Underwater treadmill and post-stroke gait training .

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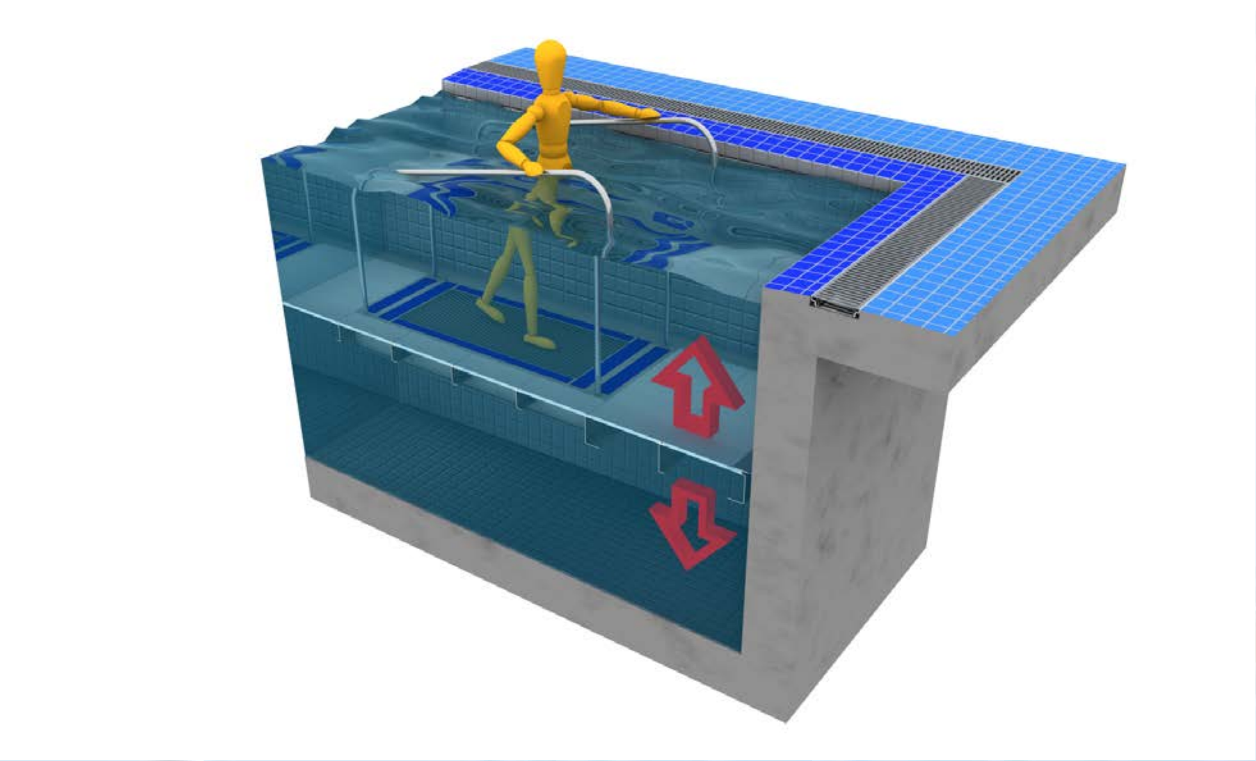


A form of distributed massed practice

Stroke :

- Main cause for remaining invalidity in industrial world .
- 200.000 stroke patn. in Germany per year.
- 60% of those suffer from significant limitations in gait and walking distance .
- 20% remain wheelchair bound.

(Kominsky-Rabas et al, 2006)

Regaining gate :

- **Nr. 1 goal** of stroke patients , regardless the gaitpattern used .
- Nr 2 goal = functional gaitvelocity.

(Bohannon R ,1988)

(re)learning to walk no 1 goal : Why ?

Being able to walk, even a few steps, means independence , dignity……….

Gait velocity in stroke as a predictor for selfreliant gait and need of care :

Gait velocity (Comf Walk Speed)	Will stay indoors	Will go outdoors	Chronic need of daily care
< 1,4 km h (< 24 m/min.)	X		
< 2,8 km/h (< 48 m/min)		x limited range	
>2,8 km/h (> 48 m/min) (*1)		x unlimited range	
≥ 1,5 km/h (≥ 25 m/min) (*2)		x in /around home	

(*1) Hesse S et al 2010
(*2) Perry J, 1995
(*3)Goldie et al , 1996

Central Pattern Generator (=C.P.G.) 1 :

- Gait experience during life leads to spinal lokomotion centre (interneurons) in spinal cord = C.P.G..
- In healthy adults centre in brain (Pons) controlls spinal C.P.G..(on/off switch)
- C.P.G. keeps up the reciprocal gait pattern.

Central Pattern Generator (2) :

In order to trigger the CPG adequately you need :

1) Velocity/cadence (25 % above comfortable walking speed of stroke patient)= ***need for treadmill (tm).*** (**s**tructured **s**peed dependent **t**readmill training (**SST**);Pohl et al. 2002 and 2007)

2) Afferent feed back.(proprio-and exteroceptive) from foot and leg to C.P.G. , that means weight shift during walking (left to right) and ≥ 50% of bodyweight on feet. Also heel strike, flat footsole contact and hip extension during stance phase .(Dietz V.,2010)

Comfortable walkingspeed (without a Treadmill) is to slow to trigger the CPG`s.

Evidence of efficacy of land ***T***readmill ***T***raining (TMT) in stroke :

Change in gait characteristics :

- Velocity (V)↑and Cadence ↑

mean max. walking V after 4 weeks **SST** 1,0 m/sec .↑

Controll group (conventional ther.) mean max. V 0,3m/sec.↑

(Pohl M et al,2002)

Motor (re)learning

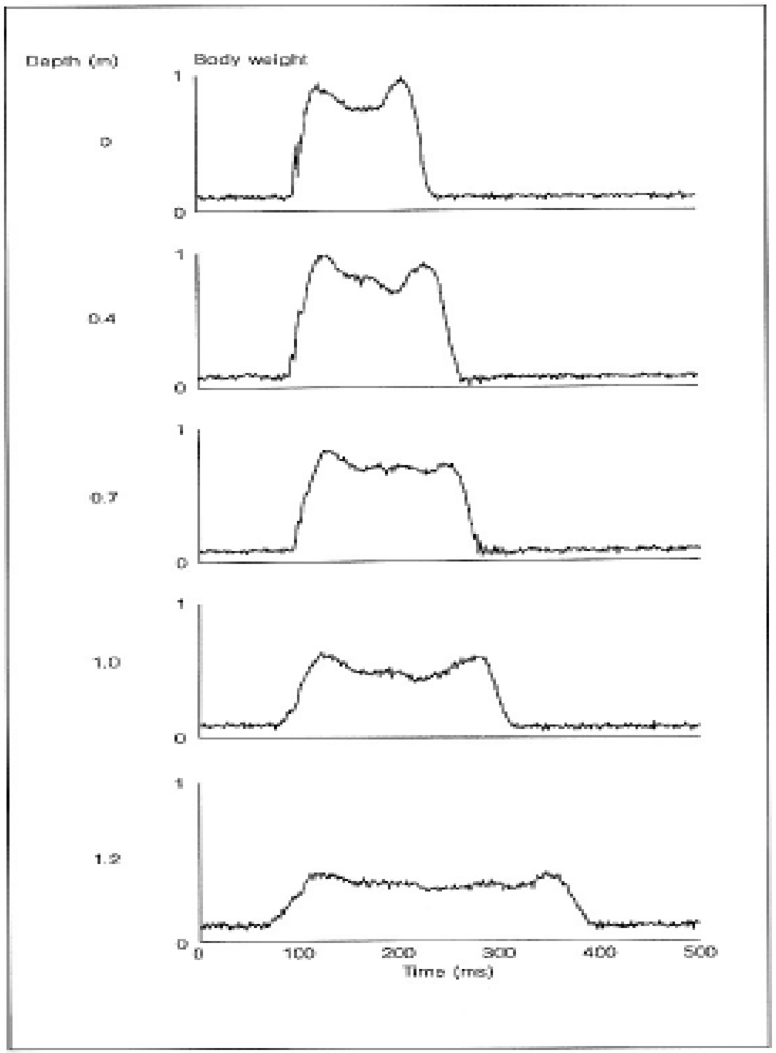
Has 2 important rules when learning an activity (like walking)

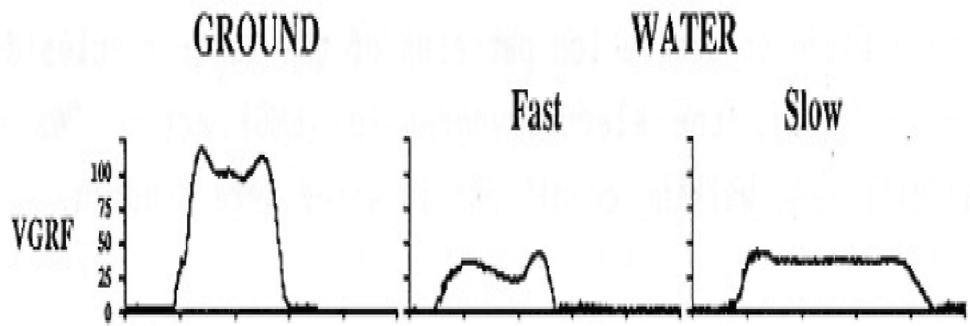
1. The training activity must have similarity with the activity you want to improve (dry land gait).
2. Options for variation of practice, vary elements of activity.

Motor learning rule 1 :

is there similarity between underwater treadmill walking and walking on land ?

GroundReactionForce(GRF) : influence of waterdepth and Velocity (Nakazawa 1994)





(Nakazawa 1994)
Walking velocity
Slow = slower than comfortable
Fast = faster than comfortable

Nakazawa 1994
Differences in depth

Biomechan adapt. in gait , land versus water (I):

Waist D water CWS	Land	water	underwater treadmill
leg swing ph. hipflex.	Almost passive	active	active
Stance ph.: Heel strike	Vert mech. impact↑	Vert mech. impact↓	Vert mech. impact↓
toe off	propulsive	propulsive ↓	propulsive↓
Arm swing	Almost passive	active with elbow flex.	active with elbow flex.

(Lambeck J. 1994)

Biomechan adaptions land v water (II):

(unpublished res.,courtesy of Lambeck J)

Waist Deep water CWS	Land	water	water treadmill
Walking pattern	cross lateral	tendency to ipsilateral	cross lateral
Trunk alignment	slight forward	Trunk forward+ hip in flex.	slight forward

Muscle activity during walking on dry land and in water 1 (Masumoto et al 2004) ⟶ (proc. xiphoid.)

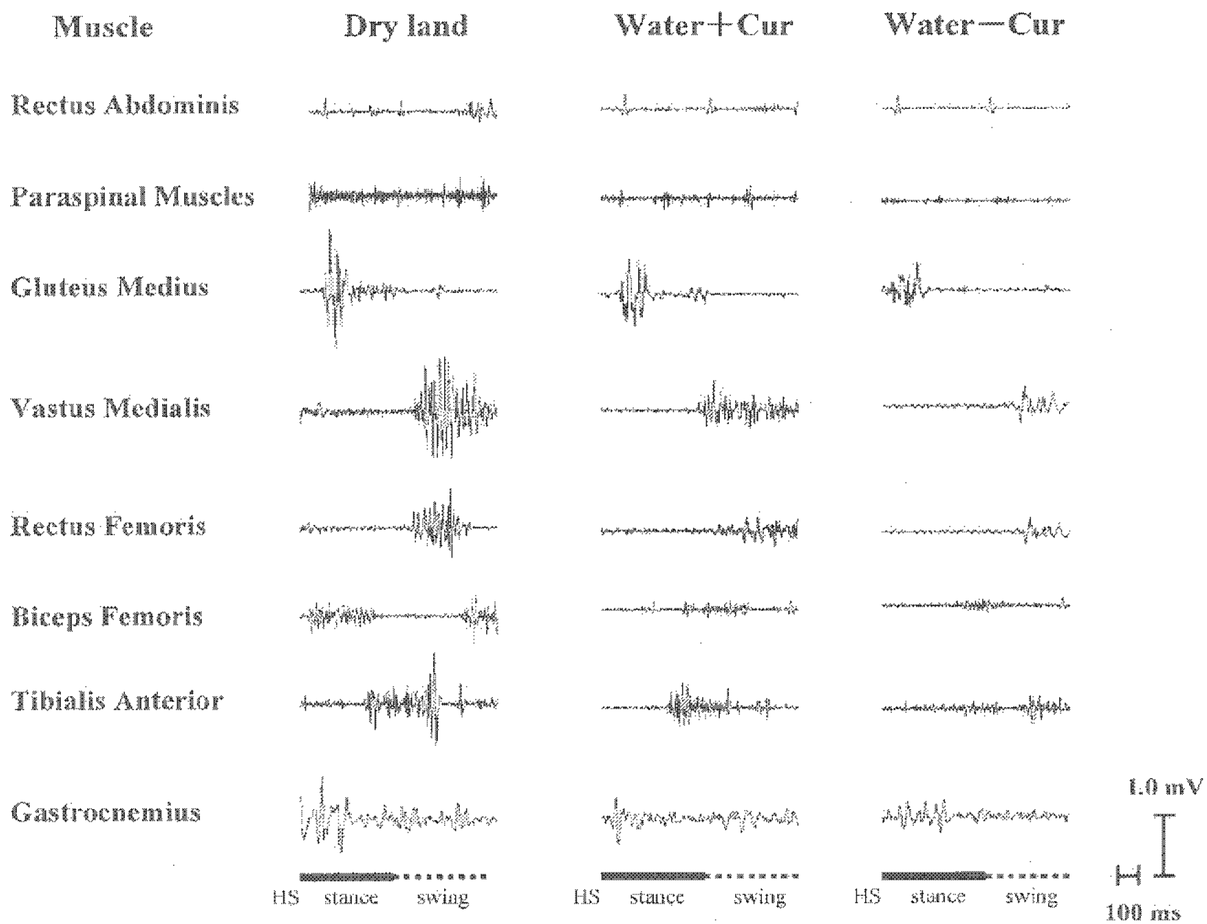


Fig. 1 Typical EMG data per gait cycle of a subject performing trials at moderate speed. HS; heel strike. Water+Cur; walking in water with current. Water−Cur; walking in water without a current.

Summary kinematics in water TMT in Thighdeep(TD) to Waistdeep(WD) water :

- less peek dorsiflex. and more peek plantar flexion .
- Stride length ↑(dep.on V)
- Stride time ↑ equal % stance/swing
- Cadence ↓

Summary kinematics in water TMT in TD-WD water (2):

- Torques and impulses are quite different (drag and buoyancy)
- Comfortable walkingspeed on water -TM is +/- 50% land
- Joint angles are roughly identical
- In total : gross similarity with gait pattern on land (in**TD-up to WD water on underwater TM**)

Summary biomechan. and EMG charact. of under water TM gait:

- EMG : less peaks , flattened signals.(dependent on waterlevel).
- Between TD and WD similarity between water gait muscle activity and land gait muscle activity.
- M.biceps femoris shows increased activity
- M.quadriceps femoris (medial part) and m.tibialis anterior increased activity when walking fast.

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Comparing gait characteristics at same comfort. walking speed on land and during underwater TM walking in Individuals with Stroke :

N=9; M=7,F=2, age range=50-76 y.
mean age 55.

(Rambhatla R et al , 2010.)

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On Water Treadmill:	hemiplegic leg	non affected leg	N=9; M=7,F=2, age 50-76 y mean 55 y
Cadence	↓	↓	(p > 0,05)
Stride length	↑	↑	(p > 0,05)
Stride time	↑	↑	(p > 0,05)
Hip movement	No diff.	No diff.	
Peek Knee flex. angle	No diff.	↓	
Peek Knee ext. angle	No diff.	↑	
Peek Ankle dorsi	↓	↓	(p > 0,05)

(Ramblatha K., 2010)

Conclusions Rhambhatla et al :

- Aquatic TMT can be used to improve stride length of people with stroke.
- Attention in aquatic TMT for patn. with ankle deformities due to increased plantar flex..

Aquatic orthesis for dorsiflex.paresis or mild plantar flexor spasticity

Tendon- and H-reflex measurements in dry and water conditions

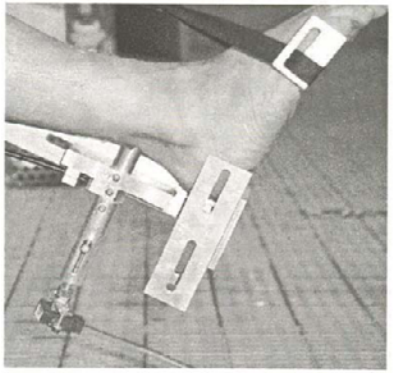
H –reflex

The H-reflex is a reflectory reaction of the muscle after electrical stimulation of the innervation nerve (tibial nerve).

The EMG response is measured from the muscle (soleus) and that response is a clear wave called H –wave, H- reflex.

Information about the reflex arch activity

Tendon reflex



The set-up for force measurements of the Achilles tendon reflexes. A waterproof reflex hammer with an accelerometer and dynamometer attachment around the forefoot.

EMGs were recorded from the soleus and medial gastrocnemius muscles

Result: tendon reflexes were decreased in water!

(Pöyhönen T.; 2002)

Summary : underwater TM gait training in stroke population offers (1):

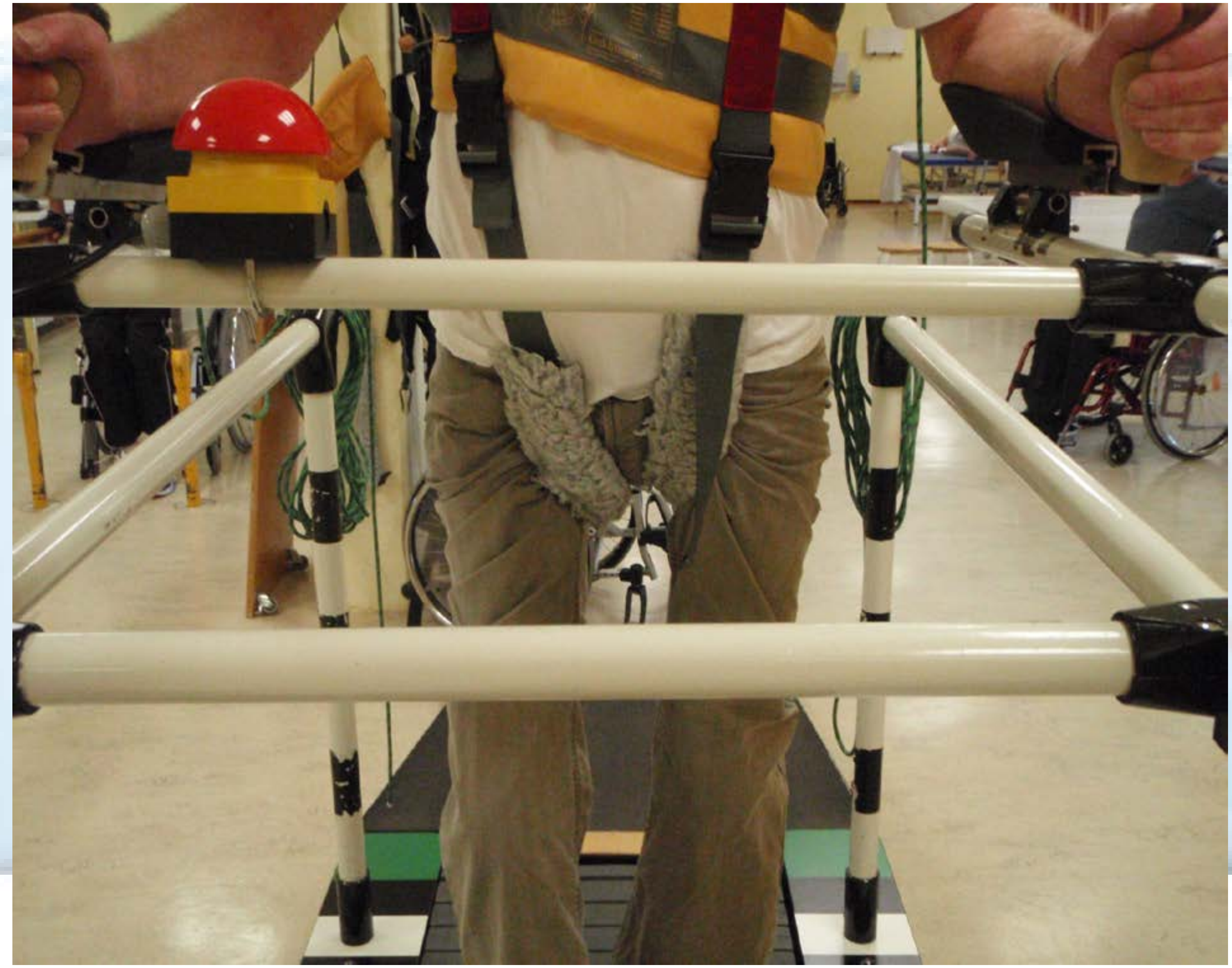
- Option for regaining gait in early rehab. as a form of **massed practice.**

  similarity with muscle activity and gait pattern on land (in thigh- to waistdeep water on UWTM)

- Unrestricted 3-dimensional mobility **without jacket**.

- On the spot combination with other Activity of Daily Living oriented watertherapy (e.g Halliwick, BRRM , Ai Chi etc.).

Water treadmill: no need for jacket….



Immediate combination with other water based therapy and therapy topics e.g.

trunkbalance

Summary :Watertreadmill gait training in stroke population offers (3):

- At TD-WD depth an excellent cardiovasc. training option, so needed in stroke pop.
- A challenging environment without fear of falling,people ***dare*** to move, go to their limits.

Motor learning rule nr 2 : vary elements of activity, possibilities on WTM

- Speed↑evt. running
- Walking sideways ,backwards
- Jumping, on one leg
- Eyes closed
- Balance reactions , sudden change in TM speed
- Dual task
- Constraint induced mov. ther.

Without risk and with easy control by therapist.

underwater-TM to influence cardiovascular capacity and /or body composition:

- Excellent Cardiovascular workout opportunity: walking (4km/h.) in thighdeep water produces cardiovascular workload that comes close to ***running*** on dry land . Rehab.opportunity

VO2 6 km/h on land ≈ VO2 3,5 km/h WTM.

(Pohl M, McNaughton L, 2003)

- Also in **overweight inactive** persons massed practice is indicated: water-TM training same effects on body composition as land-TM training

(fat%↓,lean body mass↑,VO_2 max.↑)

advantage WTMT : muskuloskeletal strain↓

(Green N.P., 2009)

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Physiol.responses to walking on treadmill in water (33 C˚) at diff. depths (TD and WD):

4 km/h walking on treadmill (n=6)	On land	In Thigh Deep water	In Waist Deep water	Running on land (7km/h)
VO2 (ml/min/kg)	9.84(+/- 0.84)	20.16(+/- 2.32)	17.48(+/- 2.47)	23.64 (+/- 0.84)
HR (beats/min)	78 (+/- 10)	104 (+/- 5)	96 (+/- 5)	124 (+/- 7)
Stride Freq. Str/min.	101 (+/- 6)	96 (+/- 7)	92 (+/- 10)	149 (+/- 12)
VO2/stride (ml/kg/min)	0.10 (+/- 0.01)	0.21 (+/- 0.04)	0.19 (+/- 0.04)	0.16 (+/- 0.03)

Thank you for your attention.