
UNIVERSITAS COMENIANA BRATISLAVENSIS
FACULTAS EDUCATIONIS PHYSICAE ET ATHLETICAE
MCMXIX

Clinical Applications of Posturography: From Research to Practice

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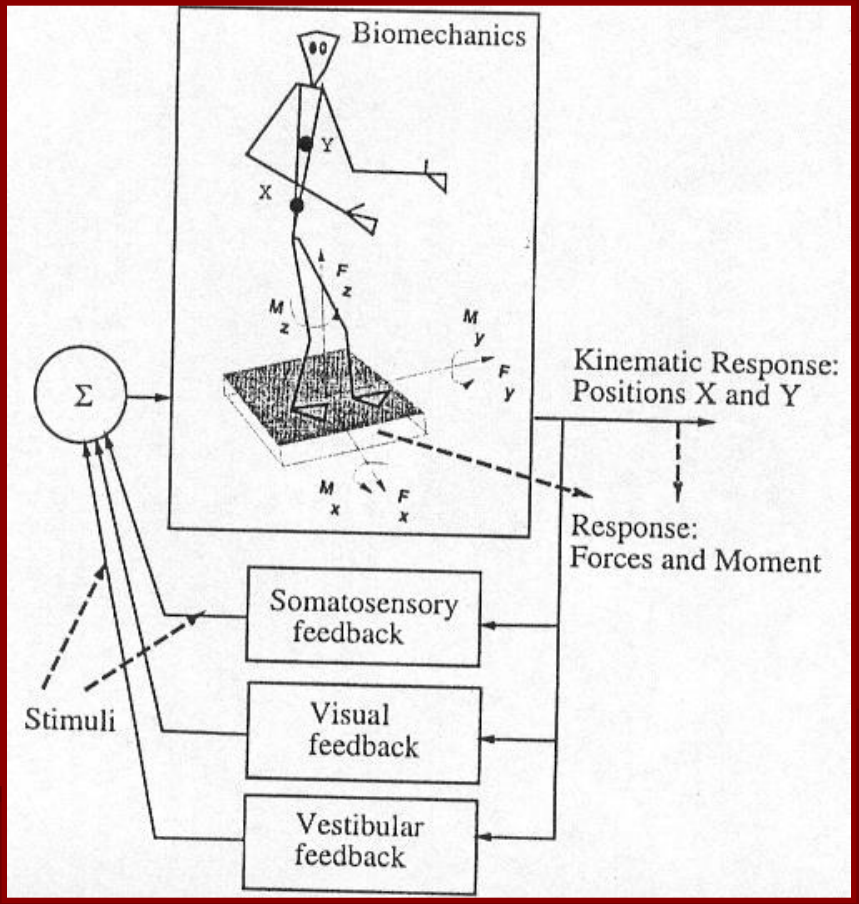
Crucial problem of balance asessement

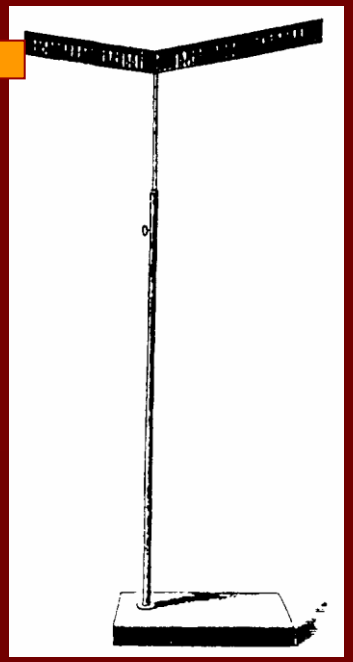


Linking of postural parameters with the underlying neurophysiology

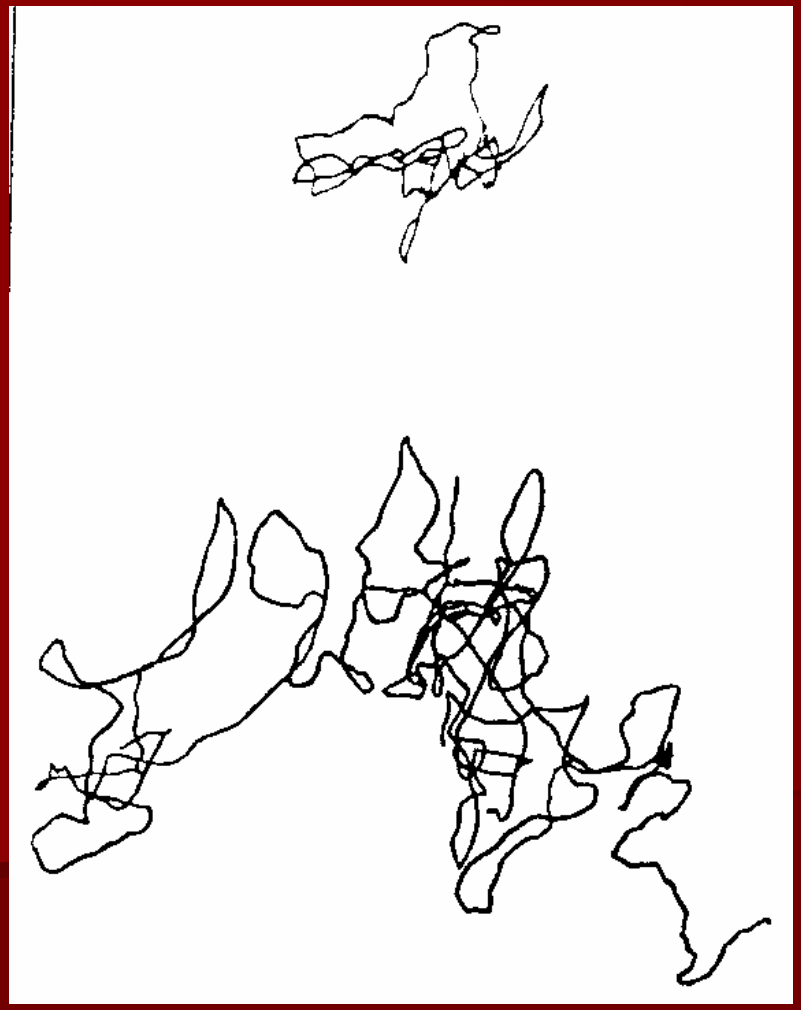
The first half of the 19th century

- Hall M. *Lectures on the nervous system and its diseases.* London: Sherwood Gilbert & Pyer, 1836: 27
- Brach B. *Med Zeitung,* 1840: 9, 215-7
- Romberg MH. *Manual of the Nervous Diseases in Men.* London: Sydenham Society, 1853: 226-7, 395-401

Mitchell´s sway meter (1895), PA



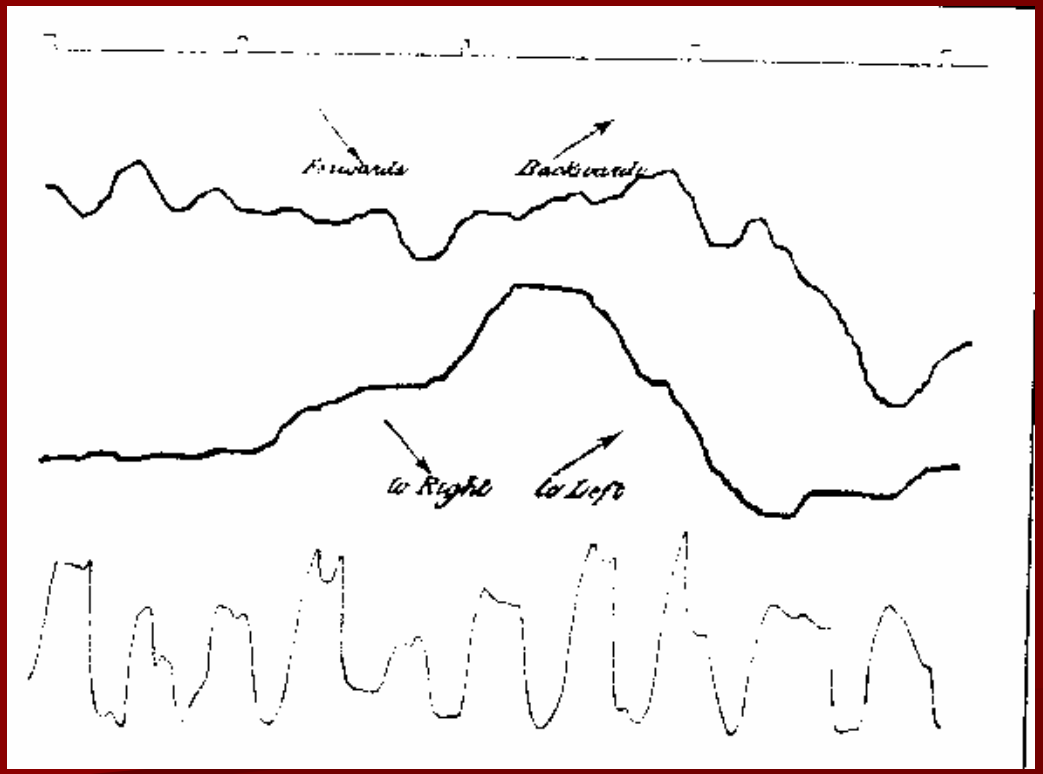
Mitchel (1895), Hinsdale (1887)



Healthy person

Patient with tabes dorsalis

Postural Apparatus (Hinsdale, 1887)

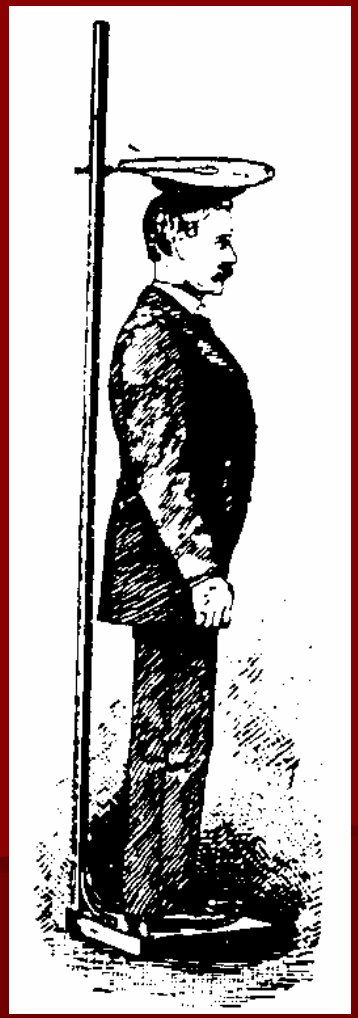


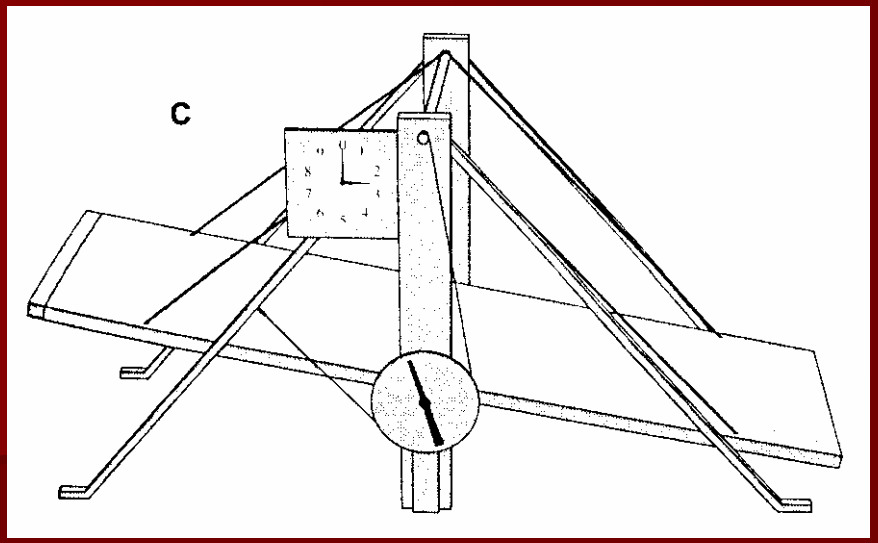
Antero-posterior sway movement

Medio-lateral sway movement

Respiration

Simple systems for the assessment of static and dynamic balance





Romberg Test (1853)

Assessing Romberg's sign

Observe the patient's balance as he stands with his eyes open, feet together, and arms at his sides. Then ask him to close his eyes. Hold your arms out on either side of him to protect him if he sways. If he falls to one side, the result of the Romberg's test is positive.

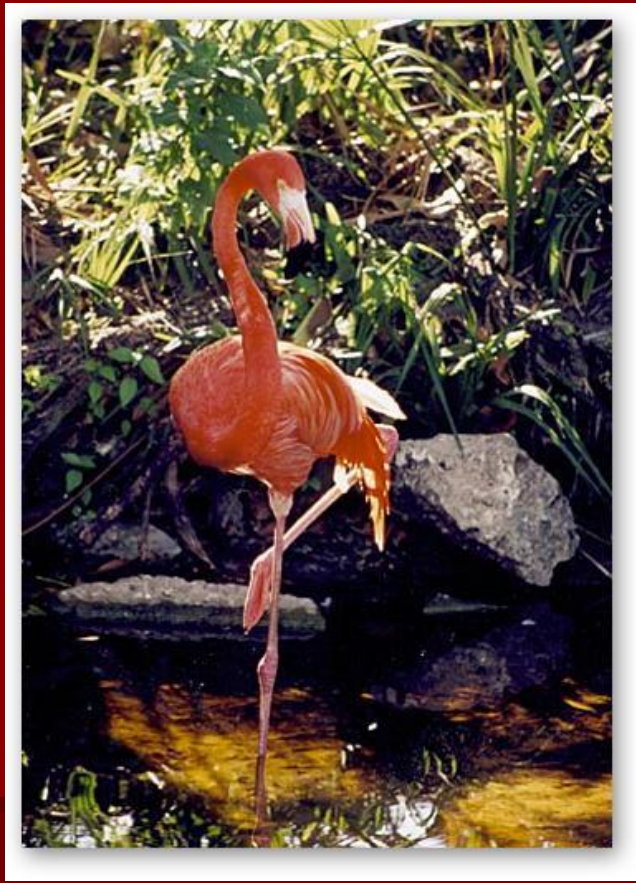
Clinical balance tests

- provide great reliability, ICC values as high as 0.99

The Berg Balance Scale, dynamic Gait Index (DGI), Gait Velocity, Physical Performance Test (PPT), Timed Chair Stand Test, Timed Up and Go, and Tinetti Performance-Oriented Mobility Assessment (POMA)

Karen W, Hayes MEJ (2003). *Arthritis Care & Research,* 49: S28-S42.

Field-testing of balance



- Bipedal and one-legged stance
- Walking on narrow surface

Instrumental measurement of balance

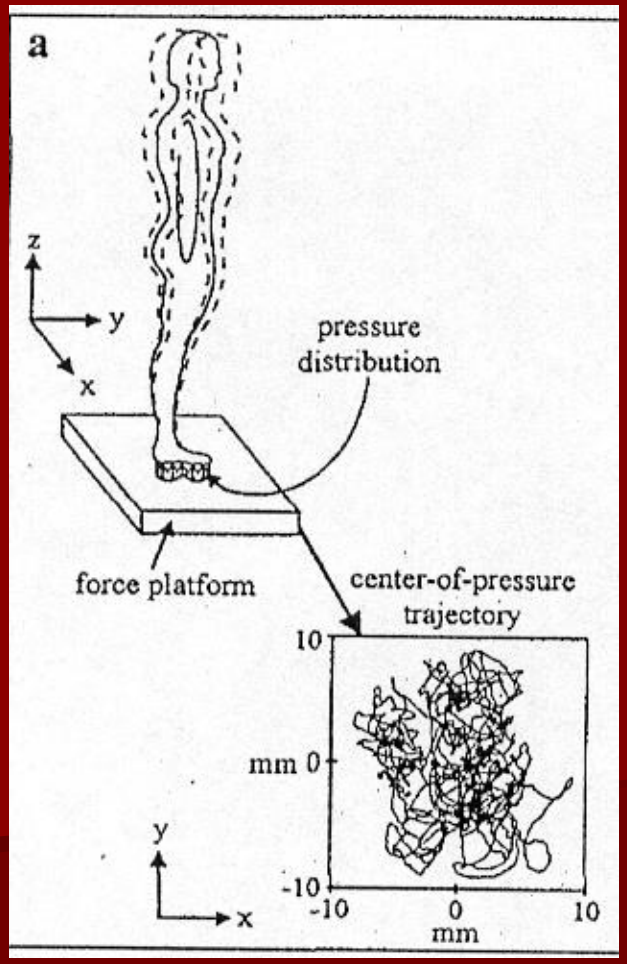
Techniques based on motion analysis or accelerometry recordings

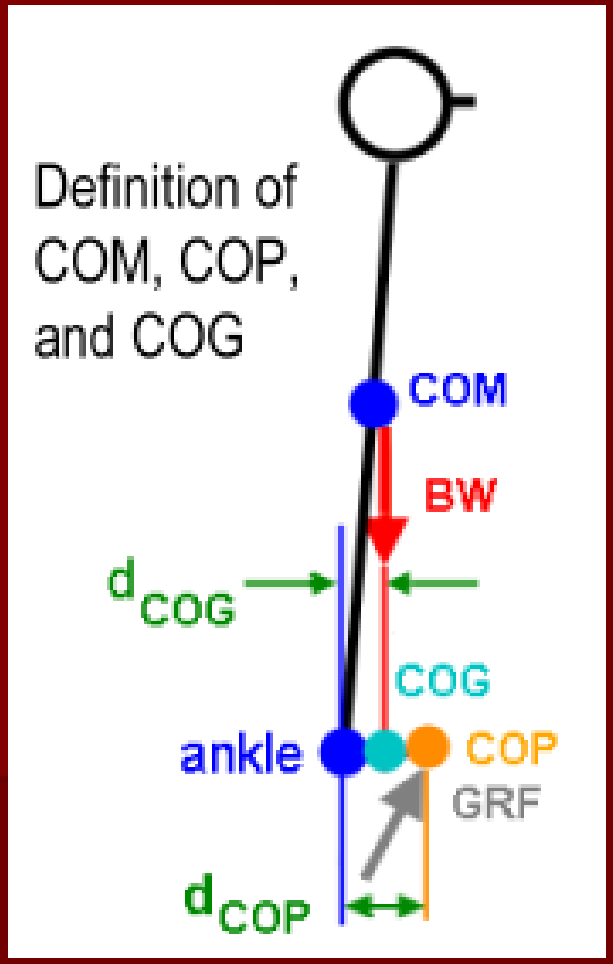
Better suited to laboratory conditions than to routine-clinical investigations

Force platforms

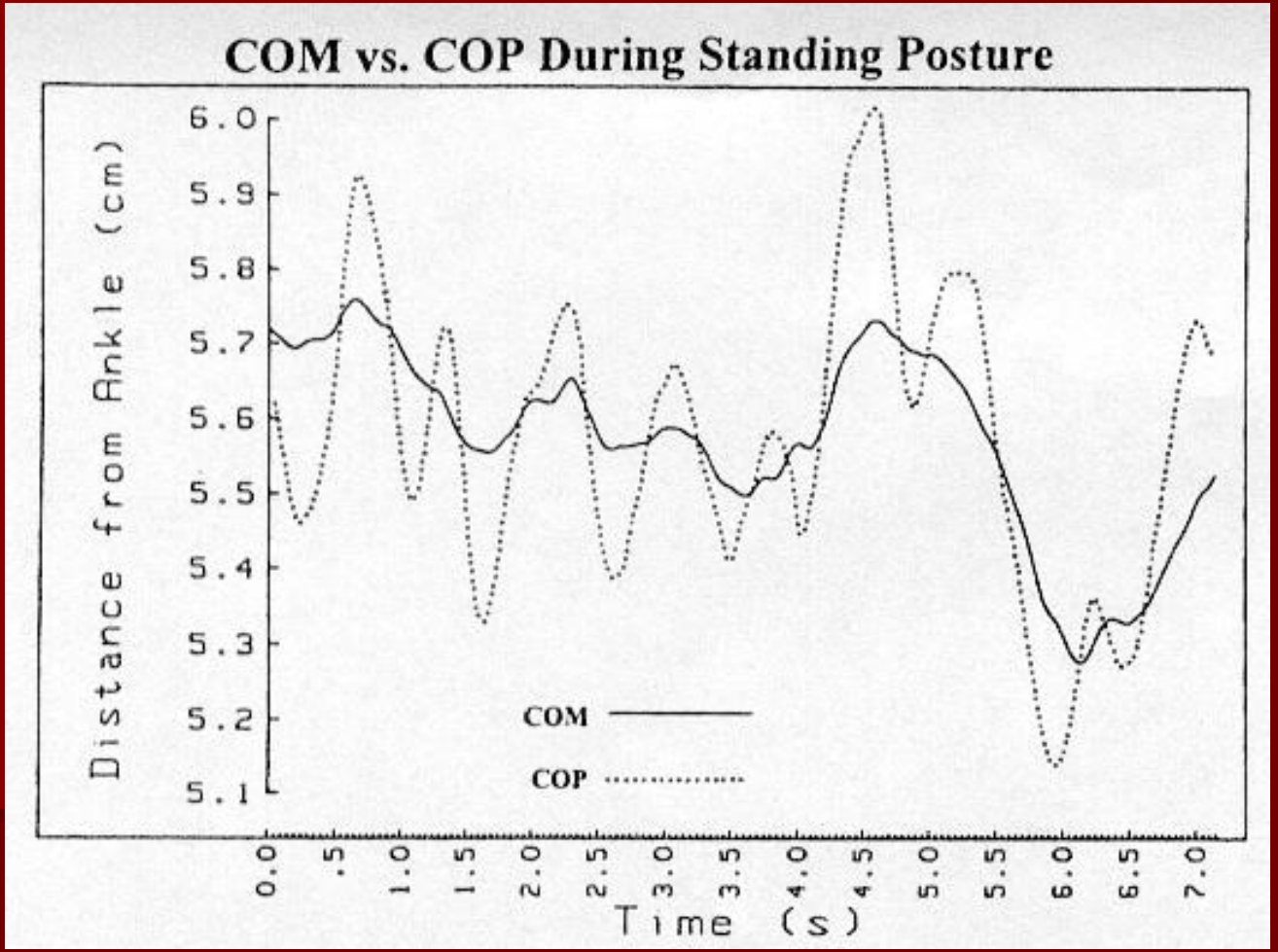
- Registration of postural sway during both quiet standing and functional task
- Low-cost
- Portable
- Well suitable for testing of various populations in a relatively short-time period
- Can be used in clinical settings, as well as in non-medical institutions and fitness centres

Centre of pressure (CoP)



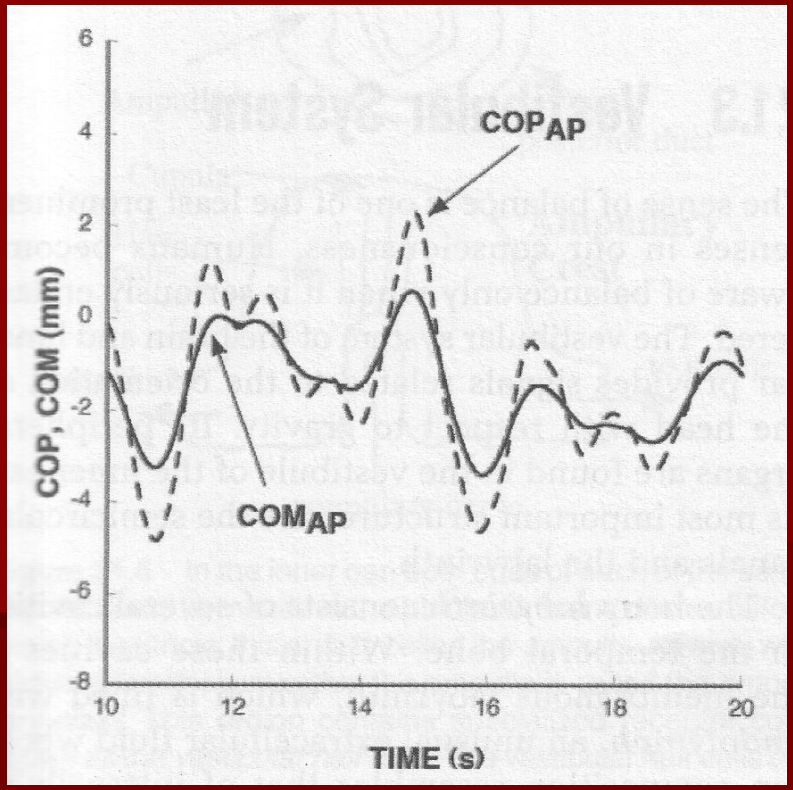


Centre of Mass vs. Centre of Pressure



Difference between the CoP and CoM

- is proportional to the horizontal acceleration of the CoM during quiet staning (Winter, 1995)



CoP – CoM amplitude

Reliability (Corriveau et al., 2001)

- ICC for antero-posterior direction 0.89 – 0.93
- ICC for medio-lateral direction 0.74 – 0.79

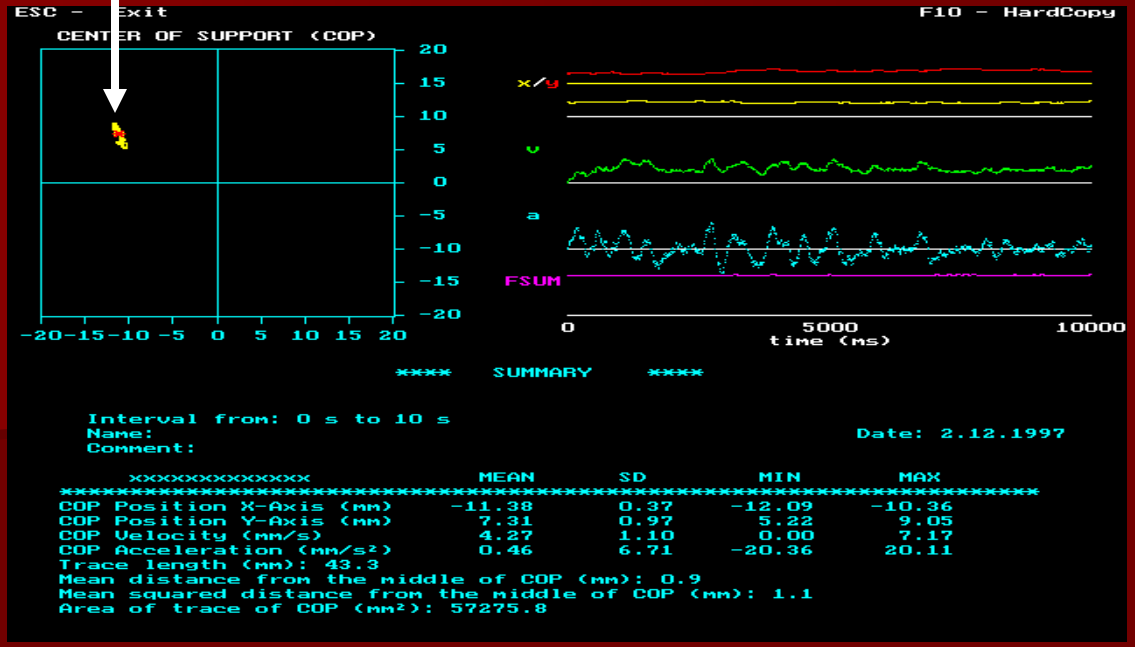
The marker placements used to calculate the CoM vary each time

Can influence test-retest and interrater reliability

Static and Dynamic Posturography

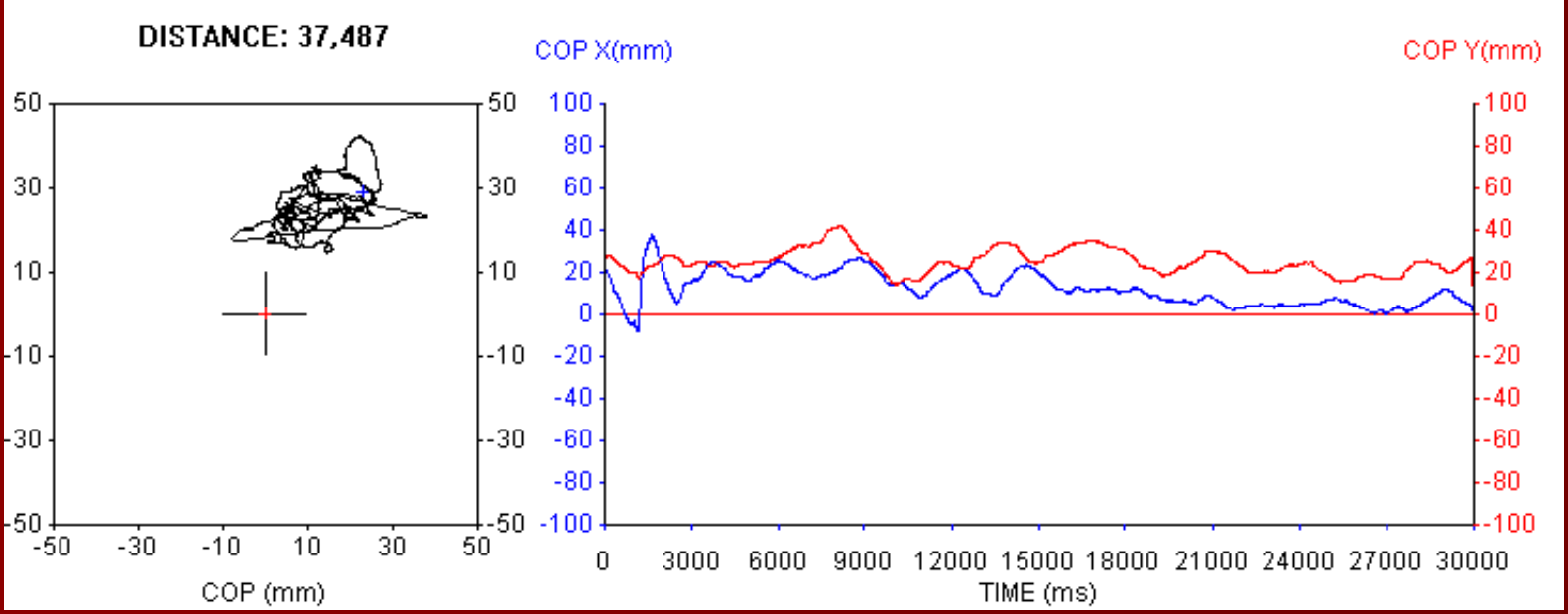
Assessment of static balance

FiTRO Sway Check
(www.fitronic.sk)



COP (100 Hz)

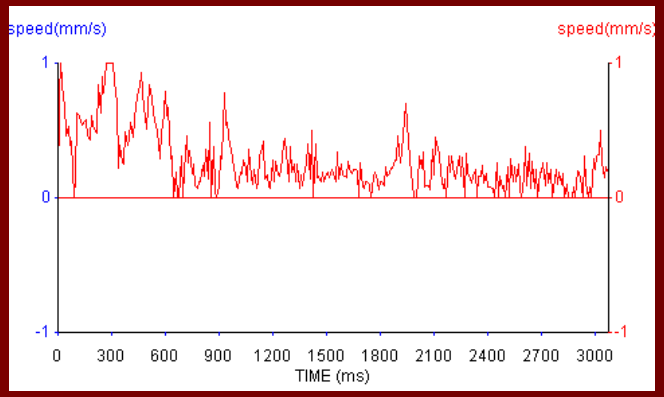
On-line display of stabilographic parameters



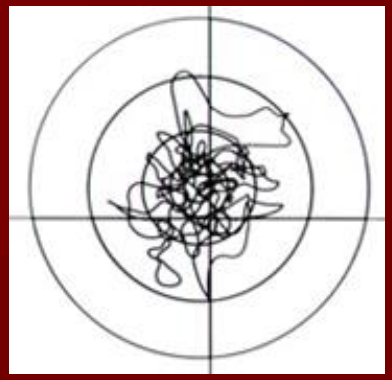
Interval	X-mean (mm)	X-SD (mm)	Y-mean (mm)	Y-SD (mm)	Length X (mm)	Length Y (mm)	DX/DY	Length (mm)	Speed-mean (mm/s)
0 - 5	-10.9	1.2	38.9	8.3	29.8	188.5	0.2	209.1	41.8
5 - 10	-13.3	0.8	35.4	1.4	18.1	31.8	0.6	45.0	9.0
10 - 15	-13.8	0.9	37.7	1.7	18.6	31.8	0.6	45.7	9.1
15 - 20	-14.2	0.6	33.8	2.5	16.7	45.5	0.4	55.9	11.2
20 - 25	-15.9	0.6	35.4	4.7	14.3	53.4	0.3	63.7	12.7
25 - 30	-16.4	0.6	34.7	2.1	14.1	59.0	0.2	68.8	13.8

Parameters of static balance

- Mean velocity of CoP

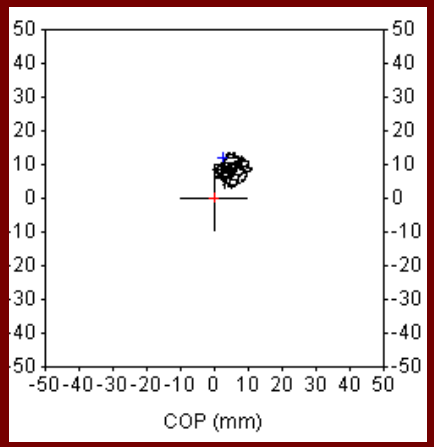


- Mean distance of points of stabilographic curve from its center

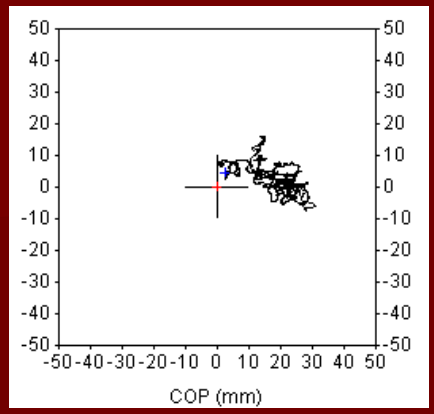


Interpretation of postural instability

- Higher CoP velocity (frequent postural correction to achieve the stability)
- Lower path length and area (Maki et al., 1990)



- Lower CoP velocity
- Greater path length and area



Reliability of the CoP velocity under static conditions

- Test-retest correlation coefficient 0.82
- Measurement error 10.4 %

Zemková E, Hamar D (1998). *National Congress of Sports Medicine.* Tále: Slovak Society of Sports Medicine, 40.
Zemková E, Hamar D (2002). *Tel Vých Šport,* 12(2): 28-30.

Proposed testing protocols

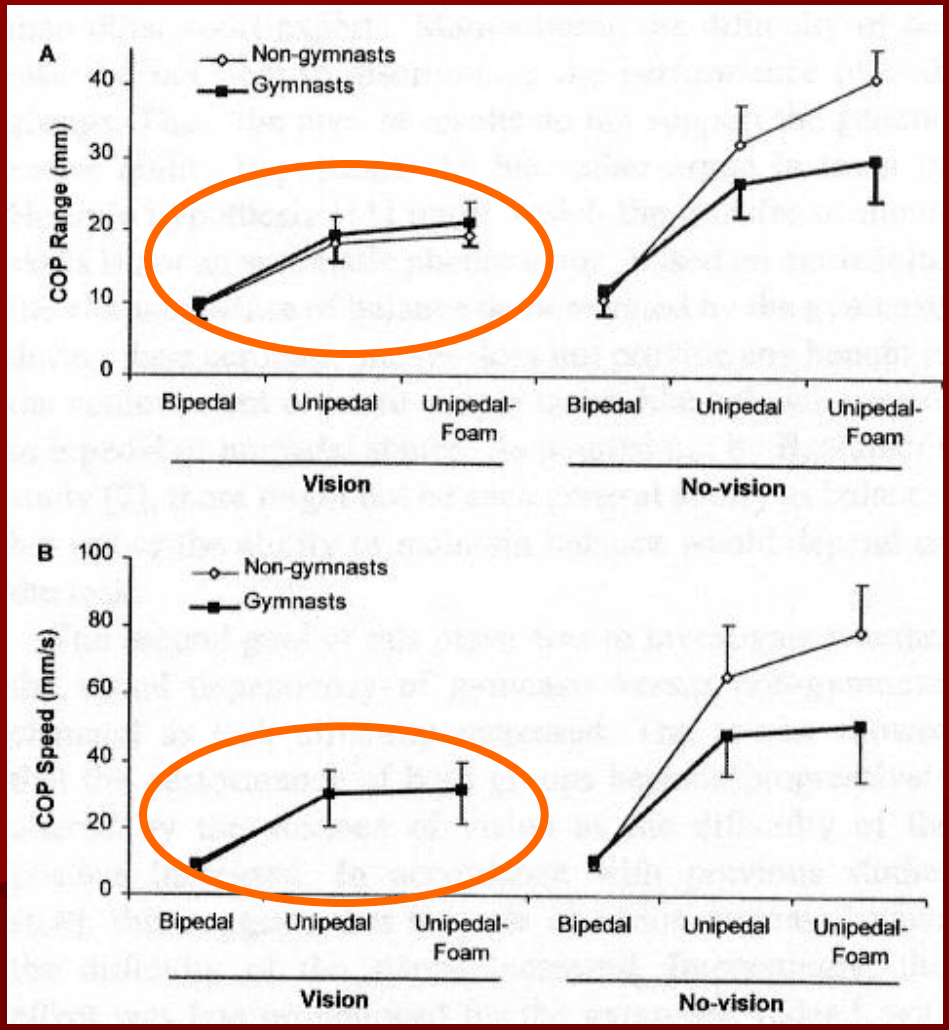
- Mean of two 30-seconds trials

$r = 0.987$, n = 38

- Mean of five 10-seconds trials (for individuals with impaired ability to keep balance for longer period of time)

$r = 0.946$, n = 47

Drawbacks of static posturography



Vuillerme et al. (2001).
Neuroscience Letters, 303: 83-6

Stance on stable surface

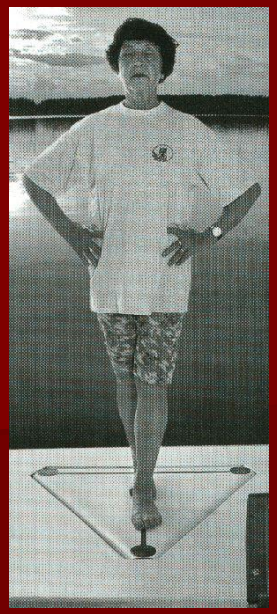
Multiple sensory inputs involved in postural control

Efficient compensation of smaller impairment of postural stability

Lower sensitivity in revealing slight differences between subjects with different level of balance capabilities

Increasing the demands on postural control

- Stance on fixed / foam surface
- Bipedal / one-legged stance
- Feet position (semi-tandem, tandem, etc.)
- Hands position (by the sides or in front of the body, fixed on the hips)
- Eyes open without or with fixed point / Eyes closed

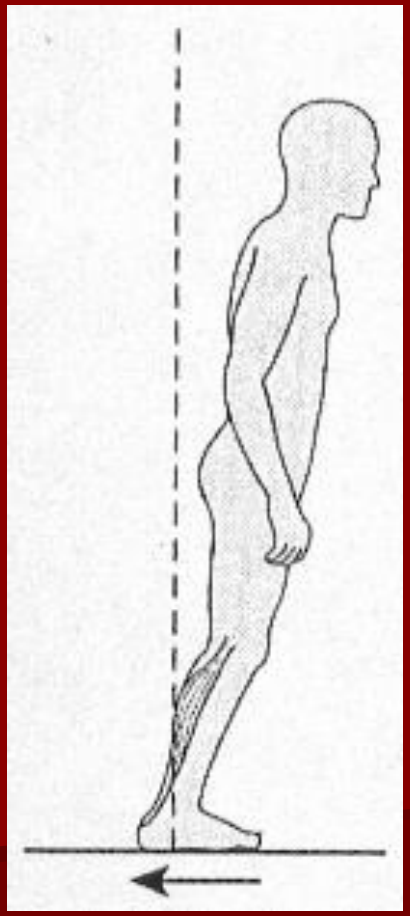


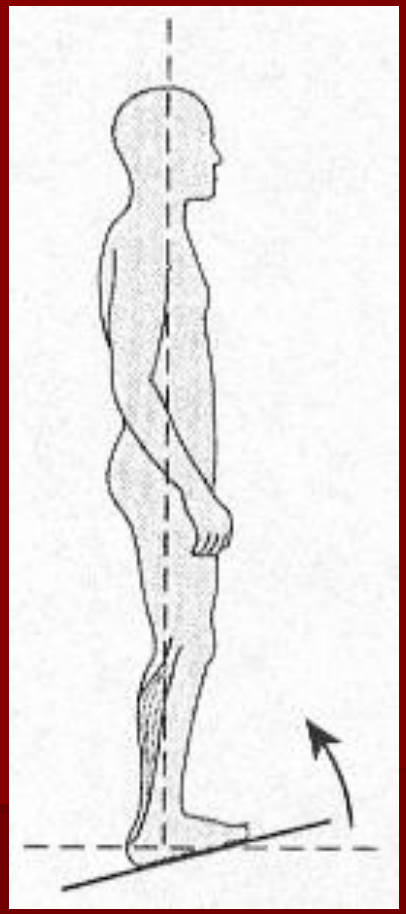
Stance on unstable surface

The control mechanisms is taxed to a substantially higher extent

Individual differences in postural sway can be revelaled

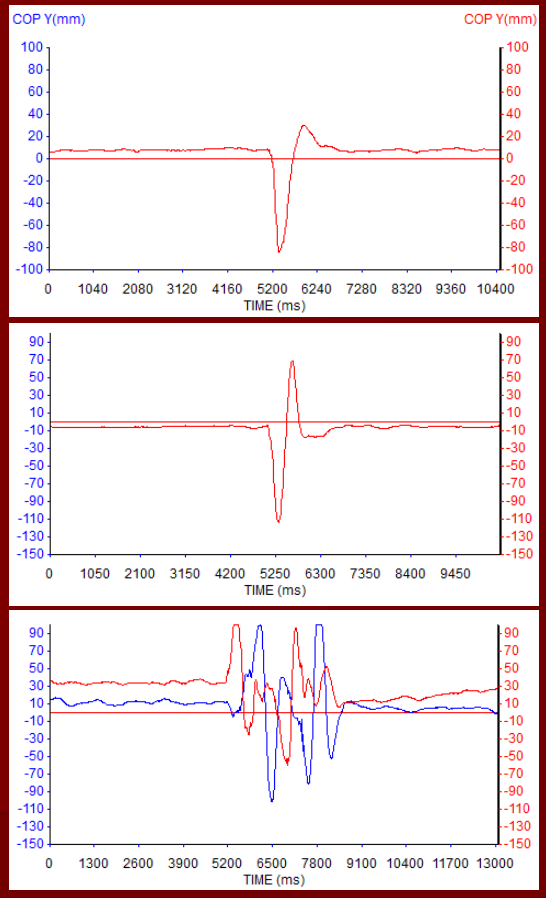
Assessment of dynamic balance





Test of dynamic balance

FiTRO Dynamic Posturography system



Zemková E, Kováčiková Z, Jeleň M, Neumannová K, Janura M (2015). Methodological issues of dynamic posturography specific to the velocity and the displacement of the platform perturbation. *Proceedings of scientific studies "From Research to Practice".* Bratislava: 10 p. ISBN 978-80-227-4485-0.

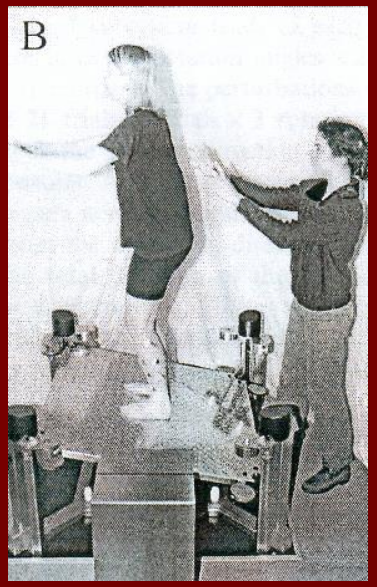
Reliability of the CoP velocity under unstable conditions

- Test-retest correlation coefficient 0.84
- Measurement error 9.0 %

Zemková E, Hamar D, Böhmerová Ľ (2005). The dynamic balance – reliability and methodological issues of novel computerized posturography system. *Medicina Sportiva,* 9 (2): 76-82

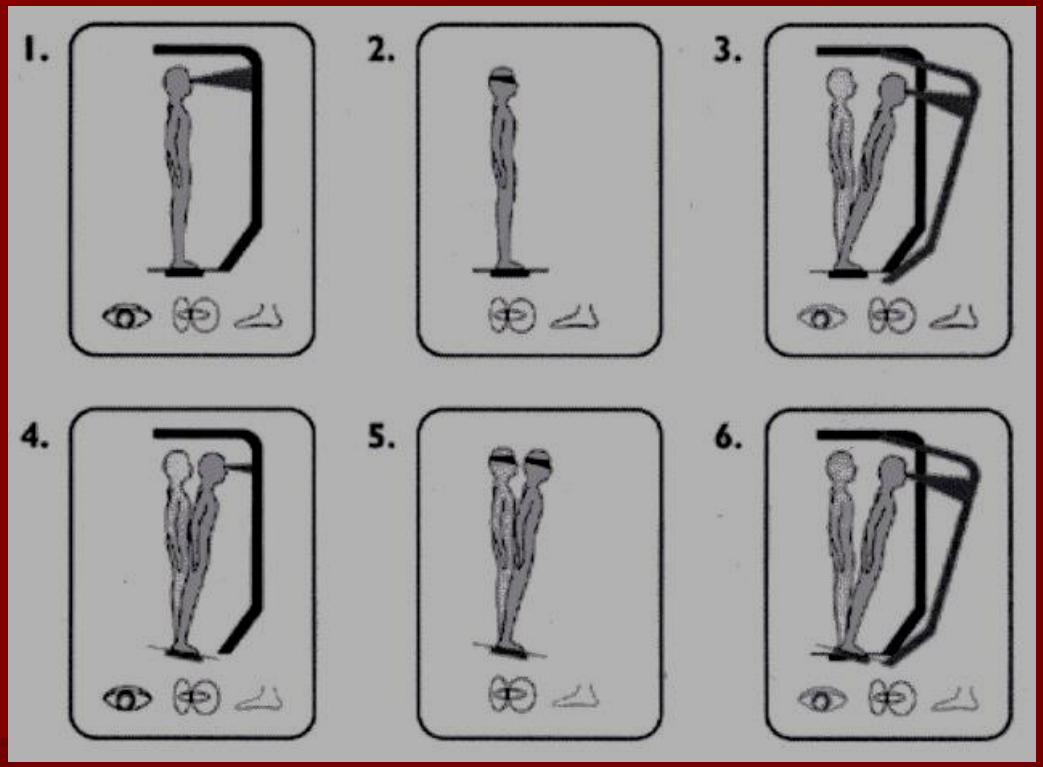
Drawbacks

- Amount of shifting or tilting for highly-skilled athletes, the elderly or untrained population ?
- Problematic comparison of data from different systems and labs

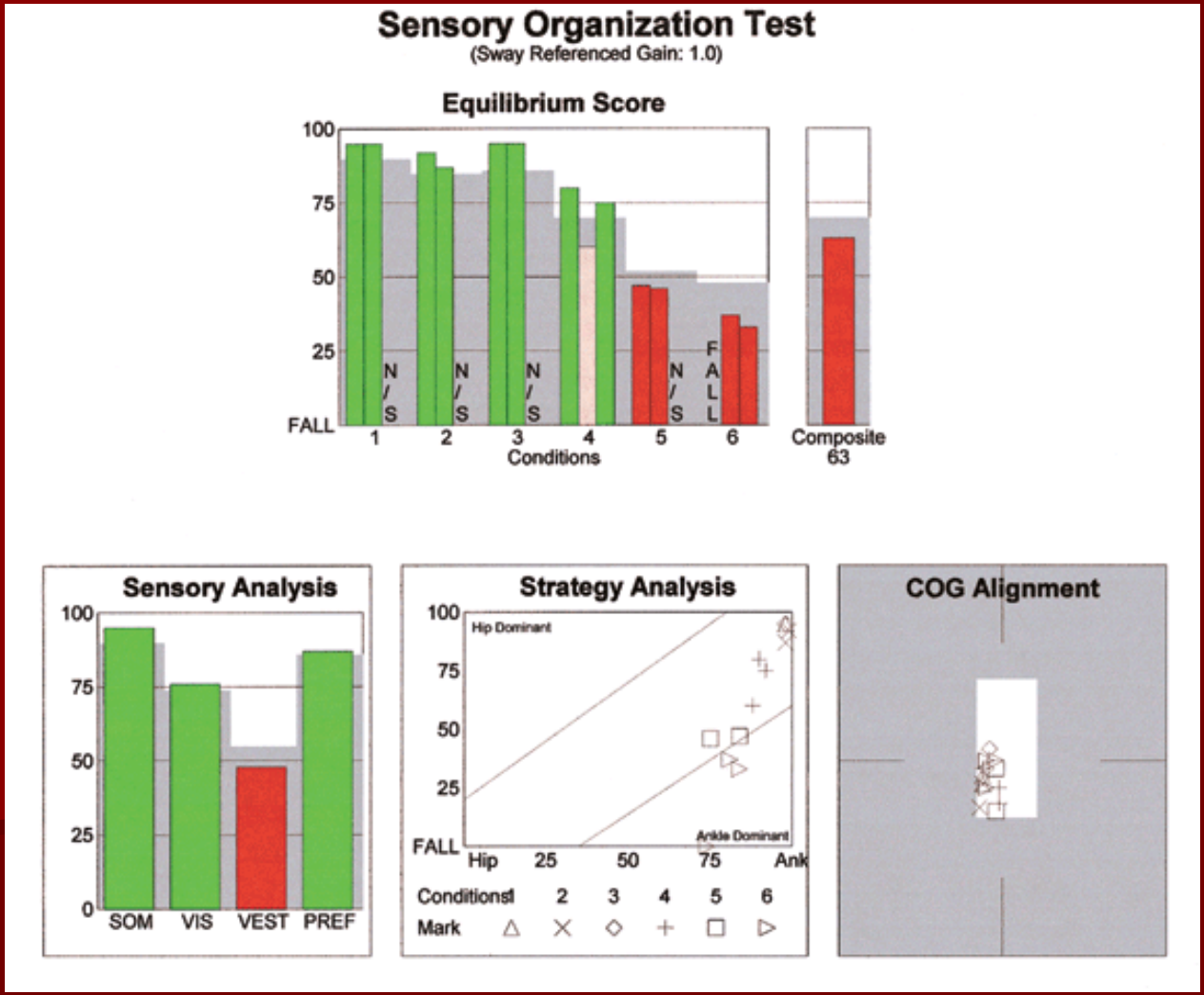


Computerized Dynamic Posturography System (Nashner et al., 1970 – 1980)

EquiTest
(www.onbalance.com)



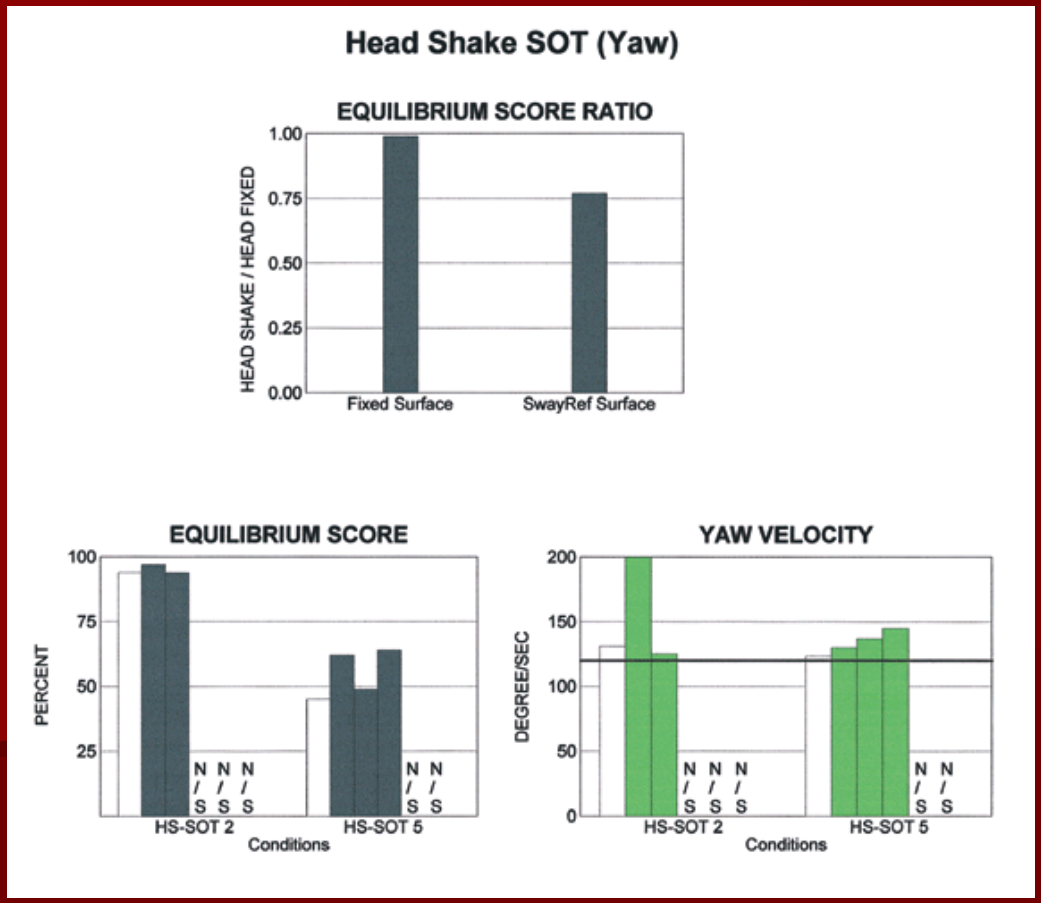
Sensory Organization Test (SOT)



Head Shake SOT



YAW PITCH ROLL



Shepard N et al. (1998). Enhancing sensitivity of the Sensory Organization Test (SOT) with the Head-Shake (HS SOT): Recommendations for clinical application. NeuroCom International, Inc., 11

Reliability, validity and sensitivity of SOT parametres

- Better sensitivity of static than dynamic posturography for detecting vestibular disorders (Di Fabio, 1995)

- Postural stability index is a more valid measure of stability than equilibrium score (Chaudhry et al., 2005)

- Significant learning effect observed for the SOT conditions in patients with chronic low back pain (Leitner et al., 2007)

Drawbacks of posturography systems

Feedback systems providing additional information on balance characteristics

Novel computerized feedback systems

- used mainly for balance training in fitness centres
- not suitable for diagnostics in research and clinical settings (e.g., orientation scales)

MTF (www.mtf-company.com)

In clinical practice - assessment of balance under stable conditions

19th Century

21st Century

Maintanance of balance - usually associated with other task

Systems for the training and assessment of balance during functional task

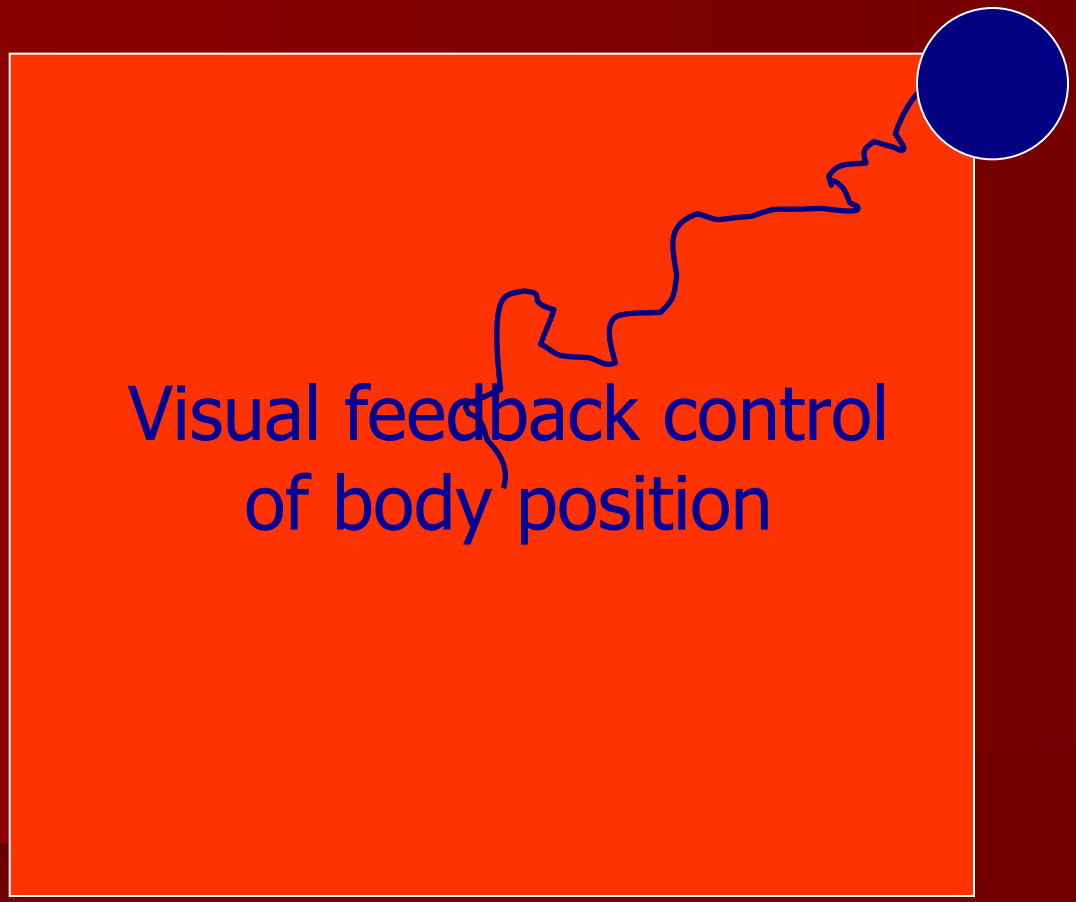
Visual Feedback

Trunk Sensor

Centre of Pressure

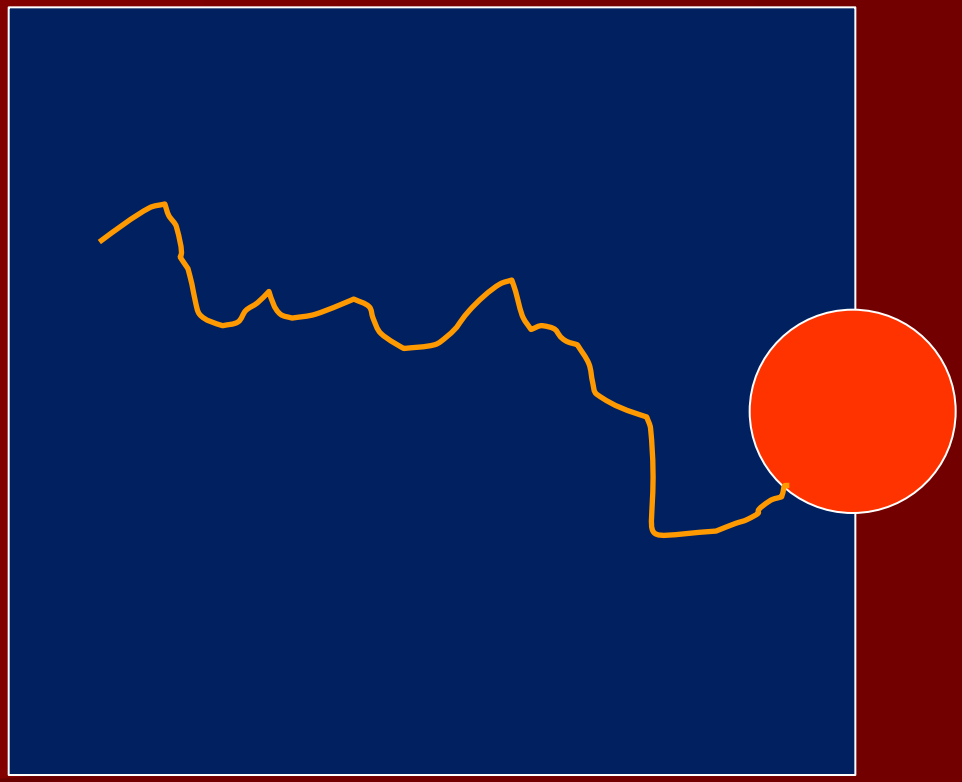
TecnoBody Rehabilitation Systems (www.tecnobody.com)

Task-oriented balance tests



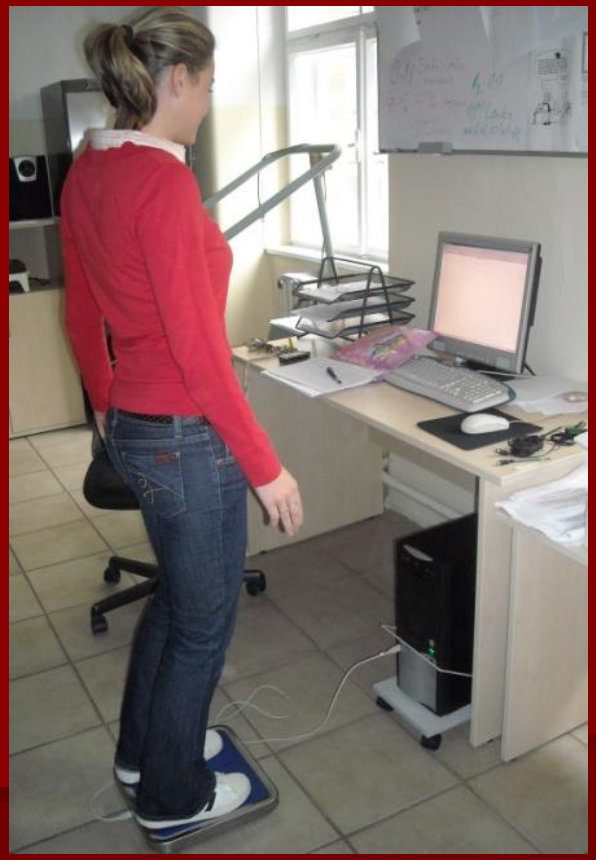
Hamar D (2008). Performačné testy stability postoja. National Congress of Sports Medicine. Trenčín: Slovak Society of Sports Medicine, 12-13.

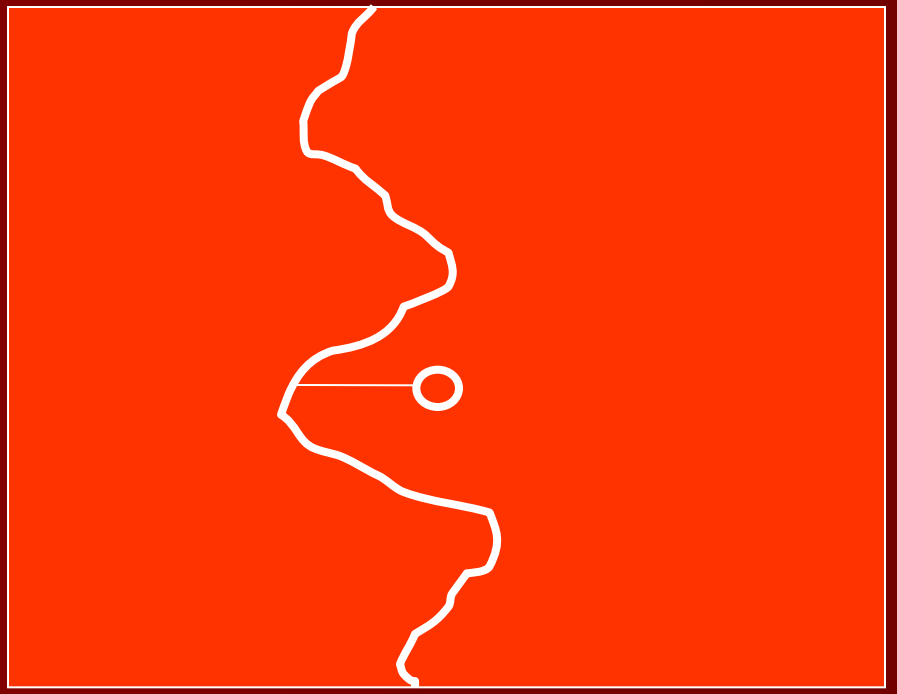
„Hit the target by shifting COM”



FiTRO Sway Check Light
www.fitronic.sk

„Trace the curve by shifting COM”





FiTRO Sway Check Light
www.fitronic.sk

Reliability of the parameters of visually-guided CoM target-matching task

	Test-retest correlation coefficients (1)	Measurement error (%)
Response time	0.76	9.9
Distance covered	0.78	8.9
CoP velocity	0.89	7.6

Reliability of the parameters of visually-guided CoM tracking task

	Test-retest correlation coefficients (1)	Measurement error (%)
Mean distance of CoP from horizontally flowing curve (AP)	0.83	6.4
Mean distance of CoP from vertically flowing curve (ML)	0.82	7.5

Task-oriented balance tests vs. tests of static balance

- Have similar reliability and measurement error
- with better potential for diferentiation between groups with different level of balance capabilities (ANOVA)

Hamar D, Zemková E (2009). Assessment of balance: From theoretical background to practical applications. *Antalya: VIth European Sports Medicine Congress. Journal of Sports Science and Medicine,* Vol 8 (suppl. 11): 30-1.
Zemková E, Hamar D (2010). Reliability and sensitivity of the test based on visually-guided COM tracking task. *Acta Facultatis Educationis Physicae Universitatis Comenianae.* L(I), 75-85.

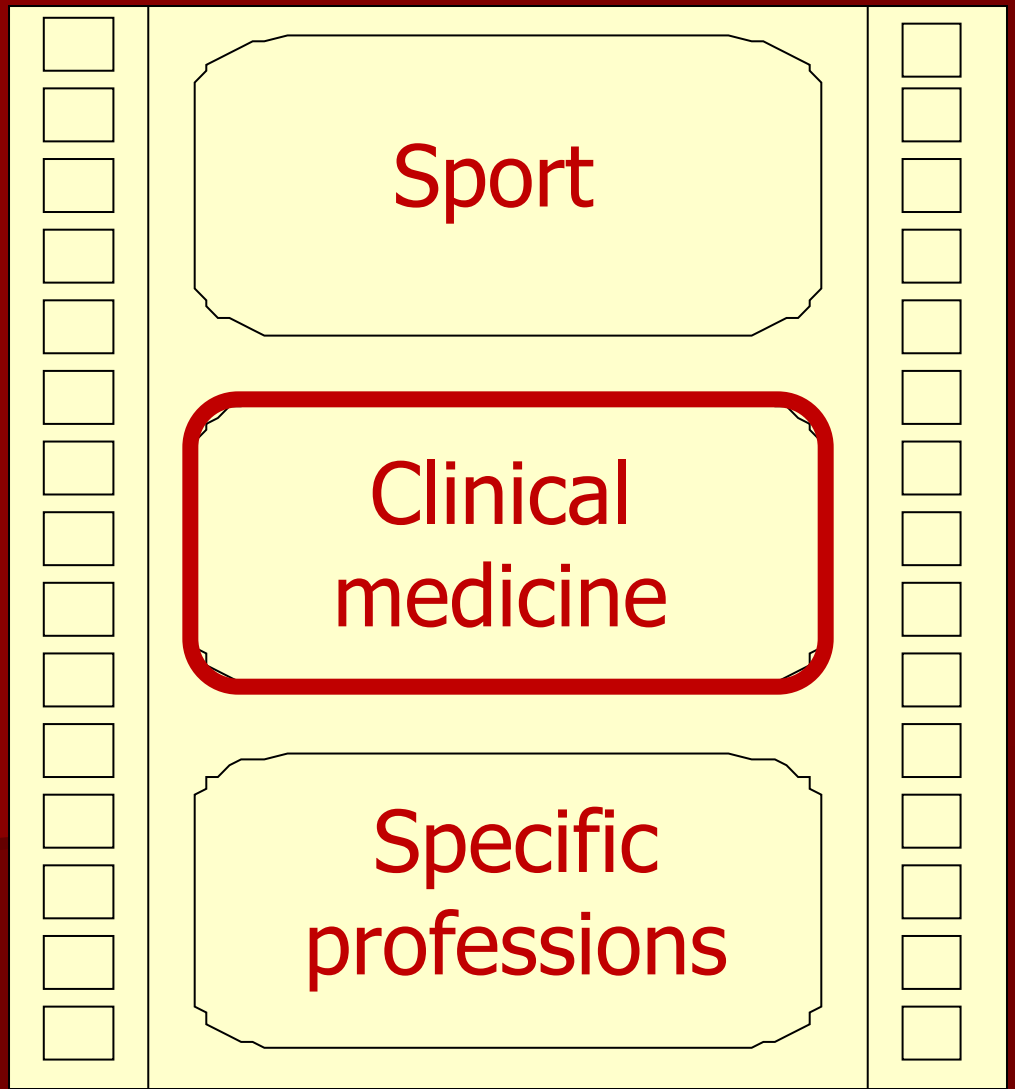
Possible applications

	Static posturography	Task-oriented balance tests	Dynamic posturography
Individuals of different age and performance level	very old people and those with impaired coordination	elderly people	elite athletes
Athletes of different sport specializations	e.g., shooting	e.g., dancing	e.g., snowboarding
Individuals after lower limb injury	post-injury phase	early phase of rehabilitation	late phase of exercise program

Possible effects of balance and visual feedback exercises on balance characteristics

Intervention	Training effects on balance characteristics			
	Static balance	Dynamic balance	Stance symmetry	Accuracy of regulation of COM movement
Balance exercises			?	
Visual feedback exercises			 (when using two force plates)	

Posturography as a part of functional diagnostics

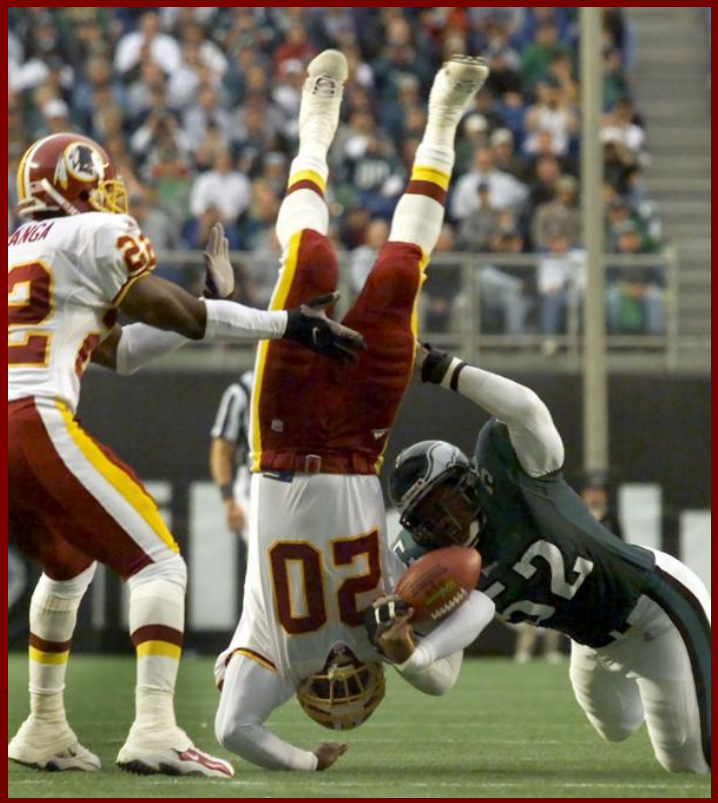


Geriatrics

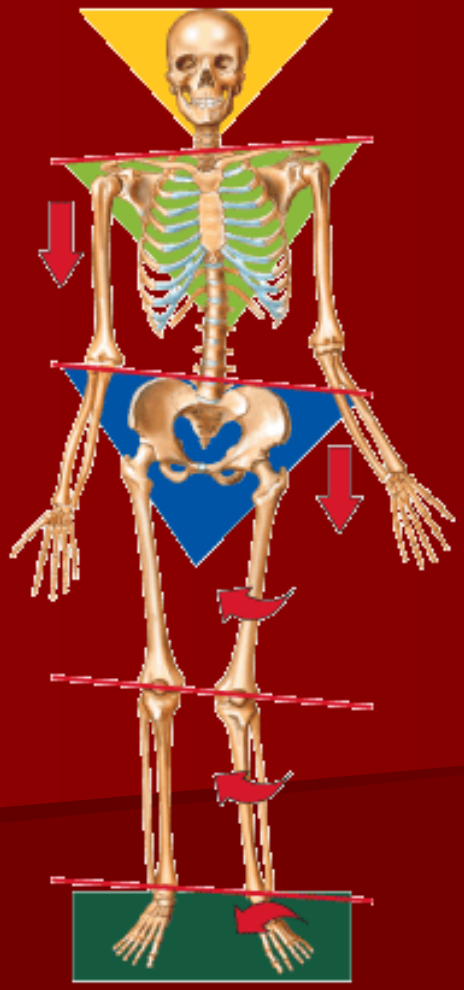
- screening of balance deterioration and evaluation the effect of exercise programs

Neurology

- evaluation of balance impairment after head injuries and progress of reconvalescence



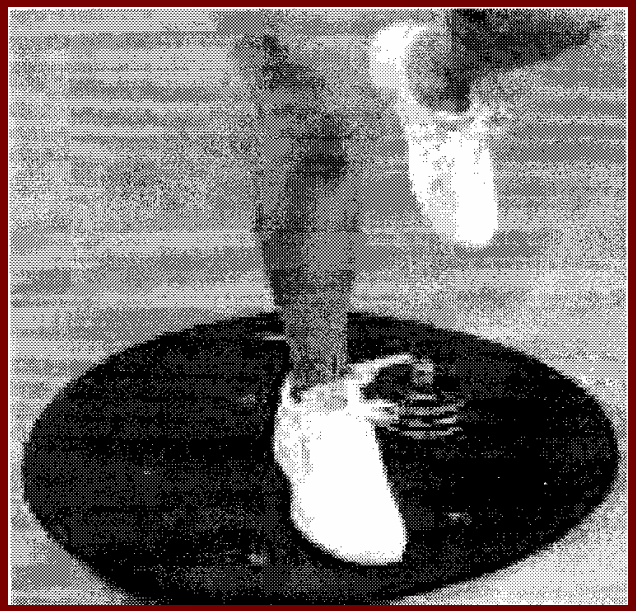
Musculoskeletal injuries



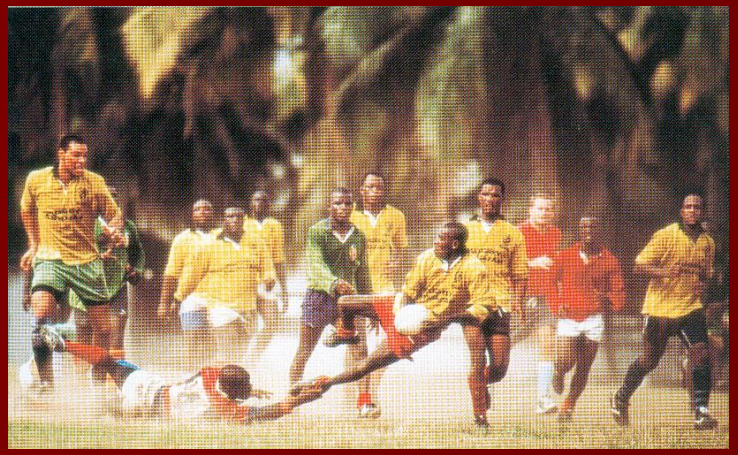
– evaluation of the impairment of proprioceptive functions and the effect of rehabilitation

No differences between the right and left leg in postural steadiness (Fridén et al., 1989; Goldie et al., 1992)

Enable the evaluation of balance on one leg and use the other as a control



Balance assessment as a possible prediction of injuries



Tropp et al. (1984) Stabilometry in functional instability of the ankle and its value in predicting injury. *Med Sci Sports Exerc,* 16: 64-66.
Cornwall, Murrell (1991). Postural sway following inversion sprain of the ankle*. J Am Podiat Med Assoc,* 81: 243-247.
McGuine et al. (2000). Balance as a predictor of ankle injuries in high school basketball players.*Clin J Sport Med,* 1 (4): 239-44

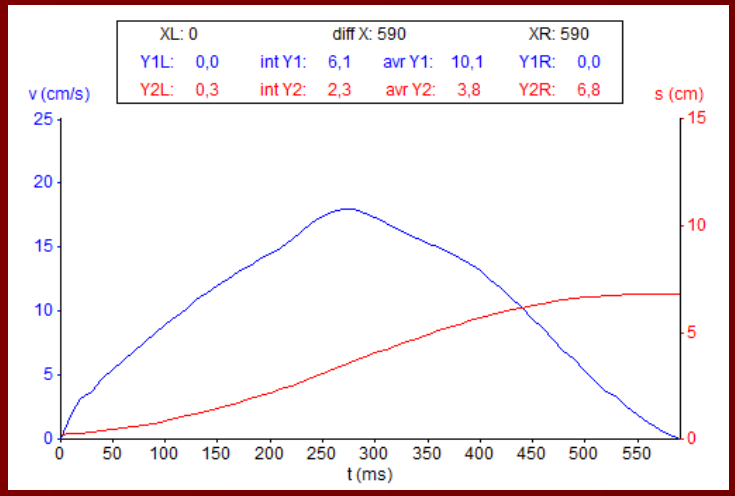
An example of applications of posturography in practice

Assessment of balance under stable and unstable conditions

FiTRO Sway Check

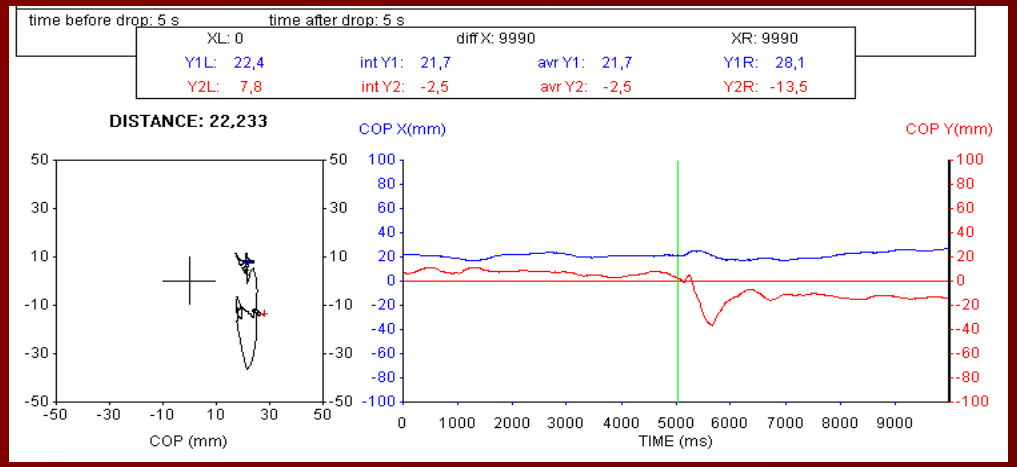
Test of dynamic balance

FiTRO Dynamic Posturography system



FiTRO Dyne Premium

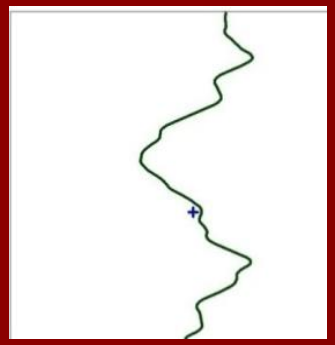
Load release balance test

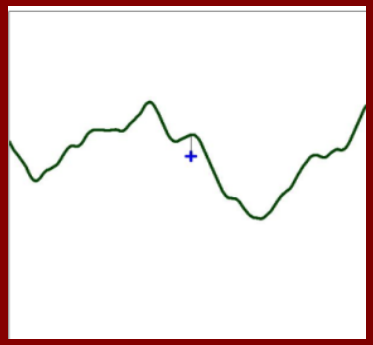


FiTRO Sway Check

Zemková E, Štefániková G, Muyor JM (2016). Load release balance test under unstable conditions effectively discriminates between physically active and sedentary young adults. *Human Movement Science.* 48, 142-152.

Visually-guided CoM tracking task

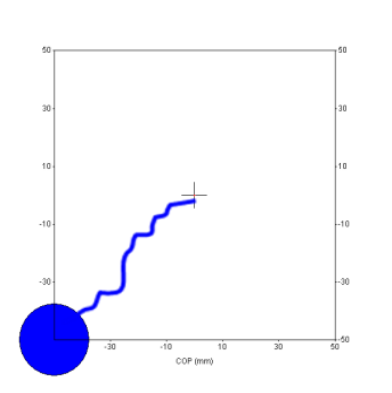




FiTRO Sway Check

Zemková E, Hamar D (2010). Reliability and sensitivity of the test based on visually-guided COM tracking task. *Acta Facultatis Educationis Physicae Universitatis Comenianae.* L(I), 75-85.

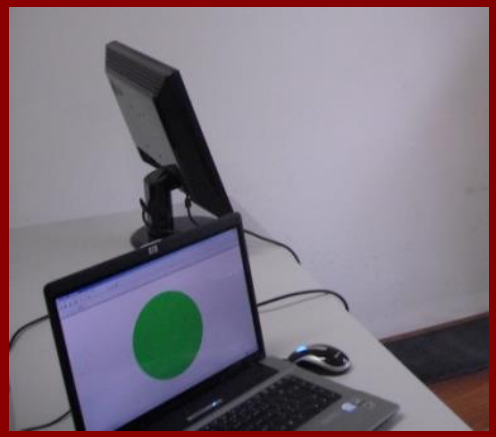
Visually-guided CoM target-matching task



FiTRO Sway Check

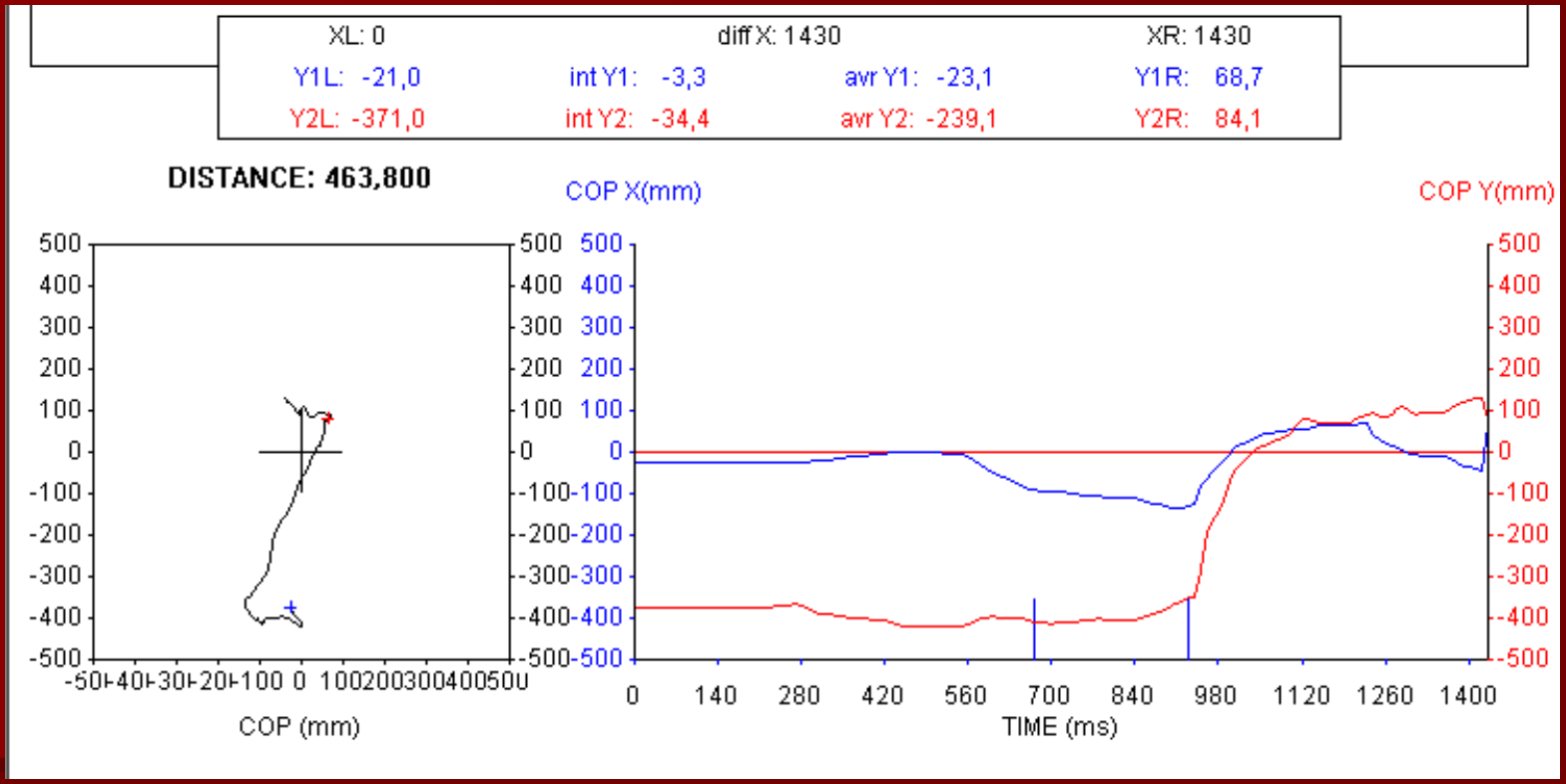
Zemková E, Hamar D (2010). Reliability and sensitivity of the test based on visually-guided COM tracking task. *Acta Facultatis Educationis Physicae Universitatis Comenianae.* L(I), 75-85.

Visually-triggered step initiation test



FiTRO Step Initiation Check

The COP shifts occurring during step execution



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