Gait variability in underwater Treadmill Training

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Aqua Leuven: EWAC Workshop

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Gait variability: normal or pathological?

- **Gait patterns are very characteristic for each people!**

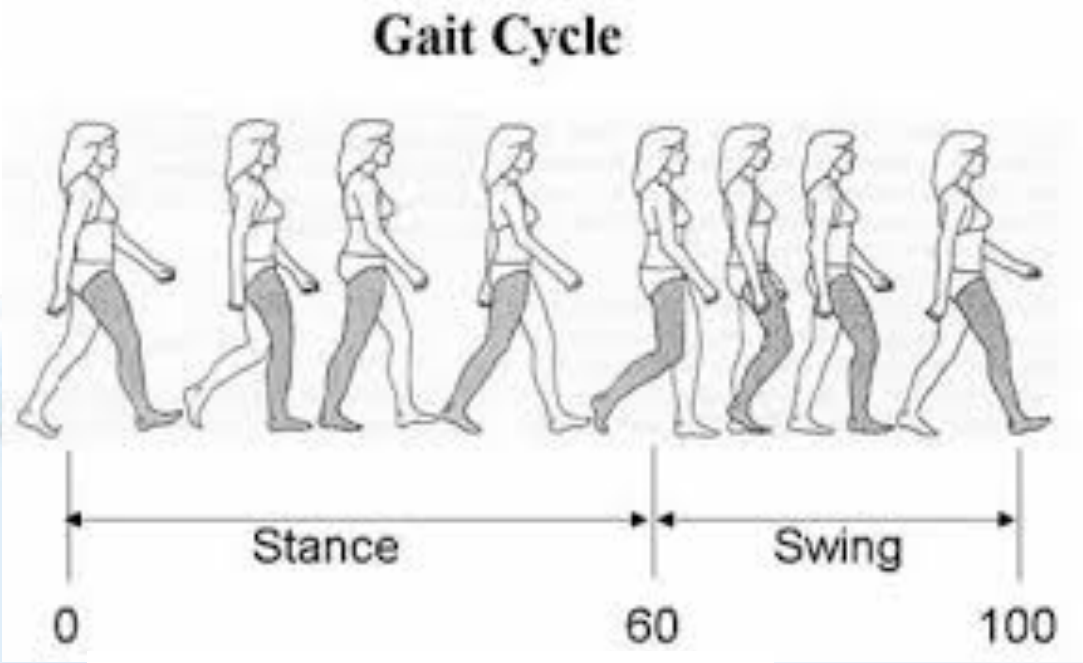
Normal gait

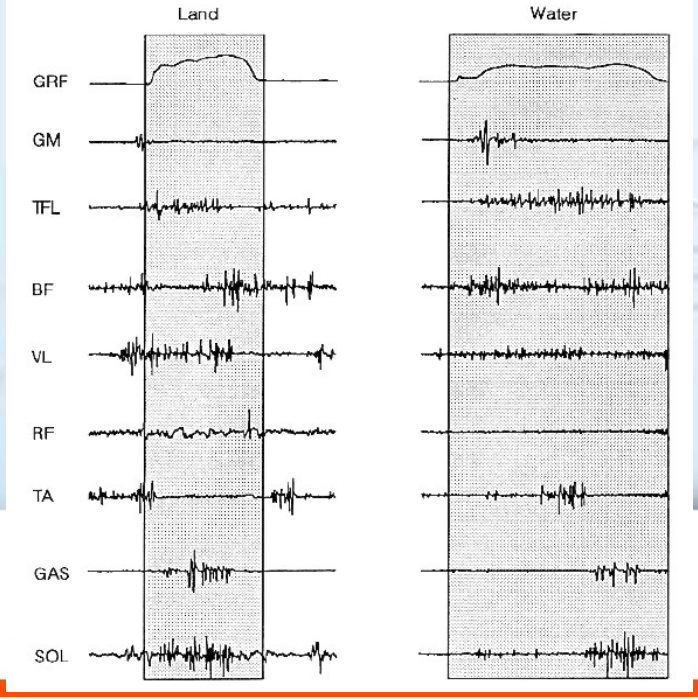
- depends on velocity
- depends on environment
- no change in multitasking
- task specific change

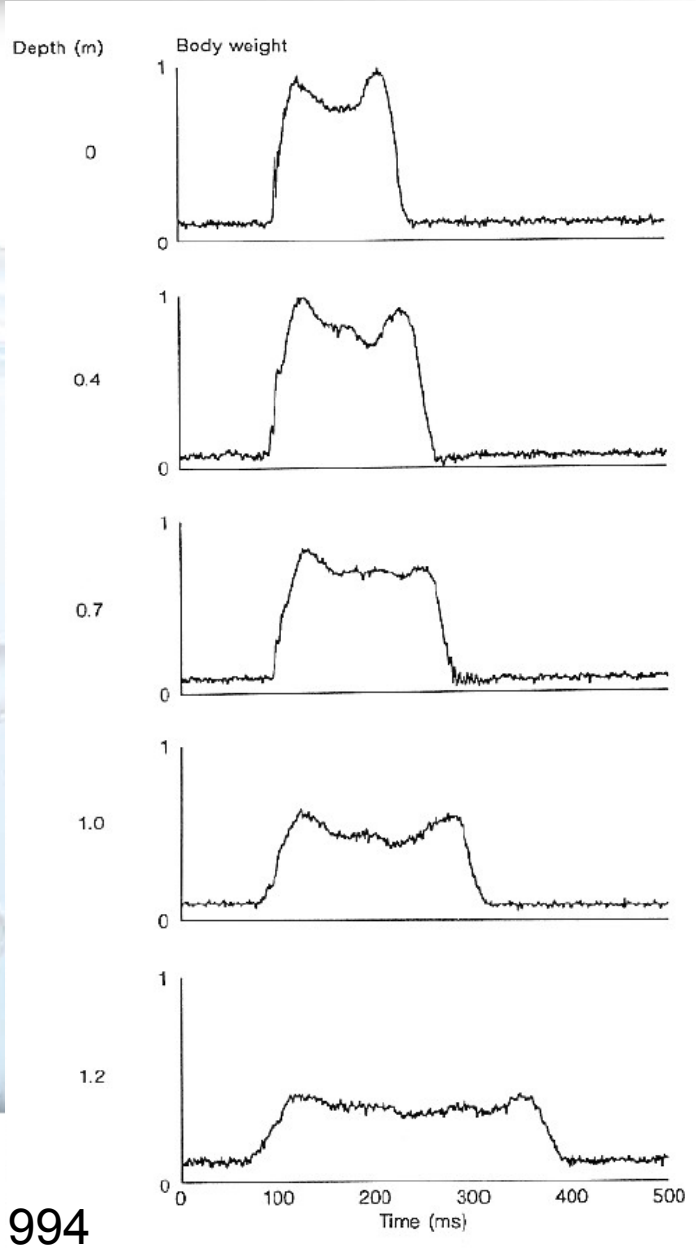
Pathological gait

- no task specific change
- multifaceted effect
- variability increase by multitasking
- stop by talking

Normal gait: Land vs. Water

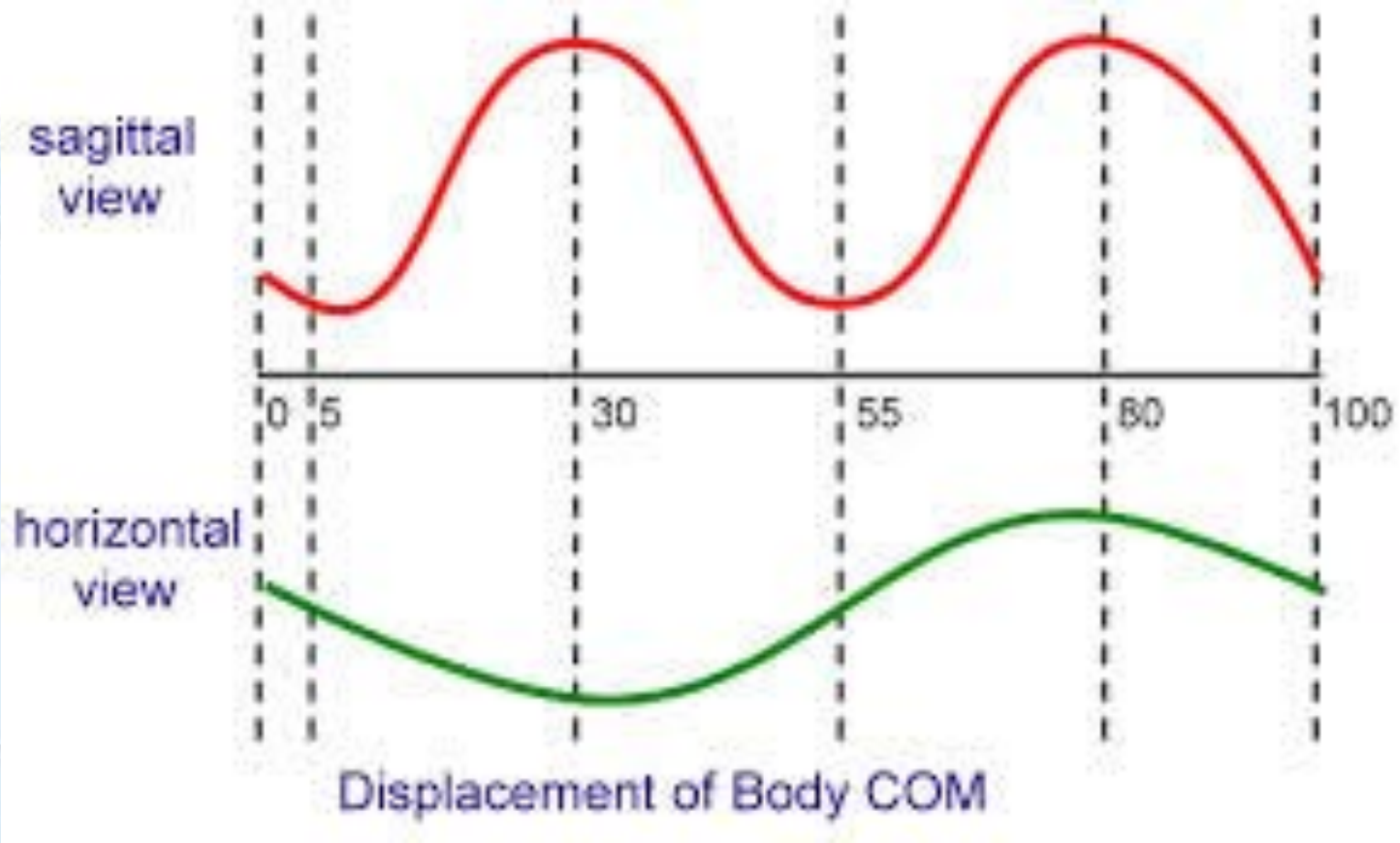




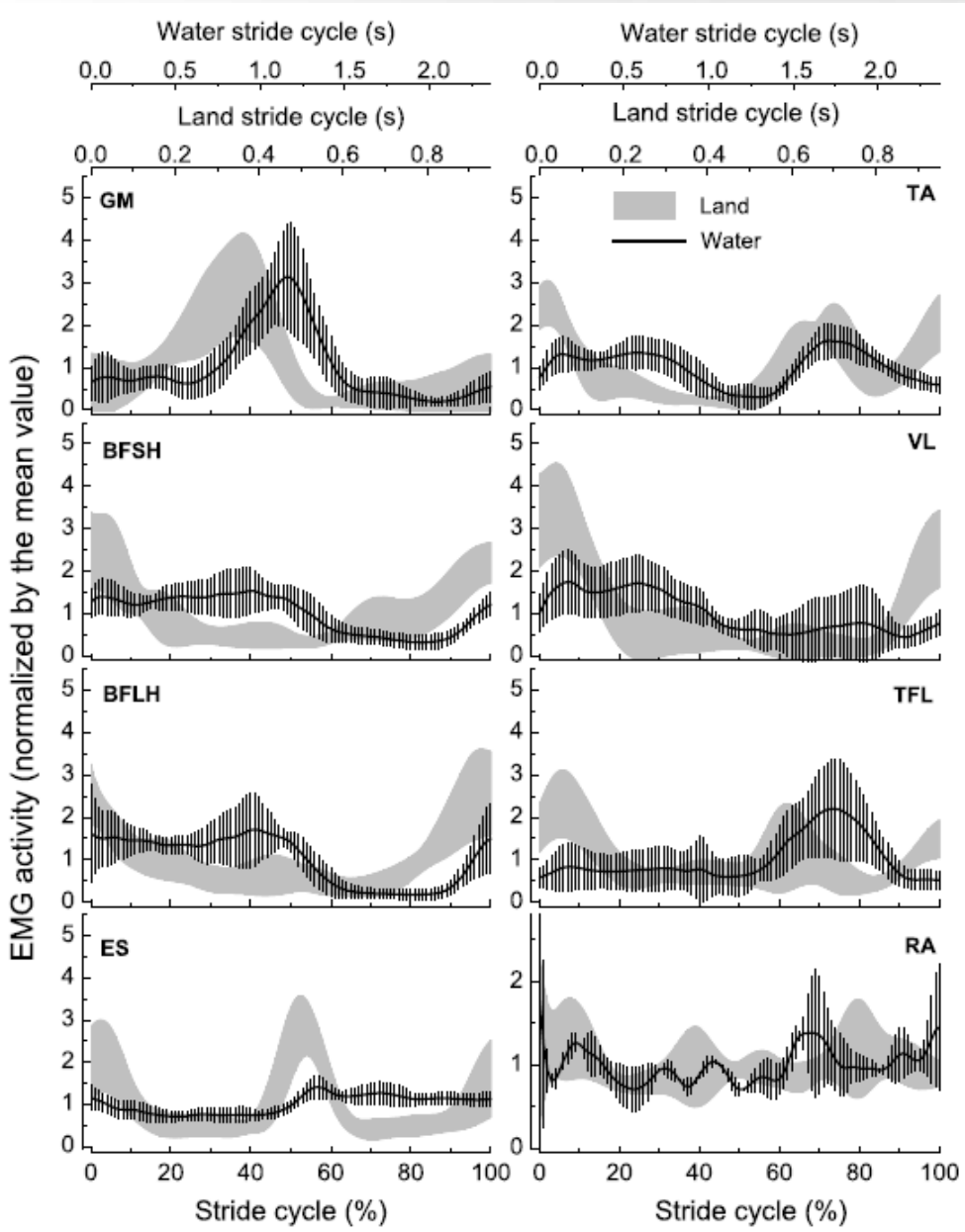


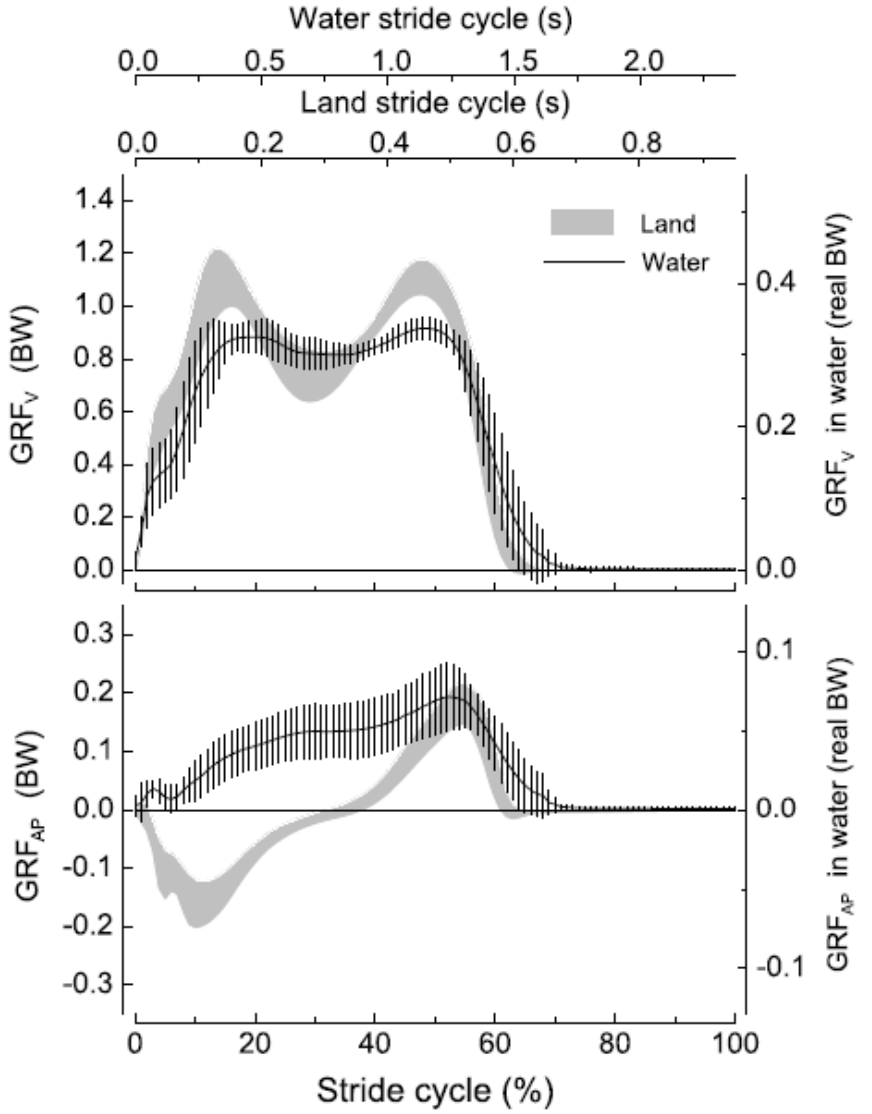
Nakazawa K et al: 1994

Displacement of centre of mass (C0M)



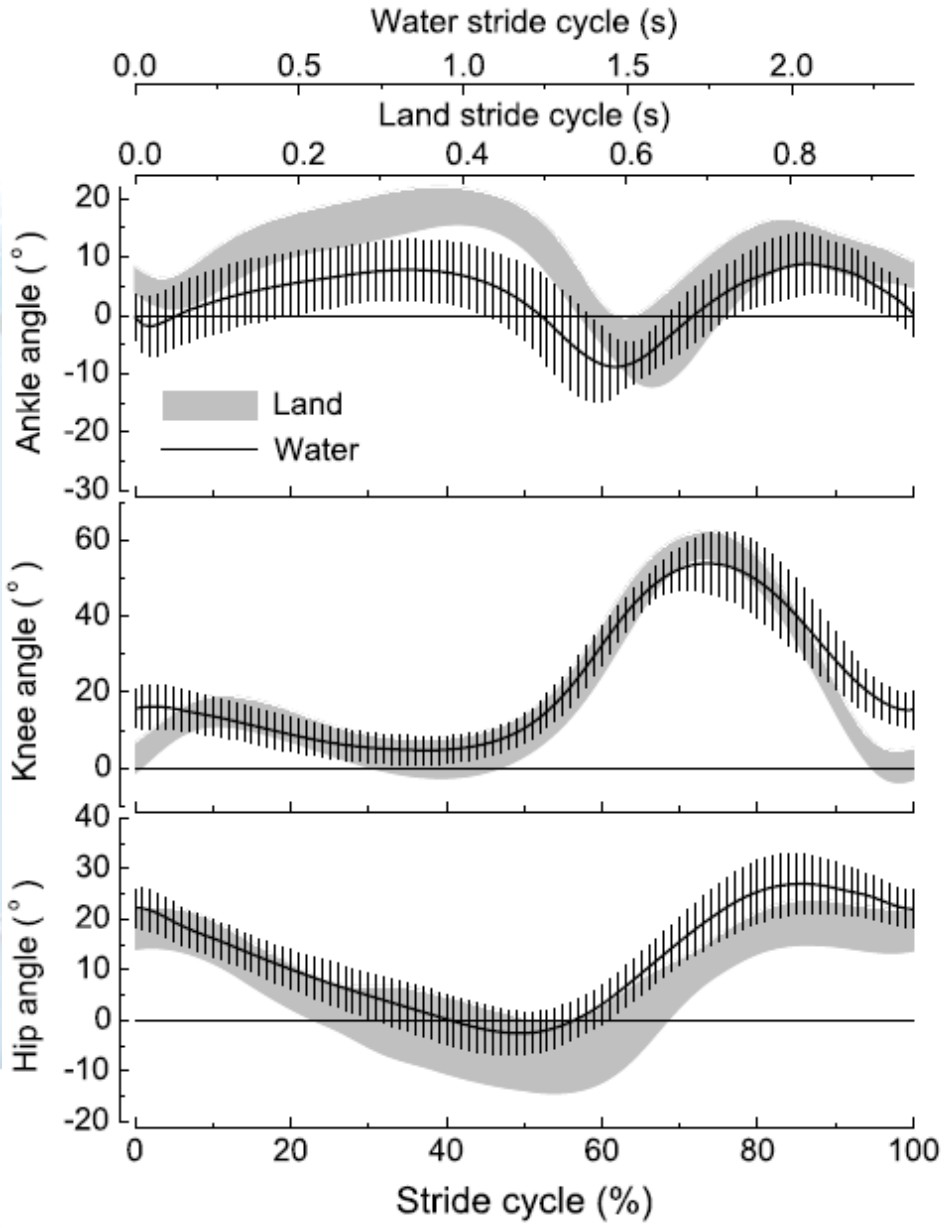
Normal gait: Land vs. Water





Barela AMF and Duarte M: 2006

Normal gait: Land vs. Water



- longer stride cycle in water
- Less dorsal flexion of the foot
- less knee flexion, more at beginning and end of cycle
- more hip flexion
- less activity of phasic muscles

Barela AMF and Duarte M: 2006

Walking velocity in water

	comfortable	slow	fast
Miyoshi (2005)	0.55 m/s		0.93 m/s
Barela (2006)	0.50 m/s		
Roesler (2006)		0.41-0.43 m/s	0.55-0.66 m/s
Masumoto (2004)		0.50 m/s	0.8 m/s
Fowler-Horne (2000)	0.51 m/s		0.61 m/s
Chevutschi (2007)	0.75 m/s		

comfortable speed
1.8 to 2 km/h

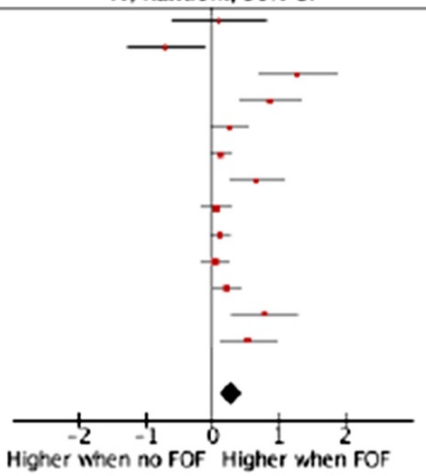
Dry Land 4.75 to 5.32 km/h Aspelin K: 2005

Gait variability and fear of falling

Fear of falling and gait variability in older adults: a systematic review and meta-analysis

Study or Subgroup	Year	Effect size	SE	FOF Total	No FOF Total	Weight	Effect size IV, Fixed, 95% CI	Effect size IV, Random, 95% CI
Maki et al.	1997	0.1	0.36	13	19	1.0%	0.10 [-0.61, 0.81]	0.10 [-0.61, 0.81]
Hausdorff et al.	2001	-0.71	0.29	20	32	1.5%	-0.71 [-1.28, -0.14]	-0.71 [-1.28, -0.14]
Herman et al.	2005	1.28	0.3	25	28	1.4%	1.28 [0.69, 1.87]	1.28 [0.69, 1.87]
Reelick et al.	2009	0.87	0.23	29	65	2.4%	0.87 [0.42, 1.32]	0.87 [0.42, 1.32]
Rochat et al.*	2010	0.26	0.15	45	605	5.6%	0.26 [-0.03, 0.55]	0.26 [-0.03, 0.55]
Rochat et al.†	2010	0.13	0.08	210	605	19.6%	0.13 [-0.03, 0.29]	0.13 [-0.03, 0.29]
Mirelman et al.	2012	0.66	0.21	25	196	2.8%	0.66 [0.25, 1.07]	0.66 [0.25, 1.07]
Donoghue et al.*	2013	0.07	0.11	96	961	10.4%	0.07 [-0.15, 0.29]	0.07 [-0.15, 0.29]
Donoghue et al.†	2013	0.11	0.07	250	961	25.6%	0.11 [-0.03, 0.25]	0.11 [-0.03, 0.25]
Ayoubi et al.‡	2013	0.05	0.1	110	648	12.5%	0.05 [-0.15, 0.25]	0.05 [-0.15, 0.25]
Ayoubi et al.§	2013	0.21	0.1	123	225	12.5%	0.21 [0.01, 0.41]	0.21 [0.01, 0.41]
Sawa et al.	2014	0.78	0.25	21	72	2.0%	0.78 [0.29, 1.27]	0.78 [0.29, 1.27]
Asai et al.	2014	0.54	0.21	32	85	2.8%	0.54 [0.13, 0.95]	0.54 [0.13, 0.95]
Total (95% CI)				**999**	**4502**	**100.0%**	**0.19 [0.12, 0.26]**	**0.29 [0.13, 0.45]**

Heterogeneity: $Chi^2 = 50.26$, $df = 12$ ($P < .00001$); $I^2 = 76\%$
Test for overall effect: $Z = 5.27$ ($P < .00001$)



*: comparison of participants with no FOF versus participants with FOF and activity restriction
†: comparison of participants with no FOF versus participants with FOF and no activity restriction
‡: comparison of participants with no FOF and no history of falls versus participants with FOF and no history of falls
§: comparison of participants with no FOF and history of falls versus participants with FOF and history of falls

Ayoubis F et al: 2015

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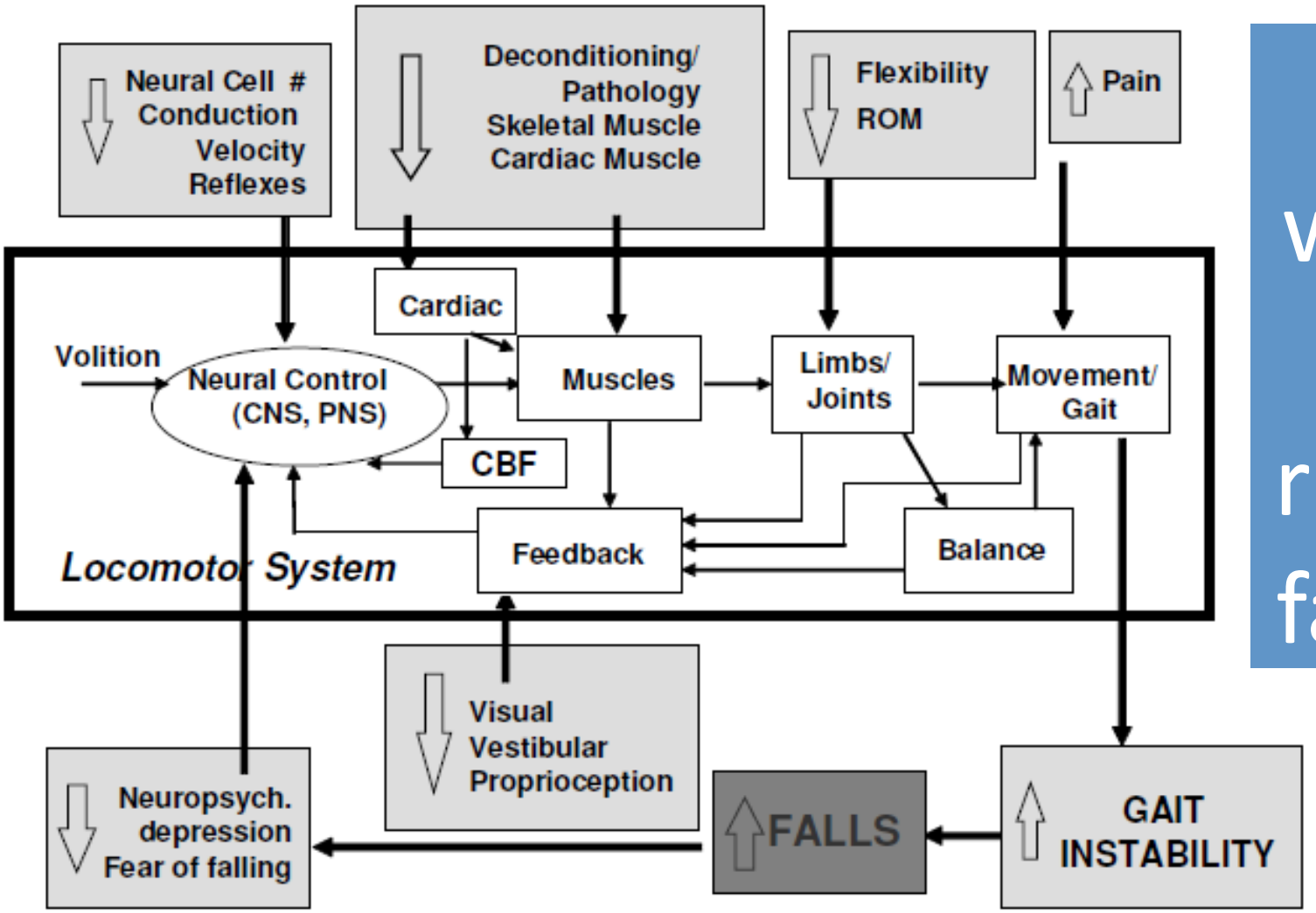
Physiologic Changes Influencing Gait Instability & Falls



In water no risk of falling

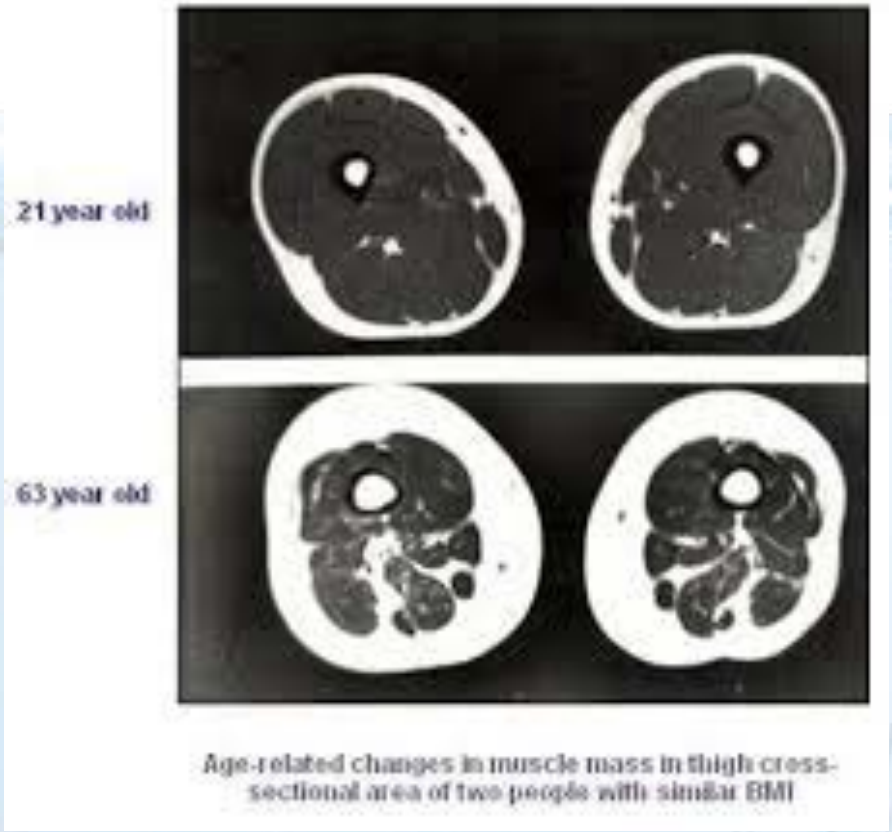
Hausdorff JM: 2005

Falls: Main risk factors

Risk factor	Relative risk
Weakness	4.4
Gait disturbance	2.9
Balance disturbance	2.9

J Am Geriatric Soc: 2001

Changes in muscle mass



Age-related changes in muscle mass in thigh cross-sectional area of two people with similar BMI

Between 30 and 80 years:

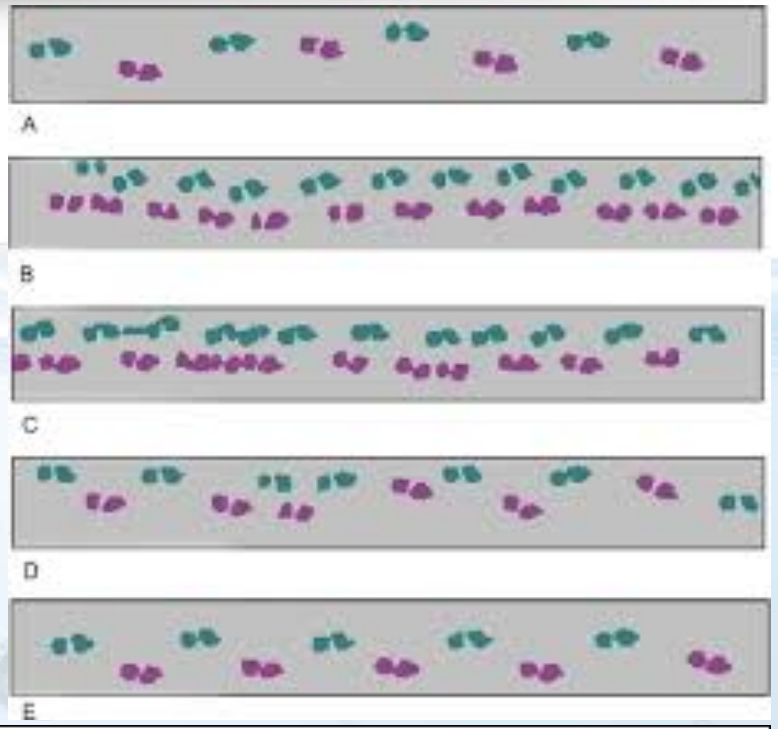
- decrease of muscle mass > 30%!
- fast twitch fibres are more affected!

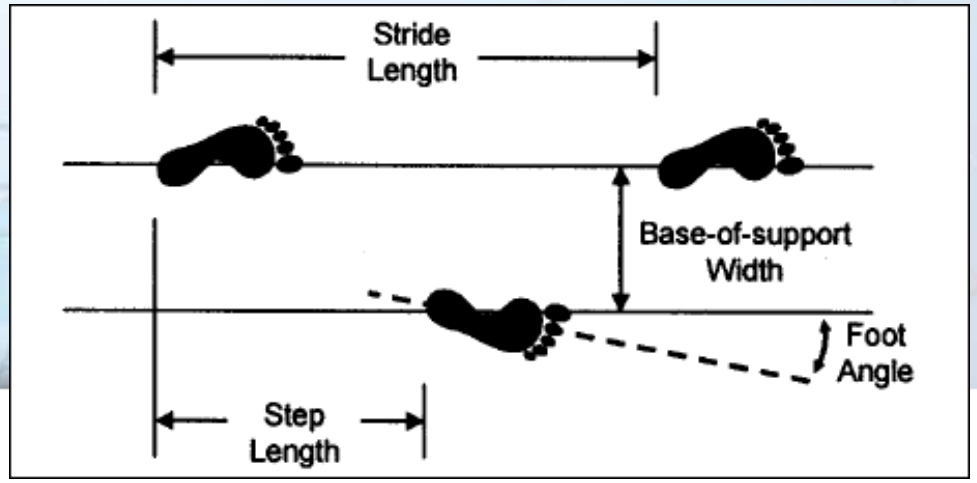
Sarcopenia

Kressig R et al: 1998, Roubenhoff R: 2007

Gait variables

- Temporal variables
  - speed
  - cadence
  - stance time
  - single limb time
  - double support time
  - swing time
- Spatial variables
  - step length
  - stride length
  - Base of support
  - degree of toe-out





Vaughan et al: 1992, *Dynamics of Human Gait* Human Kinetics Champaign

Is Treadmill Training helpful?

Stroke

Mehrholz J et al: 2014 Cochrane

Post stroke with body weight support in walking rehabilitation

Velocity	MD 0.07 m/s	95% CI[0.09, 0.11] p 0.02
Endurance	MD 26.35 m	95% CI [2.51, 50.19]p 0.03

Independent ambulatory patients

Endurance	MD 58.88 m	95% CI [29.10, 88.66] p 0.0001

Parkinson

Mehrholz J et al: 2010 Cochrane

Gait speed	SMD 0.50	95% CI [0.17, 0.84] p 0.003
Stride length	SMD 0.42	95% CI [0.00, 0.84] p 0.05
Walking distance	MD 358 m	95% CI [289, 426] p 0.0001

The Effect of Underwater Gait Training on Balance Ability of Stroke Patients

Usual care rehabilitation:

Additional underwater Treadmill Training 4 w /2 times p w / 30 min

Results:

No different between the two groups

Park SW et al: 2014

Consider of variables in Treadmill Training

- Gait speed in water three time slower than on dry land
- Displacement of centre of mass
  - transversal plane
  - sagittal plane
- Increase muscle strength in lower extremity
- Focus on fast twitch fibres
- Include balance activities
- Include stop and go activities
- High number of repetition, Constraint induced movement therapy (CIMT) type of intervention
- No risk to fall in the pool

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Questions?

monty_python-ministry_of_silly_walks

Gait variability in ADL

- Stepping strategy
  - Step sideways
  - Cross stepping
- Problem solving
  - adaptation to environment changes
  - adaptation to velocity
  - adaptation to equipment/footwear
  - adaptation to using arms