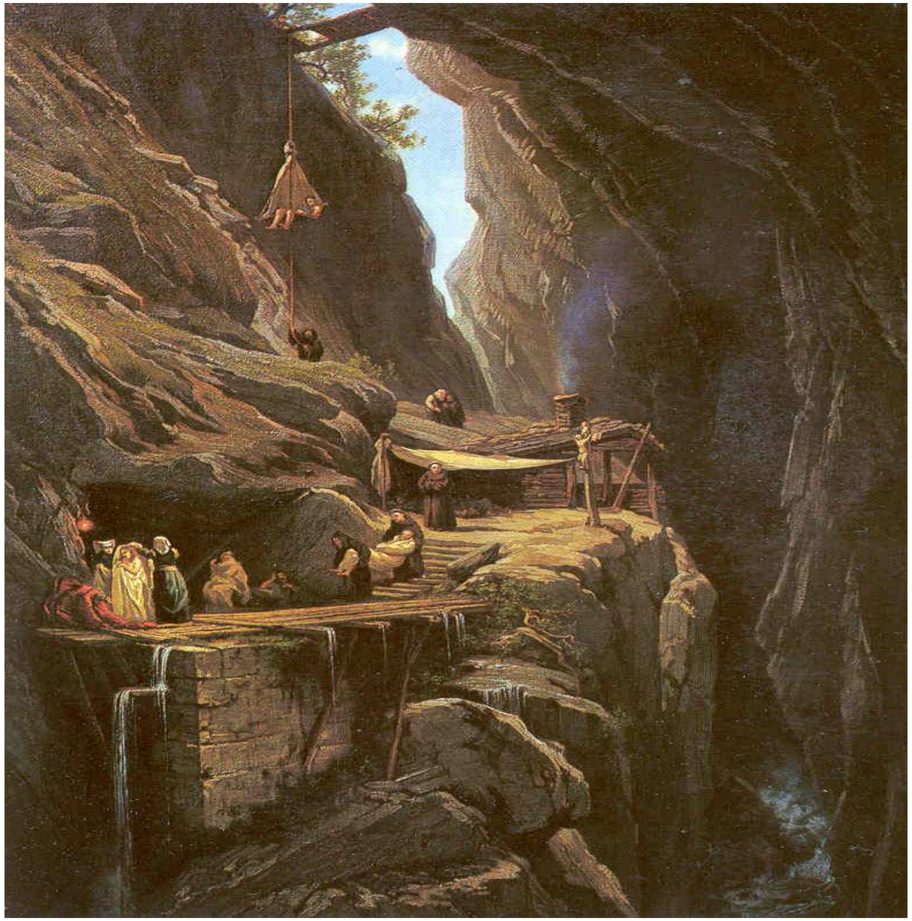
Historical overview

- **Paracelsus Philippus Theophrastus Bombastus von Hohenheim (1493 -1541)**
- **«Vom Ursprung und herkommen des Bads Pfeffers» (Basel, 1576)**

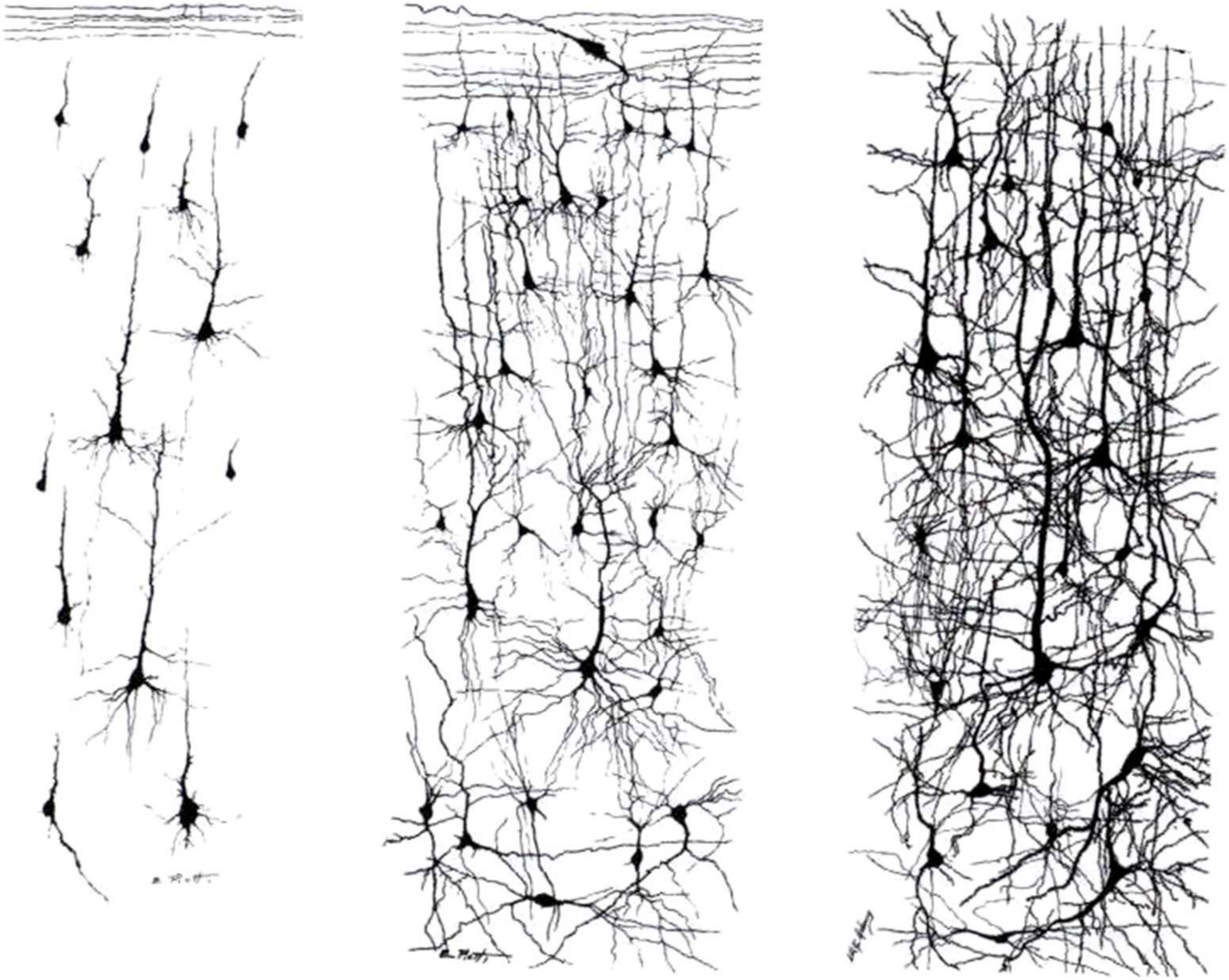
Indications:
Paralysations,
Twisted limbs



Principles of Neurorehabilitation

1. Plasticity of CNS
2. Theory of motor (re-)learing
3. Enriched environment
4. Compensation

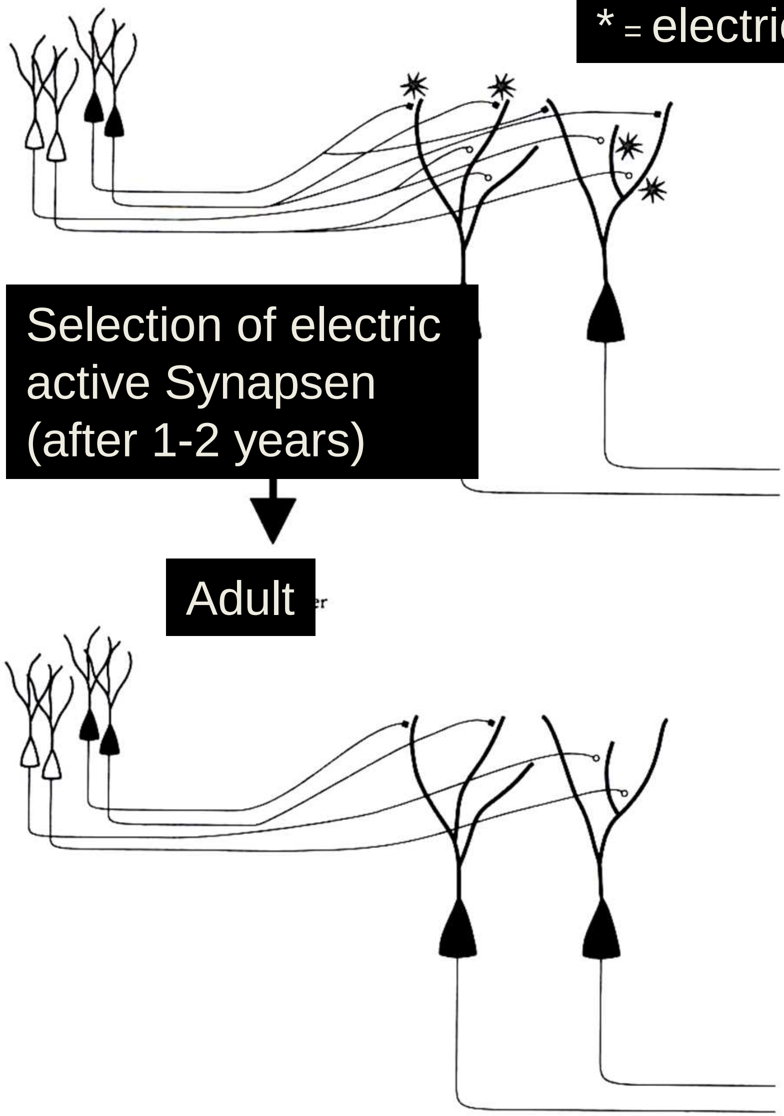
Development of neuronal network



newborn | 3 month | 2 years

„Use it or loose it“

* = electric Activityt



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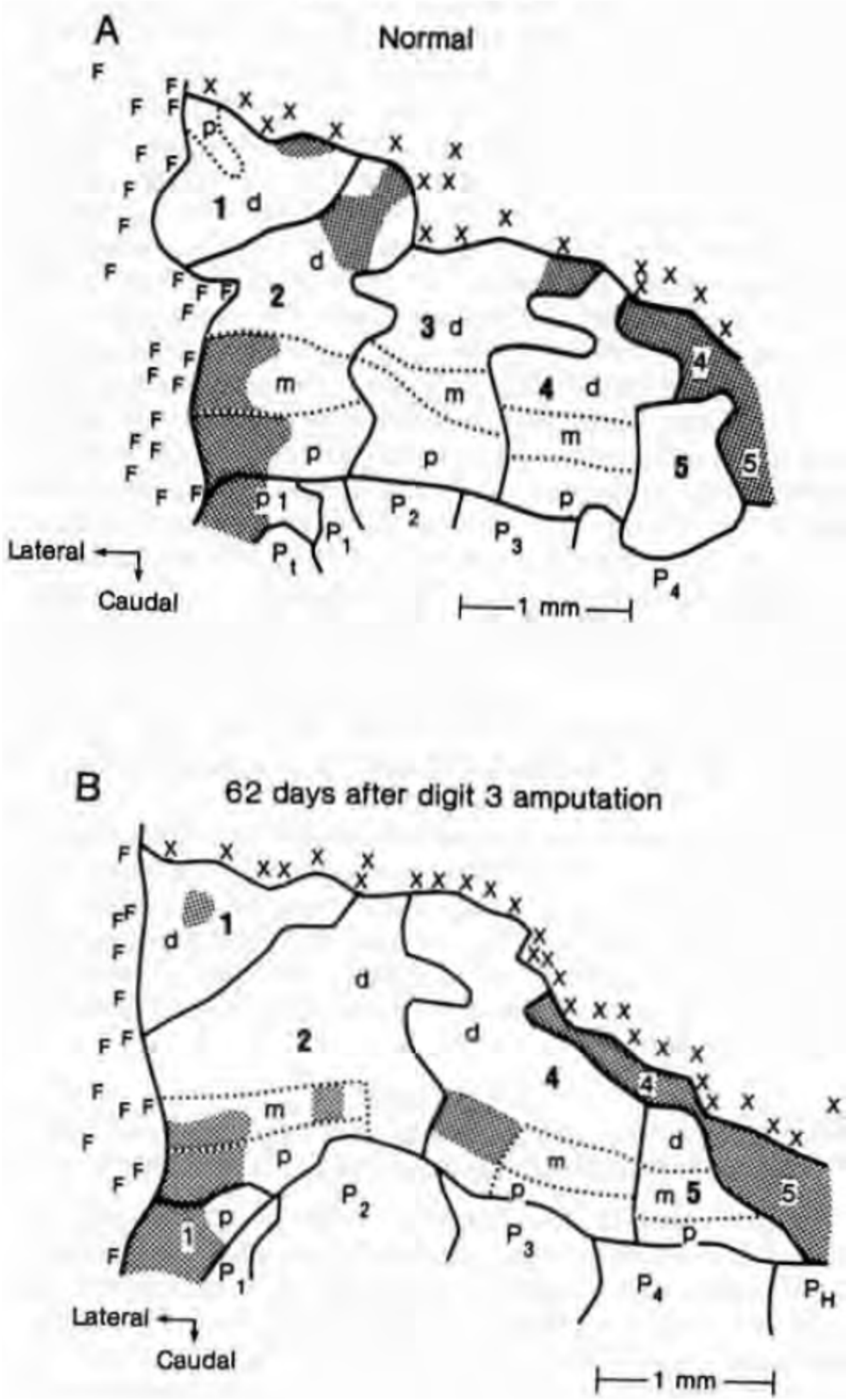
Today we know, that...

- The brain continuously reorganizes itself
-
-

These processes are called neuroplasticity!

- For frequently performed functions more brain tissue is provided



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Plasticity of cortical representation areas

Monkeys with amputated third finger

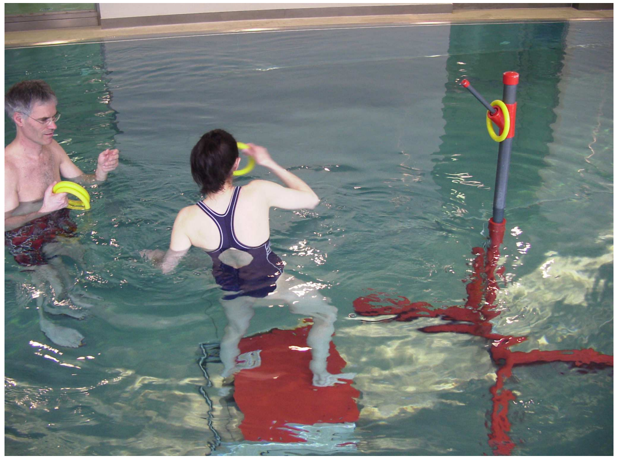
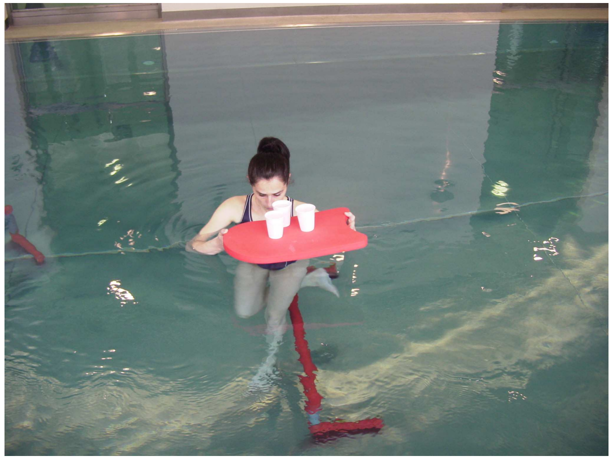
Extent of the representation area for all fingers

Merzenich MM et al: J Comp Neurology 1984

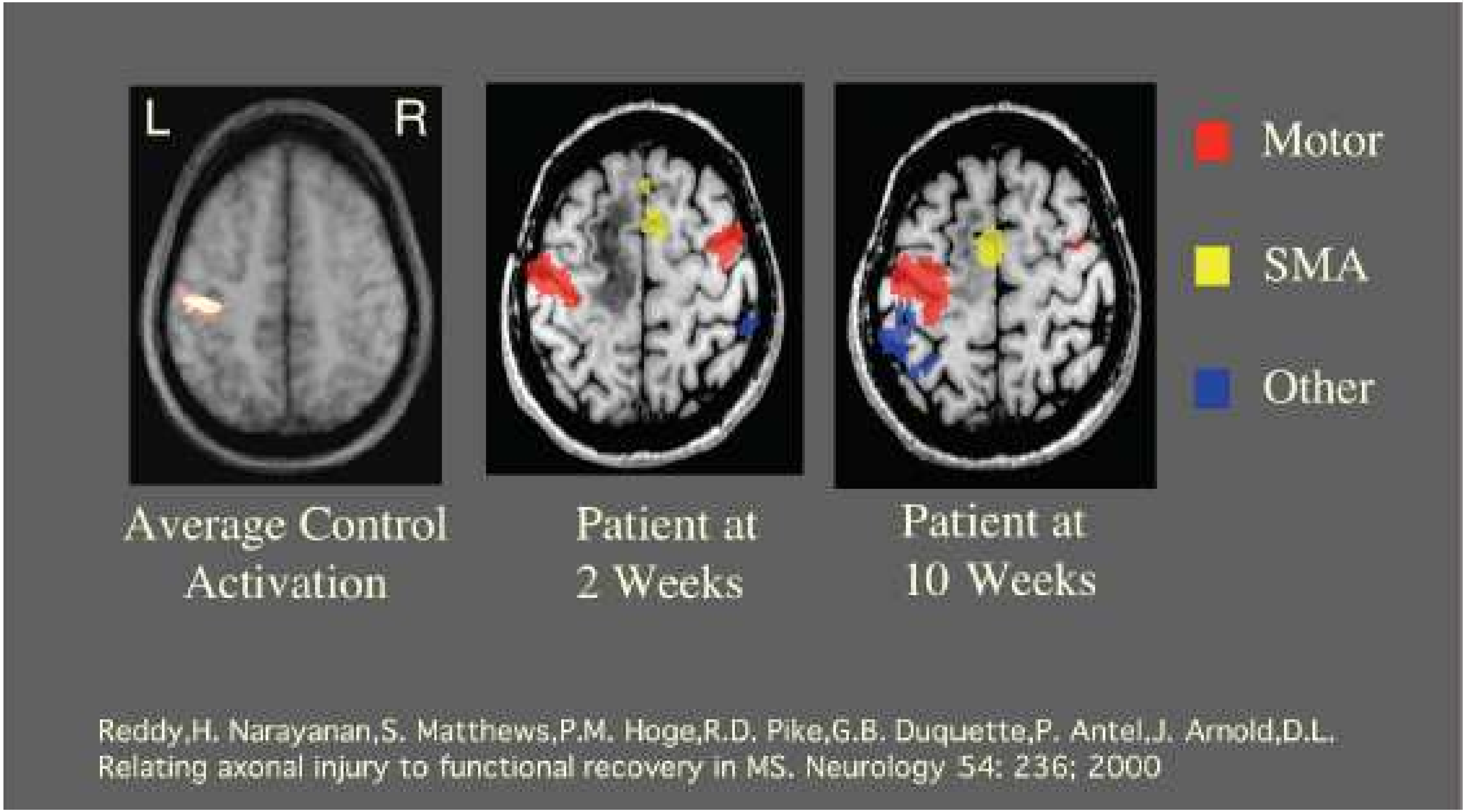
Synaptic plasticity



„repetitio est mater studiorum“

Recovery in acute MS: fMRI R-hand motor task



Effects of immersion

- Cardiatic system
- Pulmonal system
- Renal system
- Muscle system
- Nervous system

Cardio-vascular work on immersion

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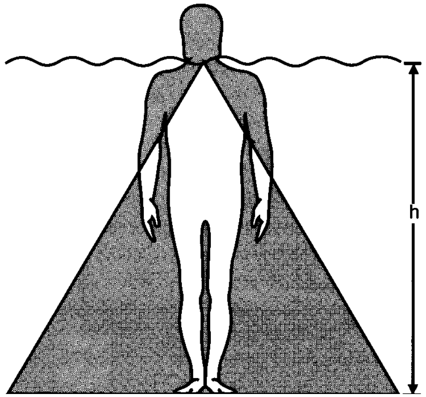
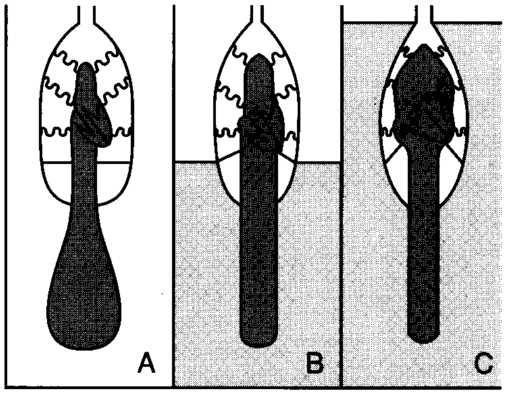


Hydrostatic pressure



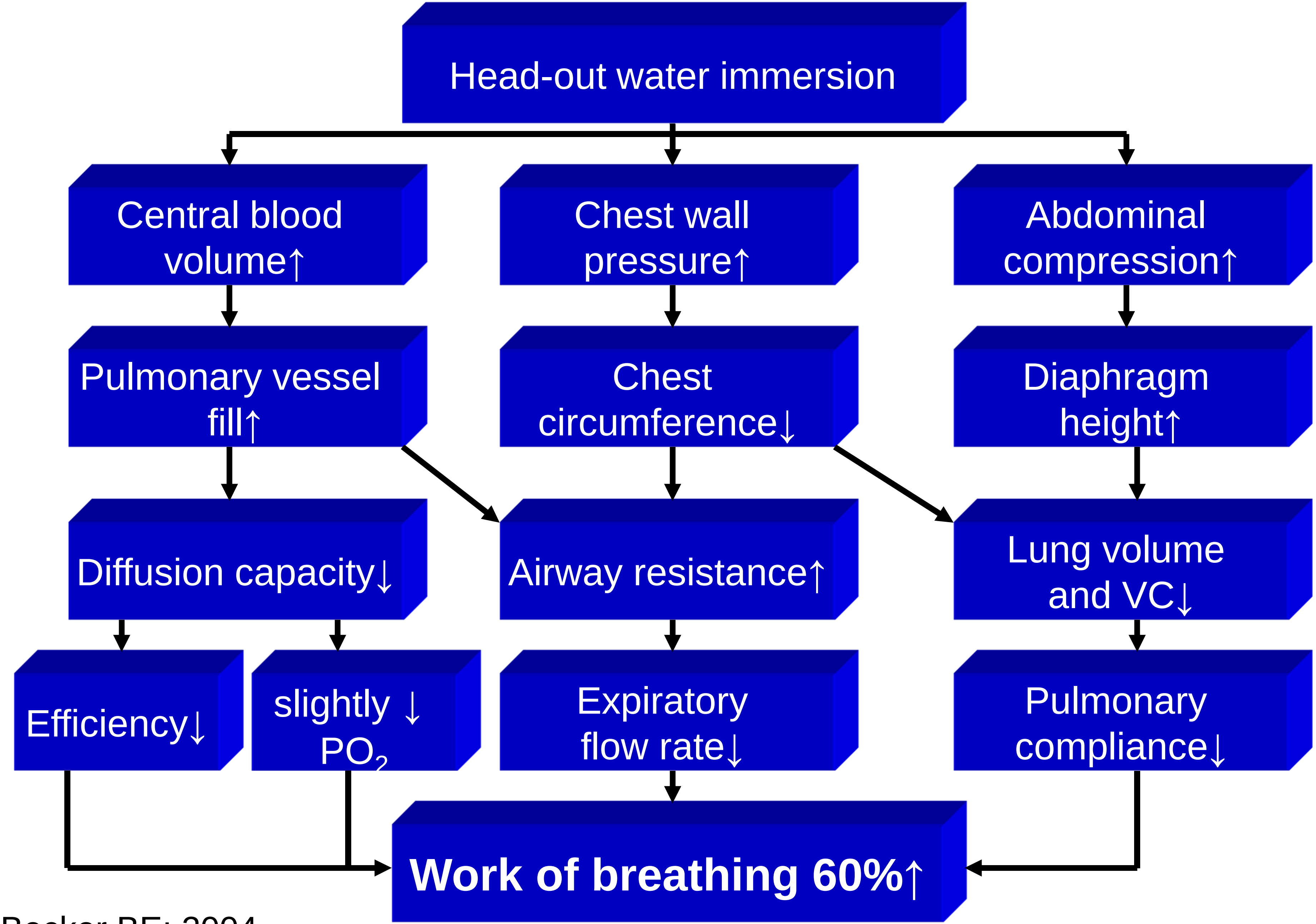
Central blood volume↑

Stroke volume increase
(Starlings‘s law)

Head-out water immersion increase stroke volume from 71 to 100 ml/beat
Aborelius M Jr et al: Aerpsp Med, 1972

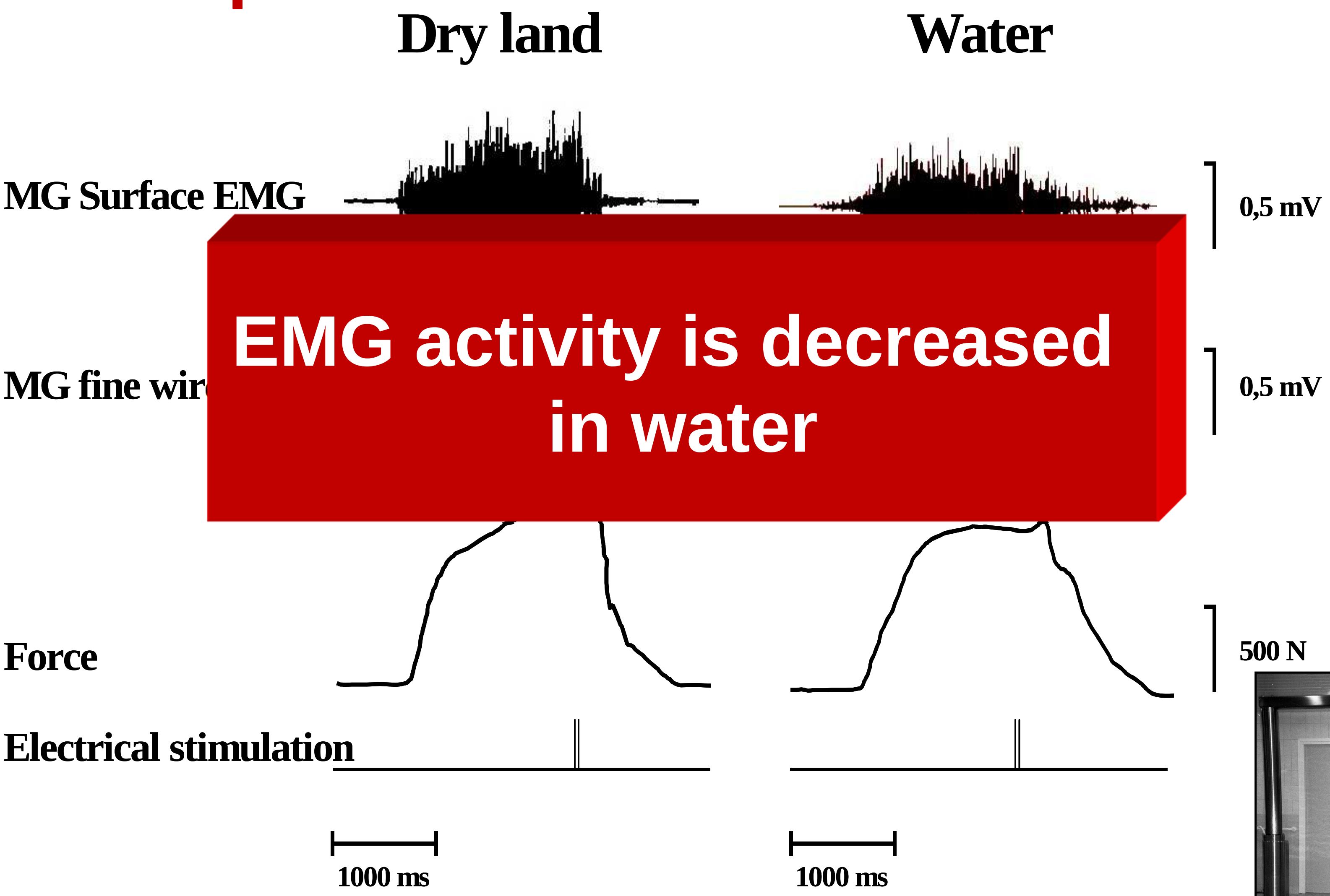
Exercise maximum for sedentary individuals
Schlant RC in The Heart, 1986

Effects of immersion on pulmonary system

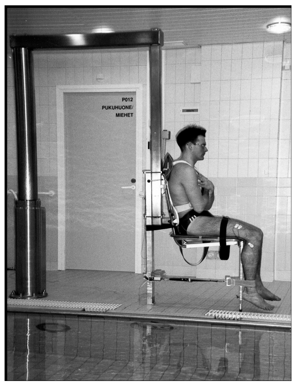


Becker BE; 2004

EMG activity and force reproduction on quadriceps muscle



EMG activity is decreased in water



Pöyhönen T: 2008

Effect on nervous system

- **Immersion, temperature and turbulences increase pain threshold** (Juve Meeker: 1998)
- **Immersion suppresses sympathetic nervous system activity** (Hildenbrand et al: 2010)
- **Immersion increases plasma dopamin and has positive effects on mood** (Krishna et al: 1983)

Neuromuscular effects of Water training

Regeneration after intensive, exccentric exercise (down-hill running) – Water training reduced loss of muscle power

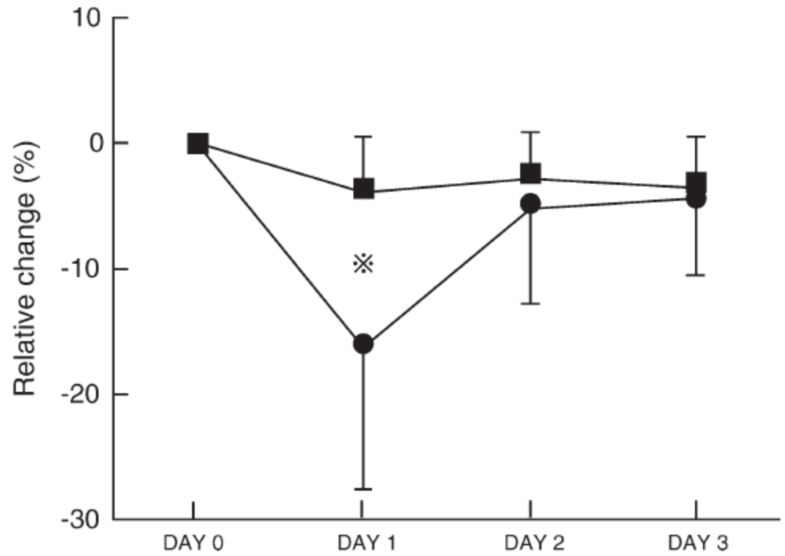


Figure 1. Relative change in leg muscle power. The values are the adjusted mean ($\pm s$) from analysis of variance. ■, aqua exercise ($n = 5$); ●, control ($n = 5$). ※ Significant difference between the two groups (power × time interaction: $P < 0.05$).

Muscles regenerate faster!

Takahashi et al. 2006

Current trends in stroke rehabilitation 1

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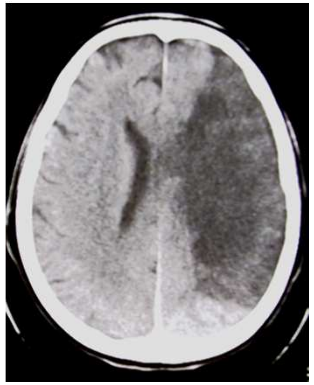
- Stroke units
  - Associated with reduced risk of death and institutional living

    (Indredavik B: Stroke 2009)



- Motor rehabilitation
  - Functional approach, specific activities, active participation of the patients, frequent and intense
  - Sensory motor stimulation (Terent A et al: J neurol Neurosurg Psychiatry 2009)
  - CIMT is not superior in early stroke rehabilitation

    (Boake C et al: Neural Repair 2007)
  - Robot-assisted therapy effects motor recovery but not functional ability

    (Kwakkel G et al: Neurorehabil Neural Repair 2008)

Current trends in stroke rehabilitation 2

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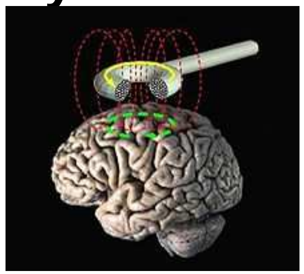
- **Motor rehabilitation**
  - **Virtual reality and robot-based training has beneficial effects**
    Mirelman A et al: Stroke 2008
    Takahashi CD et al: Stroke 2008
  - **BAT reduced motor impairment**
    Lin CK et al: Neuro
    McCombe Waller S

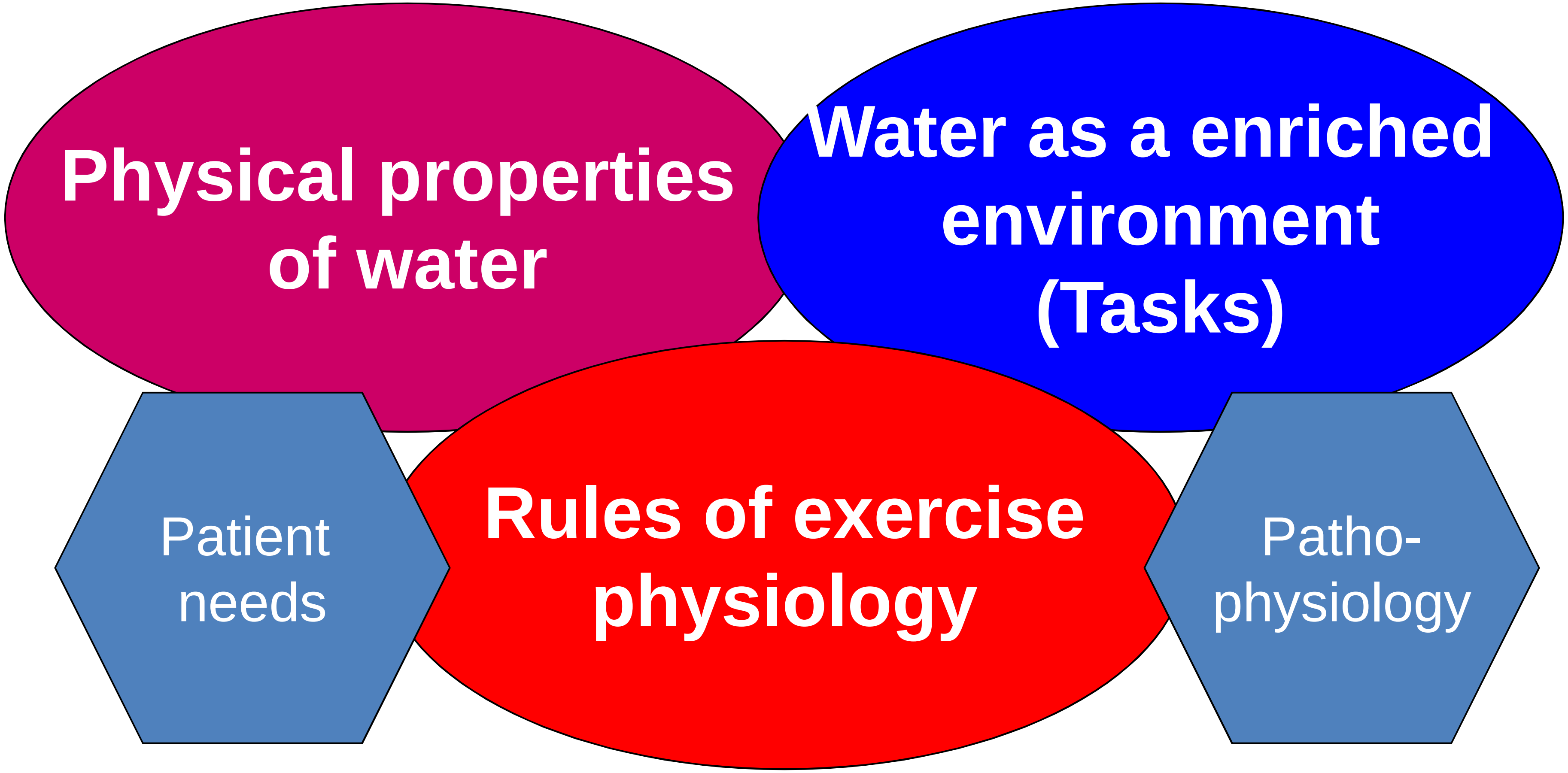
Aquatic therapy?

- **Electrical brain s**
  - **rTMS low freque… Hz excitatory effect**
  - **tDCS 20 Hz excitatory effect**
    Khedr EM et al: Acta Neurol Scand 2009



- **Multisensory interaction**
  - **Mirror therapy** Dohle C et al: Neurorehabil Neural Repair 2009
  - **Mental training** Page SJ et al: Stroke 2007
  - **Virtual reality** Rand D et al: Eur J Phys Rehabil Med 2009

Hydrotherapy



Buoyancy and ground force

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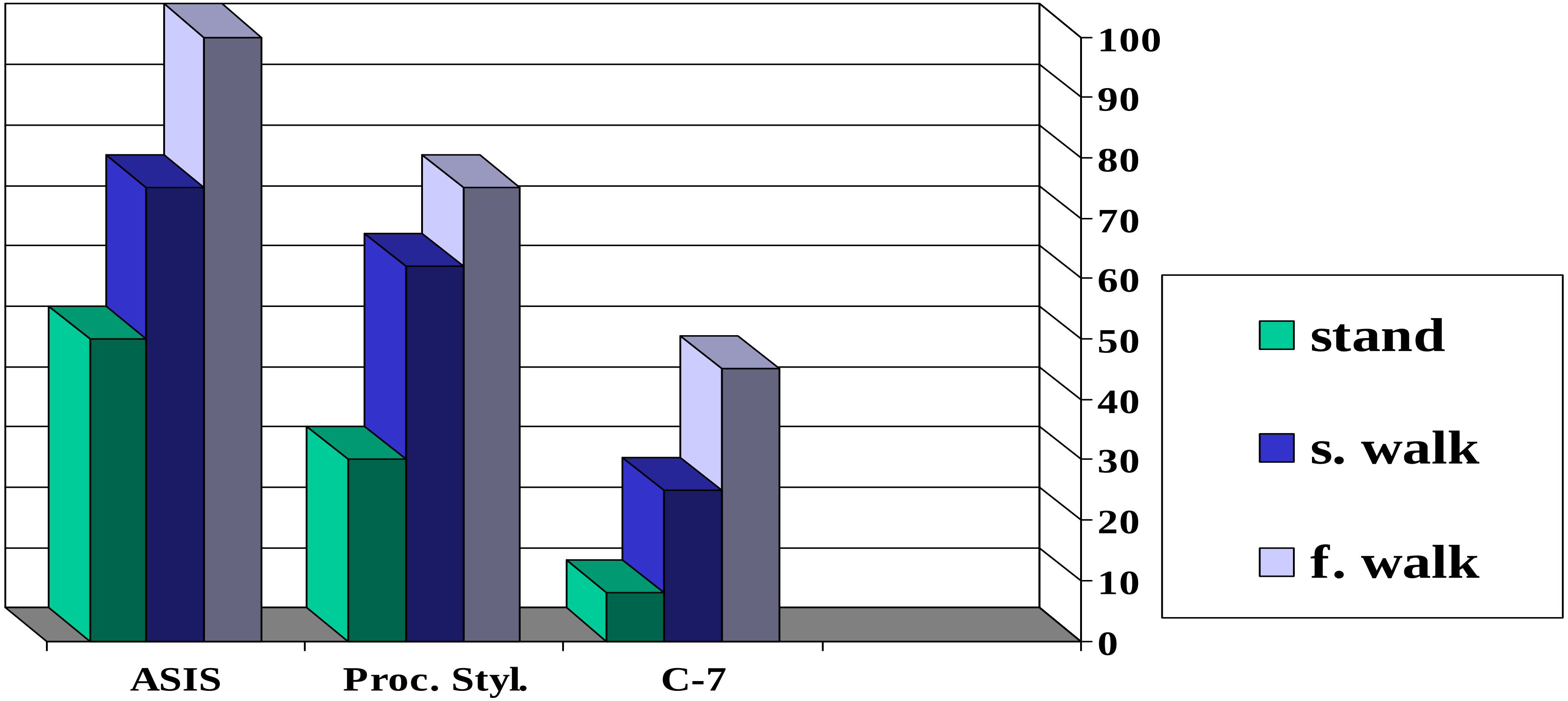
- Ground force is dependent on gait velocity
- Weight bearing increases bone mineralisation
- Balance improves function



Harisson RA et al: 1987, 1998

Shoulder muscle activation during aquatic and dry land exercises in nonimpaired subjects

Kelly B et al: J Orthop Sports Phys Ther; 2000

Muscle	Test	30° /S	60° /S	90° /S
Supraspinatus	Land Water	16.68 3.93 p=.015	17.46 5.71 p=0.015	22.79 27.32 p=0.73
Infraspinatus	Land Water	11.10 2.28 p=.0325	10.76 2.89 p=.0524	15.03 21.06 p=.5566
Subscapularis	Land Water	5.96 1.49 p=.0072	6.83 2.26 p=.0346	7.45 10.73 p=.2421
Anterior deltoideus	Land Water	15.88 3.61 p=.0047	18.82 4.49 p=.0273	22.09 32.83 p=.3273

Percentage of maximal voluntary contraction

Increase of central conduction function after cold bath in MS

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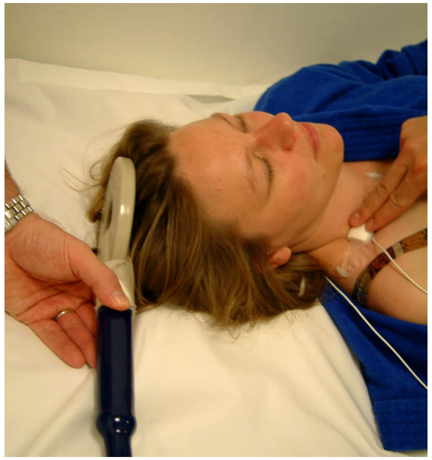
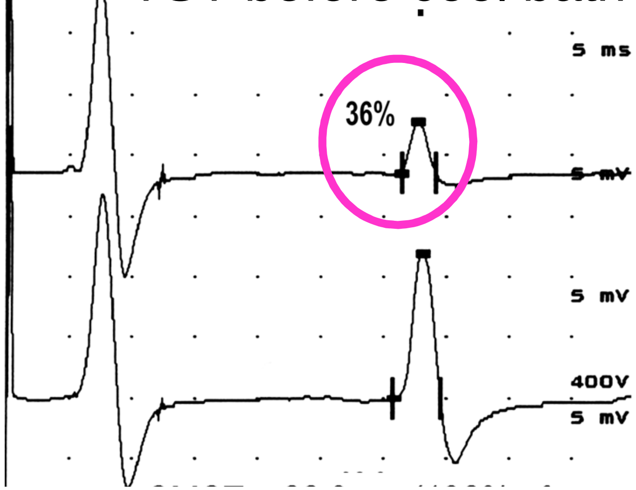


Cool bath
(15° C, 15 min)

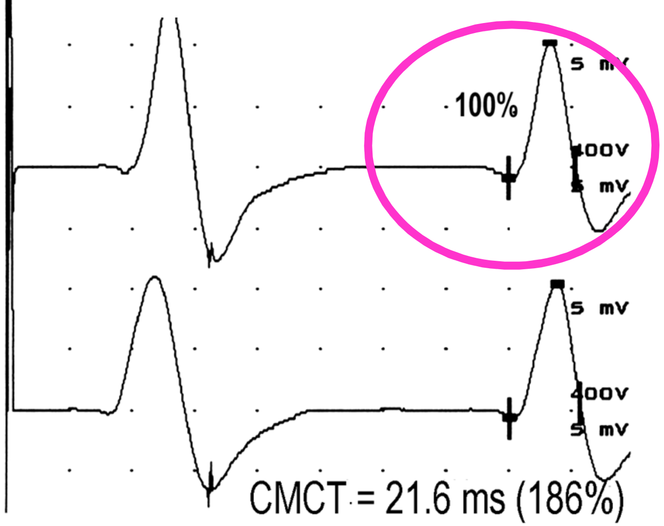
TST before cool bath

MS

Control



TST after cool bath



Humm A. et al: 2004

Water temperature in thermo sensitive and "normal" patients

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Thermo sensitive patients

Treatment in cool water when possible

- 28-30° C motor relearning
- 24-28° C aerobic and strengthen exercises

"Normal" patients

- Thermo indifferent water 32-34° C motor relearning
- 28-32° C aerobic and strengthening exercises

Very early versus delayed mobilisation after stroke

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Bernhardt J et al: Cochrane 2009 (1)

1 study n=71

Death

Analysis 1.2. Comparison 1 Very early mobilisation versus standard care, Outcome 2 Death.

Review: Very early versus delayed mobilisation after stroke

Comparison: 1 Very early mobilisation versus standard care

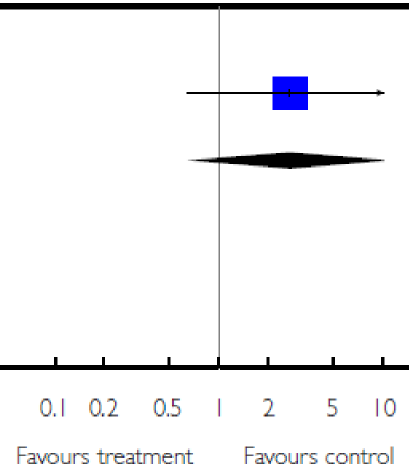
Outcome: 2 Death

Study or subgroup	Treatment n/N	Control n/N	Odds Ratio M-H,Fixed,95% CI	Weight	Odds Ratio M-H,Fixed,95% CI
1 Mortality at 3 months					
AVERT II	8/38	3/33		100.0 %	2.67 [0.64, 11.03]
Total (95% CI)	**38**	**33**		**100.0 %**	**2.67 [0.64, 11.03]**

Total events: 8 (Treatment), 3 (Control)

Heterogeneity: not applicable

Test for overall effect: Z = 1.35 (P = 0.18)



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Feasability of two different water based exercise program in patients with parkinson's disease

Ayan C and Cancela J: Arch Phys Med Rehabil: 2012

n=21, 12 w, 2x/w 60 min.
low: walking, balance, dynamic exercise, cool down
high: walking, submaximal exercise 15 rep, 2-3 sets, cool down

	Group	Pretrain	Posttrain	95% CI	p	Effect size
UPDRS	low	13.7(6.9)	11.7(4.9)	-1.68 to 5.68	.240	0.28
Motor scale	high	16.2(6.6)	11.2(2.9)	1.54 to 9.11	.012	0.75
PDQ-39	low	42.4(18.7)	23.8(10.6)	4.08 to 35.46	.020	0.99
	high	42.3(20.7)	25.1(12.7)	6.51 to 27.88	.005	0.83
FTSTS	low	14.7(3.4)	12.5(3.1)	-1.18 to 4.26	.224	0.64
	high	18.6(4.2)	13.4(4.3)	3.68 to 6.82	.001	1.23

Water-based exercise for improfing activities of daly living after stroke

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Mehrholz J et al: Cochrane 2011 (1)

Activity daly living

4 RCT; n=94

Analysis 1.1. Comparison 1 Water-based exercises versus no water-based exercises, Outcome 1 Activities of daily living.

Review: Water-based exercises for improving activities of daily living after stroke

Comparison: 1 Water-based exercises versus no water-based exercises

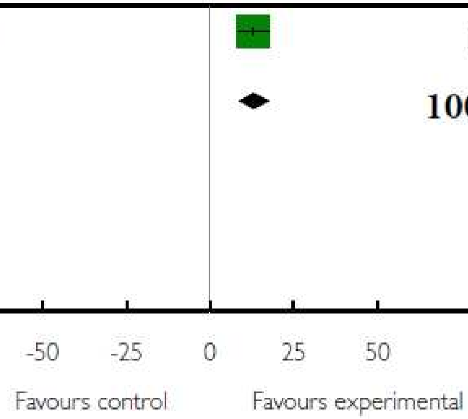
Outcome: 1 Activities of daily living

Study or subgroup	Experimental N	Experimental Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
Aidar 2007	16	59.2 (5.4)	15	46 (8)		100.0 %	13.20 [8.36, 18.04]
Total (95% CI)	**16**		**15**			**100.0 %**	**13.20 [8.36, 18.04]**

Heterogeneity: not applicable

Test for overall effect: Z = 5.35 (P < 0.00001)

Test for subgroup differences: Not applicable



Water-based exercise for improving activities of daly living after stroke

Mehrholz J et al: Cochrane 2011 (1)

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Postural control

Analysis 1.3. Comparison 1 Water-based exercises versus no water-based exercises, Outcome 3 Postural control.

Review: Water-based exercises for improving activities of daily living after stroke

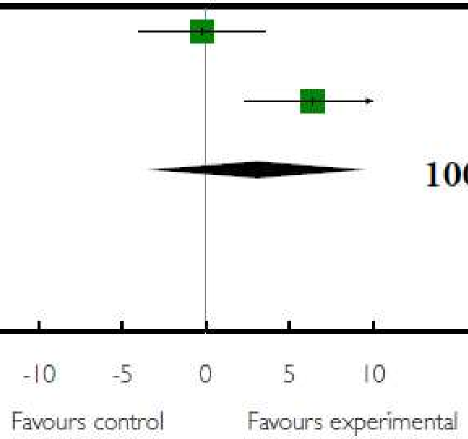
Comparison: 1 Water-based exercises versus no water-based exercises

Outcome: 3 Postural control

Study or subgroup	Experimental N	Experimental Mean(SD)	Control N	Control Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Chu 2004	7	52 (3.3)	6	52.2 (3.6)		50.7 %	-0.20 [-3.98, 3.58]
Noh 2008	13	50.9 (2.8)	12	44.5 (6.7)		49.3 %	6.40 [2.32, 10.48]
Total (95% CI)	**20**		**18**			**100.0 %**	**3.05 [-3.41, 9.52]**

Heterogeneity: $Tau^2 = 17.75$; $Chi^2 = 5.40$, df = 1 (P = 0.02); $I^2 = 81\%$

Test for overall effect: Z = 0.93 (P = 0.35)



Effect of aquatic exercise training on fatigue and health related quality of life in patients with MS

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Kargarfard M et al: Arch Phys Med Rehabil; 93, 2012

Table 2: Comparison of Fatigue and Quality of Life in Exercise and Control Groups at 4 and 8 Weeks

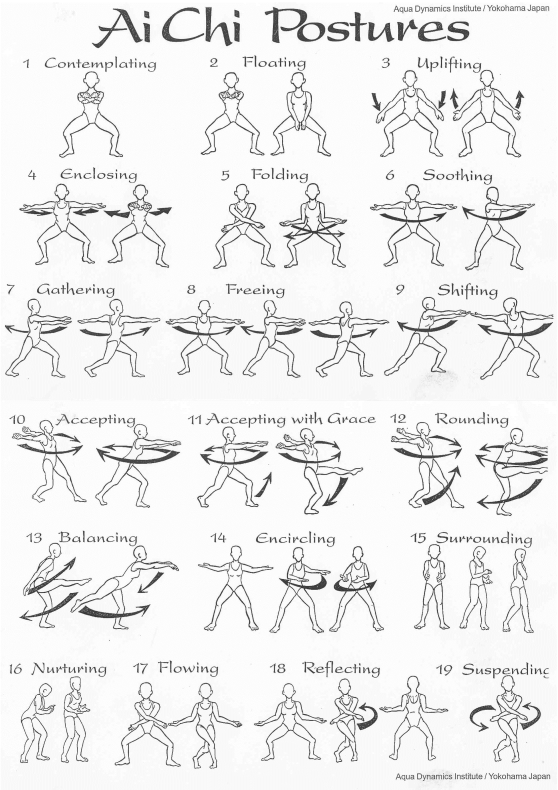
	Control			Exercise			Group Effect	Group-Time Interaction
Characteristics	Baseline	4wk	8wk	Baseline	4wk	8wk	*P**	*P**
MFIS–overall	45.6±8.9	53.8±13.9	60.8±9.0	42.1±14.1	39.9±11.4	32.3±6.4	.002	<.001
MFIS–physical	20.7±8.2	24.8±8.6	29.5±5.8	19.2±6.6	16.2±4.1	14.0±3.3	.003	<.001
MFIS–psychosocial	18.6±7.7	22.9±6.6	24.5±5.7	17.1±7.6	18.3±7.0	14.4±3.0	.027	.018
MFIS–cognitive	6.2±1.5	6.1±1.1	6.7±1.5	5.8±1.8	5.4±1.2	3.9±1.7	.009	.008
MSQOL-54–physical	43.5±5.8	44.0±6.1	44.2±4.4	43.9±6.8	54.3±5.3	65.4±6.6	<.001	<.001
MSQOL-54–mental	42.5±10.5	42.5±9.9	43.6±8.9	44.4±9.3	56.9±4.6	70.2±5.7	<.001	<.001
Physical health	46.4±10.5	48.2±5.6	44.5±9.9	45.5±10.5	50.5±7.6	62.5±7.9	.019	.001
Mental health	45.1±18.7	43.3±19.4	40.7±16.6	49.6±19.2	60.0±19.9	70.8±18.8	.036	<.001
Health perception	57.7±12.5	55.0±10.7	54.5±7.2	59.5±17.7	62.5±11.1	76.0±10.7	.030	.002
Energy	35.3±8.5	41.1±11.0	40.7±10.5	34.0±11.0	50.8±9.6	60.4±8.9	.021	<.001
Role limitation–physical	38.6±13.1	36.4±20.5	36.4±17.2	40.0±12.9	50.0±20.4	67.5±20.6	.036	<.001
Role limitation–emotional	33.3±29.8	36.4±23.3	39.4±20.1	36.7±39.9	53.3±39.1	66.7±27.2	.217	.026
Bodily pain	36.1±15.1	37.9±16.6	41.8±14.1	33.7±15.5	57.7±12.4	71.7±15.0	.014	<.001
Health distress	49.5±14.9	45.4±11.3	50.4±11.9	48.5±12.0	62.5±16.5	71.0±21.4	.034	.005
Social functioning	45.4±11.9	49.2±5.8	47.7±8.4	47.5±11.8	59.2±9.9	66.7±15.2	.014	.009
Cognitive function	50.9±9.4	49.1±12.4	52.7±9.8	52.0±15.5	55.5±13.8	61.5±12.0	.296	.059
Sexual function	40.5±16.3	41.7±11.8	44.0±10.5	44.0±21.4	47.6±20.3	50.0±19.3	.566	.757

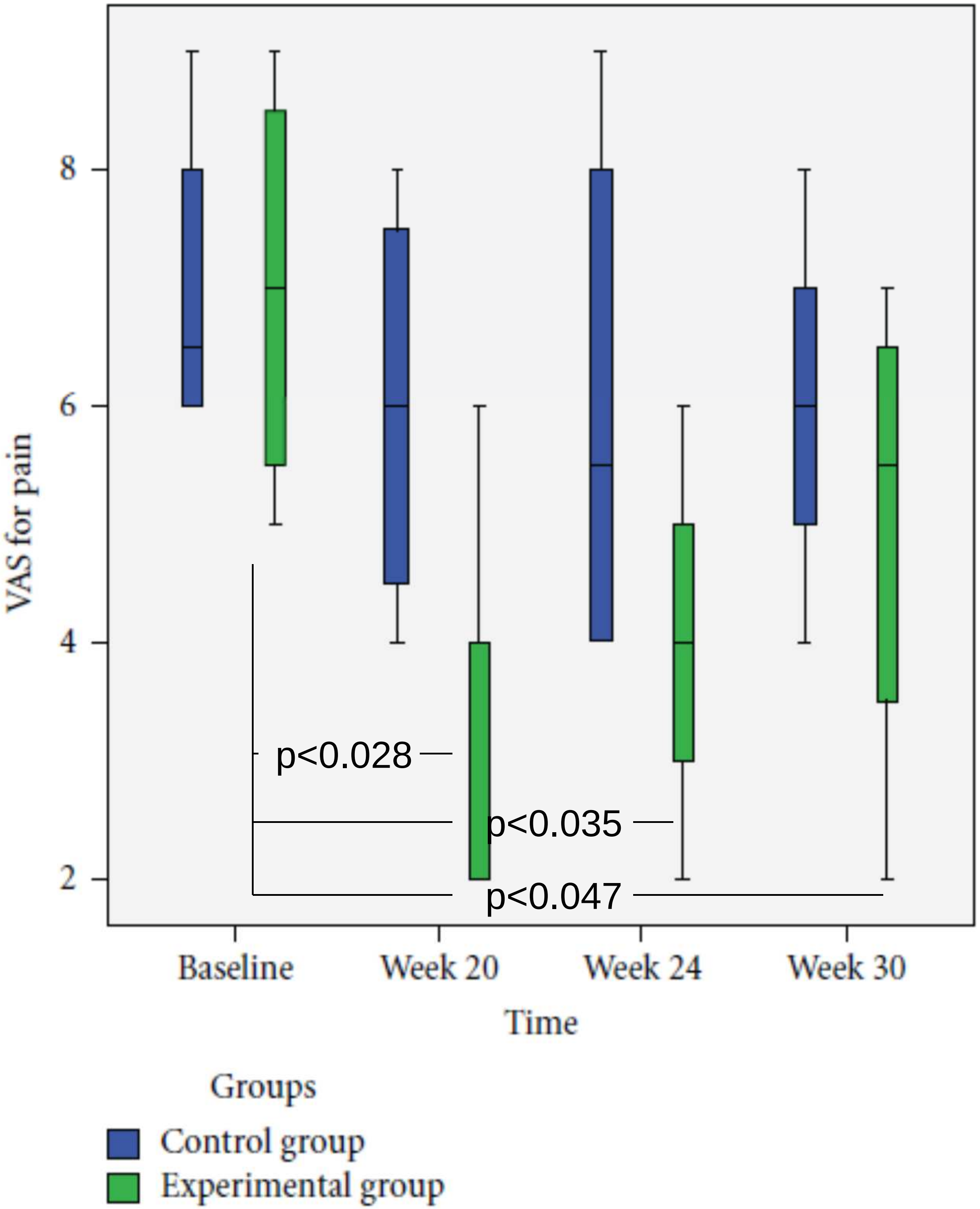
n=21,EDSS 3.5, RCT, 8 w 3t/w 60 min, 50 to 75% max HR.
Control: no changes

Hydrotherapy for treatment of pain in people with multiple sclerosis: RCT

Castro-Sanchez AM et al: 2012

n=50, 20w/2/w, 60 minutes, 36° C, Ai Chi, EDSS 6.3; control relaxation and breathing EDSS 5.9

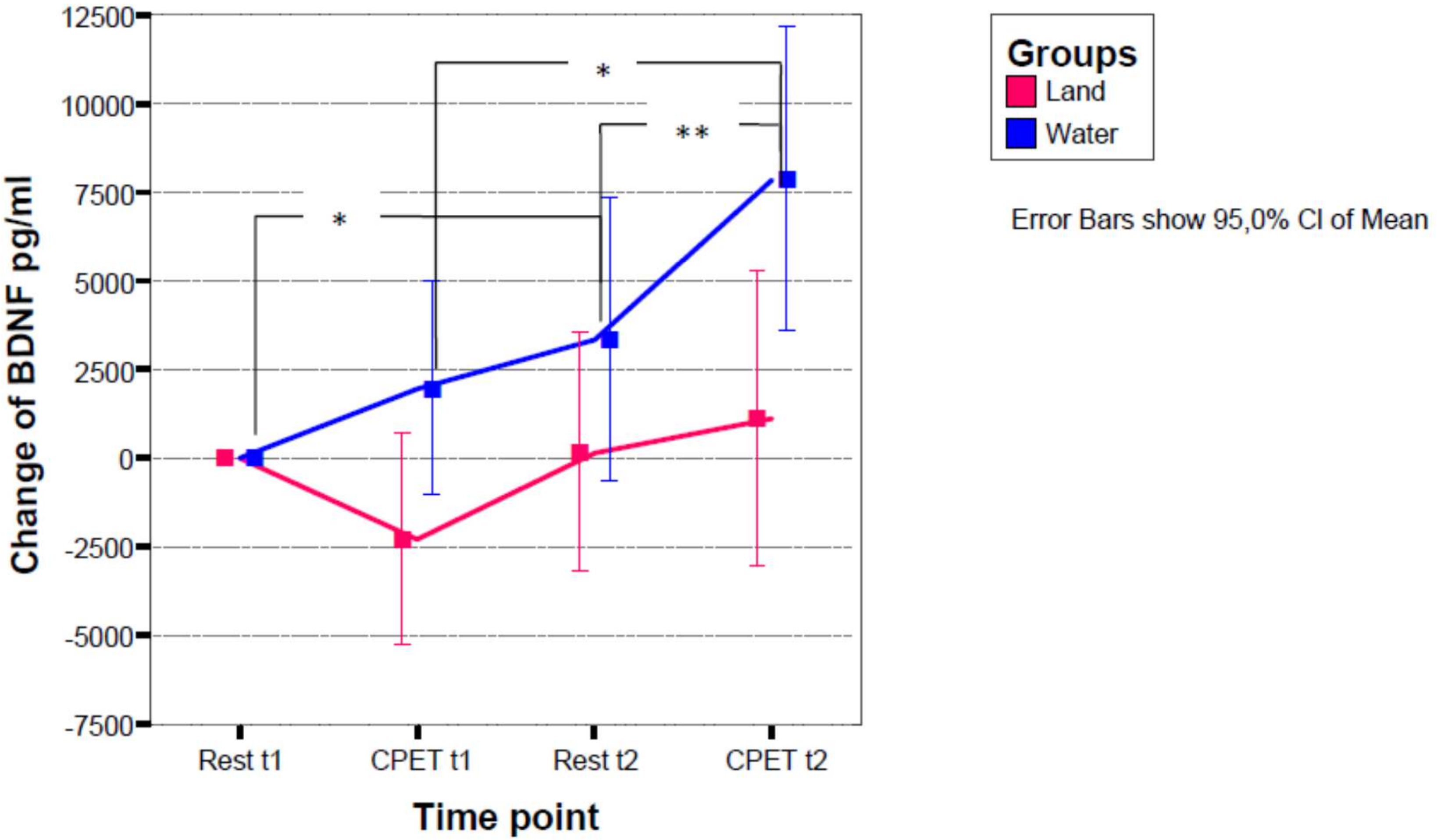




Training in MS - Influence of two different endurance training protocols (aquatic versus overland) on cytokine and neurotrophin concentrations during three weeks randomized controlled trial

Bansi J et al: Multiple Sclerosis J, 2012

n=60; EDSS 1.0-6.5; 3w; 5/w 30 min 60% VO_2max, 28° C



Aquatic therapy versus conventional land-based therapy für parkinson's disease

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Vivas J et al: Arch Phys Med Rehabil; 2011 (92)

n=11 H&Y 2-3, 4w 2/w 45 minutes 1:1, trunk mobility, postural stability, transfering onself

Test	Intervention	Pre-	Post-test	p
UPDRS	Water	45.80 (10.38	32.20 (5.85)	.036
	Land	36.33	32.67	ns
Functional reach		27 (9)	32 (6)	.001
BBS	Water	46.80 2.39)	53.60 (1.67)	.010
	Land	49.67 (7.20)	51.83 (6.11)	ns
TUG		16.87 (5.22)	15.21 (3.20)	ns

Take home message

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1. Immersion studys show benefical effects for neurologic patients

2. Recommendations for hydrotherapy are only Delfi founded

3. Principles for sensory-motor rehabilitation can be used under immersion and should be added with waterspecific elements

4. Most aquatic therapy studies are of low quality

5. Future research on aquatic therapy must focus higher quality levels (definitions of primary outcomes and number of cases)

Questions?