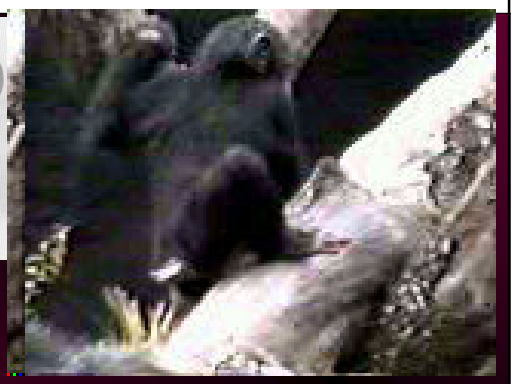
POSTURAL CONTROL

To control the body CoM relative to gravity and the base of support for any perturbation or during any task



Postural control is a behavior
Acquired during development and practice

- Requirements for Postural Stability
- * Ability to detect movement of CoM (sensory selection processes
- *Ability to move CoM (motor strategies)

POSTURAL CONTROL

Involves multidimensional sensorimotor integration of the CNS for control of posture and movement.

Postural Orientation

Postural Adjustments

GOAL

To stabilize oneself in space

Regaining, anticipating CoM displacement

POSTURAL ORIENTATION

To maintain the appropriate posture of the whole body with respect to the environment and the task

- Weight support
- Alignment
- Equilibrium

Weight support: generating activity in muscles supporting body weight

Postural tone regulated through the myotatic reflex loop (TSR),

Note::postural reflexes, supporting and placing reactions are integrated in normal motor control.

Alignment arrangement of body segments to one another, position of body with reference to gravity and base of support

Alignment over base of support:

- determines the effort required to support the body against gravity
- determines the constellation of movement strategies

Postural reflexes are integrated in motor tasks

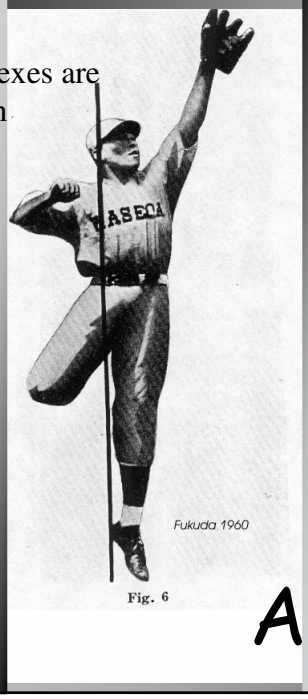
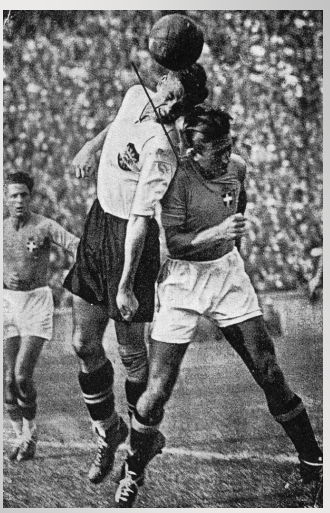


Fig. 6



ATNR

Tonic labyrinth reflex

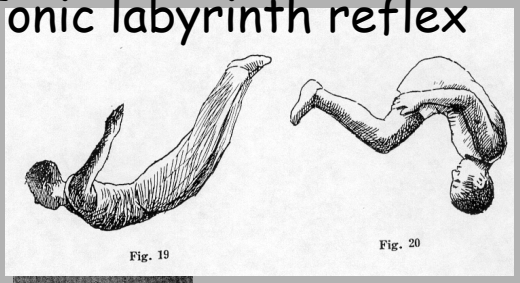
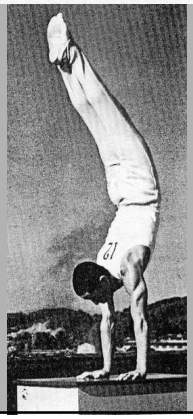


Fig. 19

Fig. 20



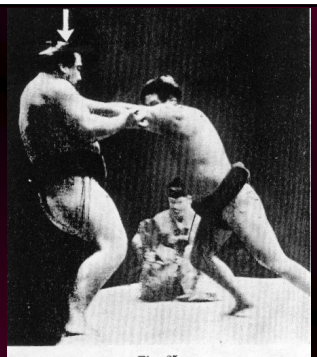
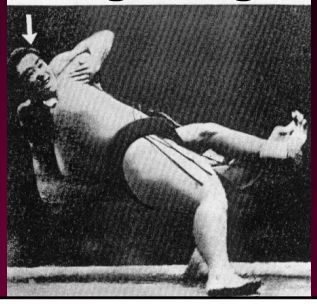


Fig. 25

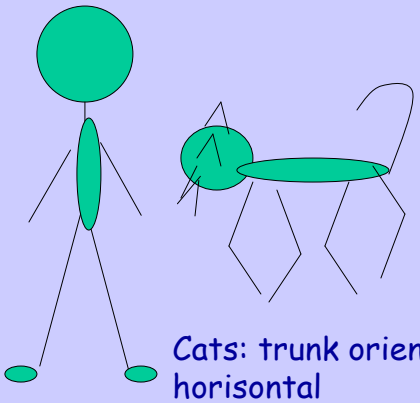
Righting



Fukuda 1960

Alignment

ART-SPECIFIED POSTURES



Somatosensory system detects intersegmental alignment, and support surface conditions

Visual, vestibular systems detect head orientation in space

Cats: trunk orientation to horisontal

Humans: Trunk orientation to vertical (Gravity receptors?)

Sensory information from multiple sources – process of unifying inputs

Vestibular System

Vision

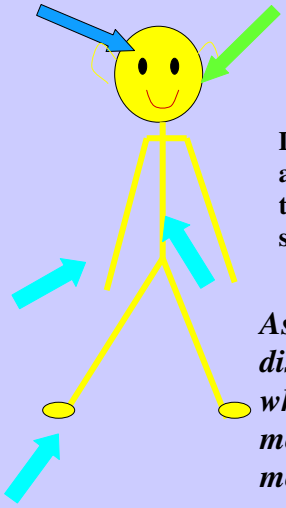
Eyes register our movements and movements in the sourrounding

(can be fooled, i.e. moving train)

Somatosensory system

(skin afference and proprioception)

Self- to- self and self- to-object information



Detects position and motion of the head in space

Assists in discriminating whole body movement from movement of the sourround

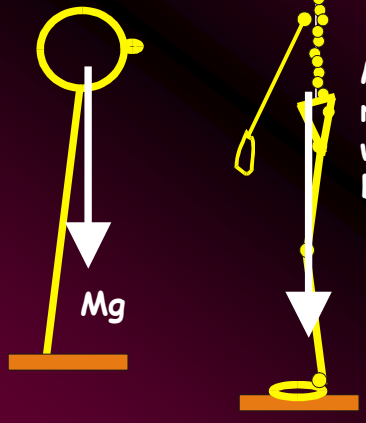
SENSORY SELECTION PROCESS

CNS organizes sensory information to accomplish the task.

CNS seems to rely on different combinations of sensory information *"reweighting" senses* depending on their usefulness

EQUILIBRIUM

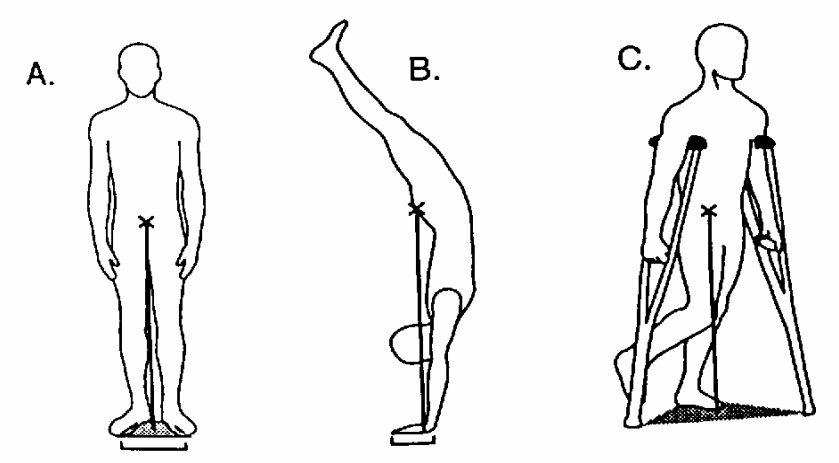
Human body modeled as INVERTED PENDULUM



Multi-Link Body

Maintaining equilibrium requires CoM projection within base of support During static conditions

EQUILIBRIUM



CoM may lie inside or outside the body. During static condition GRF takes its origin within support base and must pass through CoM

POSTURE

Is a dynamic interaction among a complex set of organisms organized around the control of functional goals such as the orientation of the trunk and head to various frames of reference

(Horak and Macpherson, Handbook of Physiology Vol.12, 1996)

POSTURE CONTROL makes use of ADAPTIVE-CONTROL = a control process capable of estimating and modifying output variables on the basis of

INTERNAL MODELS of expected behavior (evidence from microgravity studies)

Sensory disorder / CNS must have an accurate picture of where the body is in space (integration of sensory input)

Disruption - prevents development of accurate internal models-
•effects orientation of body with respect to gravity and the environment
•influences a patients ability to adapt to changes in task and environmental demands
•disrupt motor learning
•influences ability to anticipate
•causes compensatory modifications

Misrepresentation of stability limits
Sensory problems affect postural movement strategies.

Postural control of standing

Human stance – is a surprising ability

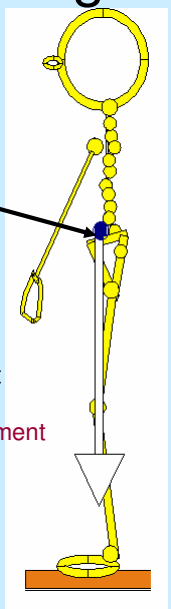
66% av body mass high above base of support
CoM located at about 66% of body length

•postural muscle tone (antigravity function)

•Alignment

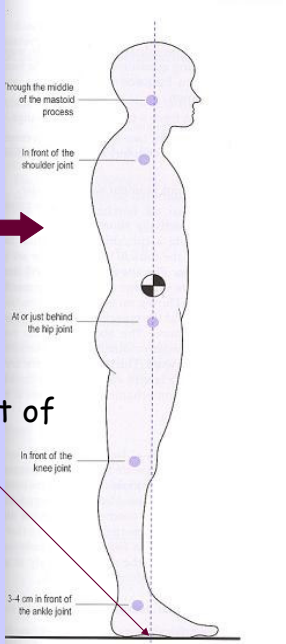
• Balans, equilibrium
(CoM projection within base of support

Erect posture is a reference for movement is the interface to the environment for perception and action.



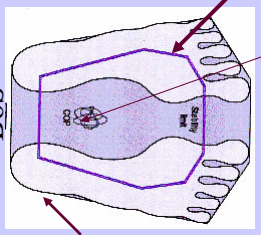
Gravity line: projection of vertical axis through CoM to the floor.

anatomical landmarks close to the gravity line



Stability limits

BoS



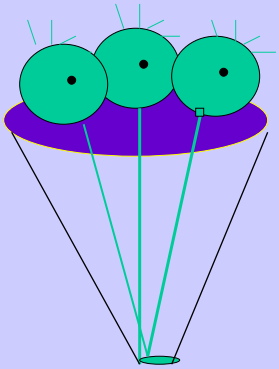
CoP: application point of GRF

CoP located 2-4 cm in Front of ankle joints

Base of support

Fig modif."Human Movement" 2000

STABILITY LIMITS

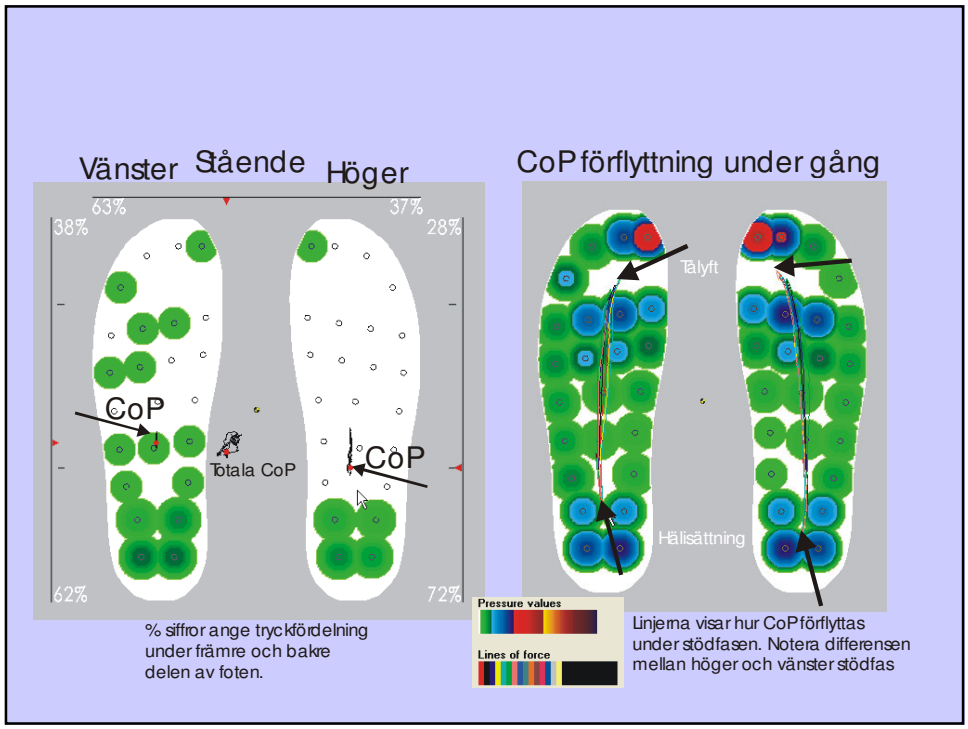


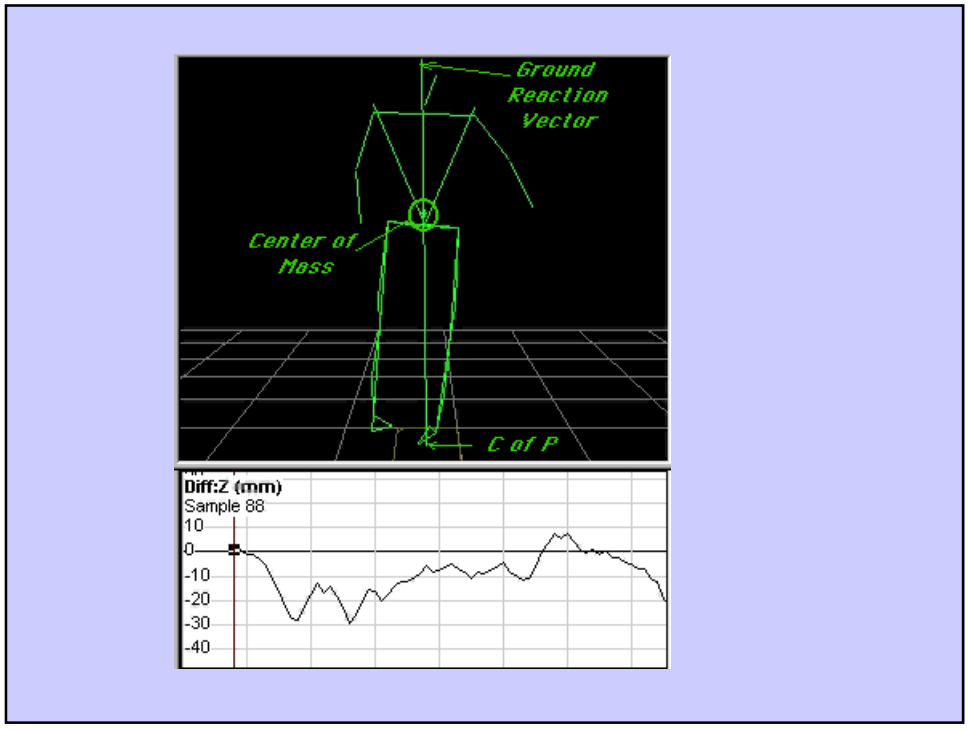
Mechanical limits of stability

area determined by the biomechanics, the environment, and the task

Internal model of stability limits

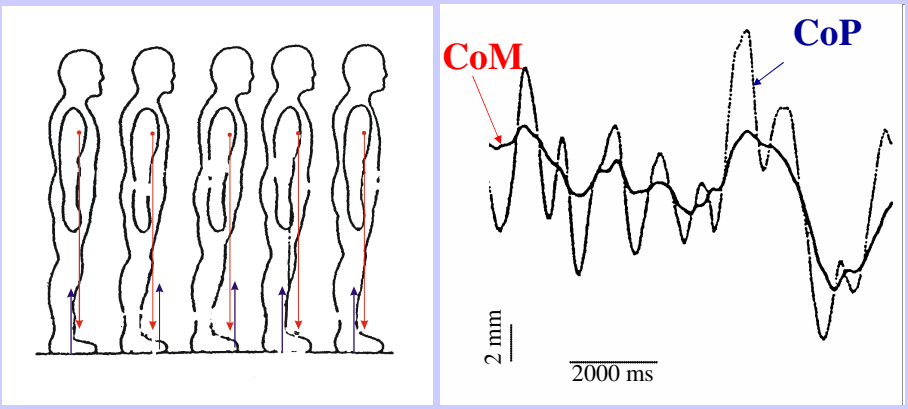
internal representation of the area in which the individual is stable


Vänster Stående Höger
63%
37%
38%
28%
CoP
Totala CoP
CoP
62%
72%
% siffror ange tryckfördelning
under främre och bakre
delen av foten.
CoP förflyttning under gång
Tålyft
Hälisättning
Pressure values
Lines of force
Linjerna visar hur CoP förflyttas
under stödfasen. Notera differensen
mellan höger och vänster stödfas


Ground
Reaction
Vector
Center of
Mass
C of P
Diff:Z (mm)
Sample 88
10
0
-10
-20
-30
-40

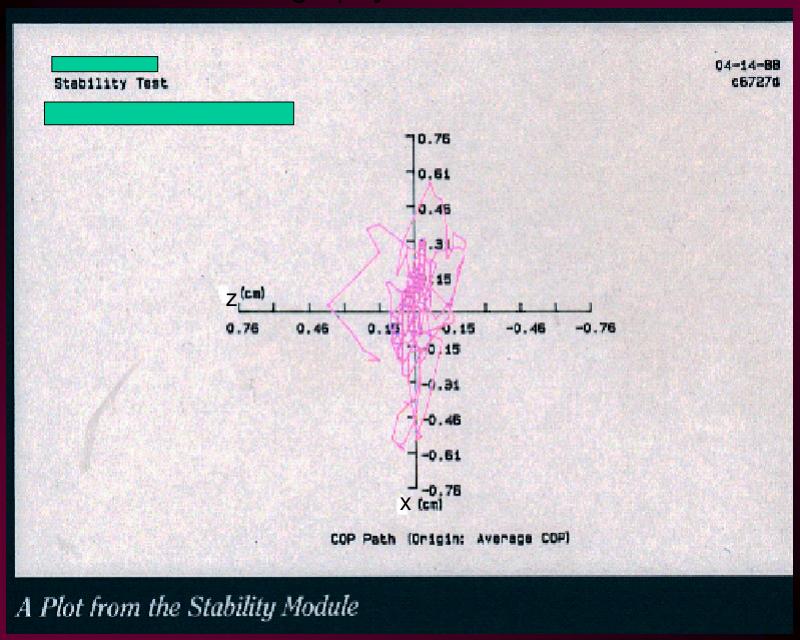
BODY SWAY

CoP and CoM interaction



(D.Winter 1980)

Posturography

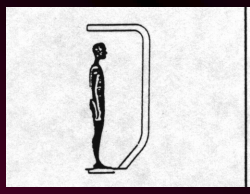


A Plot from the Stability Module

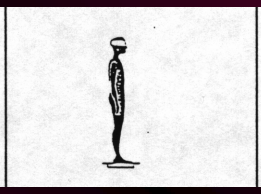
EQUITEST ***(Nashner, NeuroCom 1988)***

Provides 6 different sensory conditions

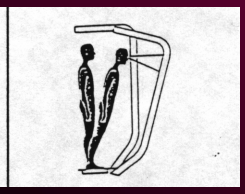
1. Normal vision fixed support



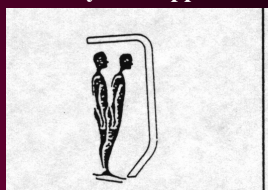
2. Absent vision fixed support



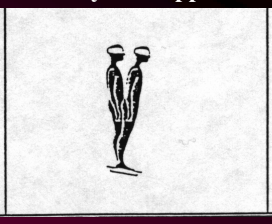
3. Sway-referenced vision, fixed supp.



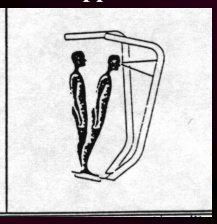
4. Normal vision sway-ref. support



5. Absent vision sway-ref. support



6. Sway ref. Vision and support



3 common patterns of postural instability found in vestibular patients

Vestibular Loss Pattern

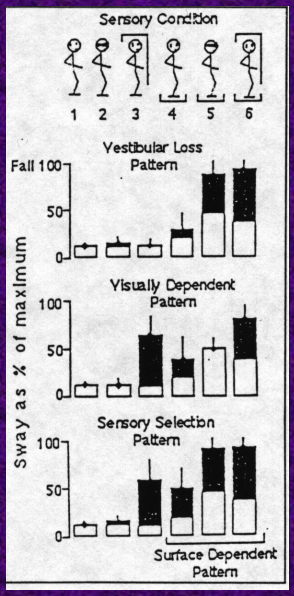
(Fall conditions 5,6

Visually dependent pattern

(Fall when vision inaccurate conditions 3,6 or 2,3,5,6)

General Sensory Selection Pattern

(Fall conditions 3,4,5,6)



Balance control in elderly

Many older adults have balance control like younger adults

Many factors can contribute to declining balance control in older adults who are symptomatic for imbalance and falls.

Falls are the 7th leading cause of death in people >75 years.

Change of standing posture

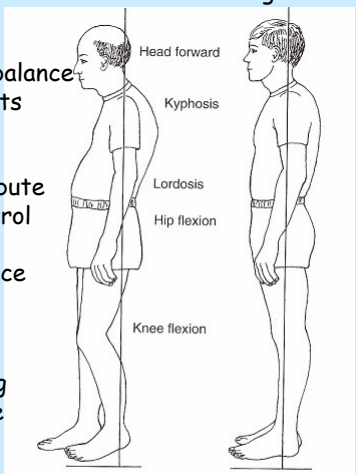


Figure 8.2. Changes in spinal flexibility can lead to a stooped or flexed posture in many elderly people. (Adapted from Lewis C, Bottomley J. Musculoskeletal changes with age. In: Lewis C, ed. Aging: health care's challenge. 2nd ed. Philadelphia: FA Davis, 1990:146.)

Postural control is a behavior therefore, balance can be improved through training also in older adults.

POSTURAL ADJUSTMENTS

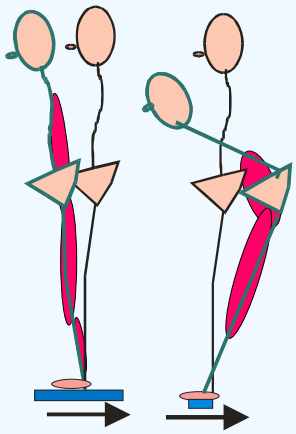
Are composed with respect to the reference frame of postural orientation

Requirements for Postural Stability

*** Ability to detect movement of CoM (sensory selection processes**
***Ability to move CoM (motor strategies)**

Compensatory and anticipatory postural responses are direction specific and show task dependent shaping.
Importance: flexibility

Postural Adjustments to Surface Translation



Nashners perturbation platform

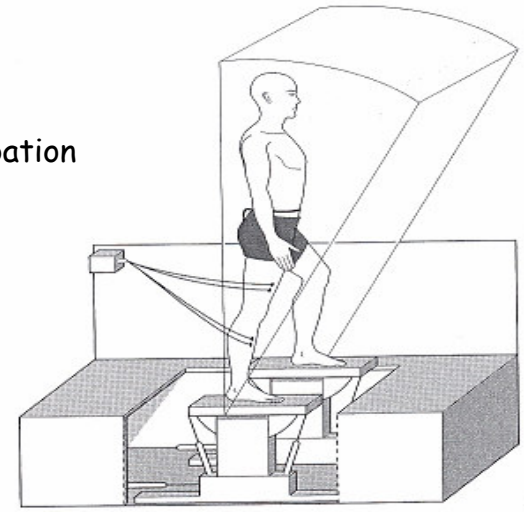
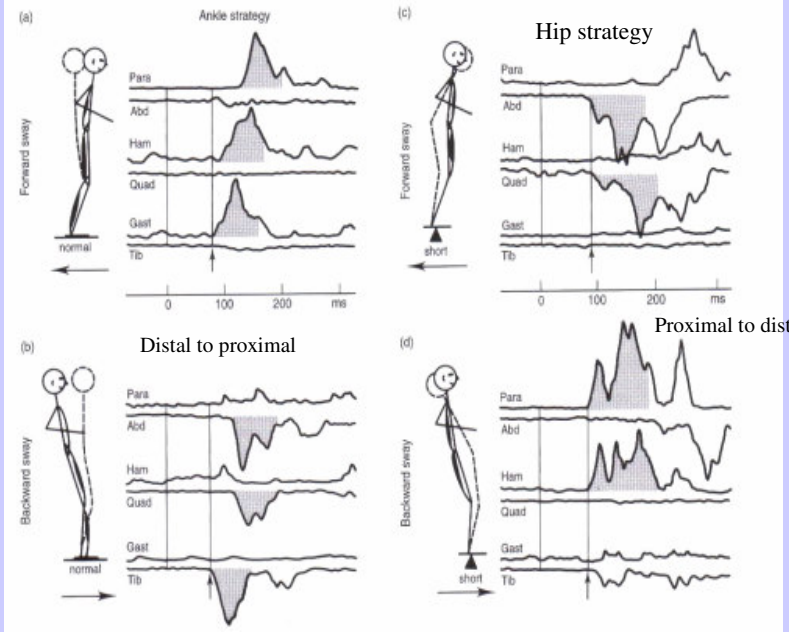
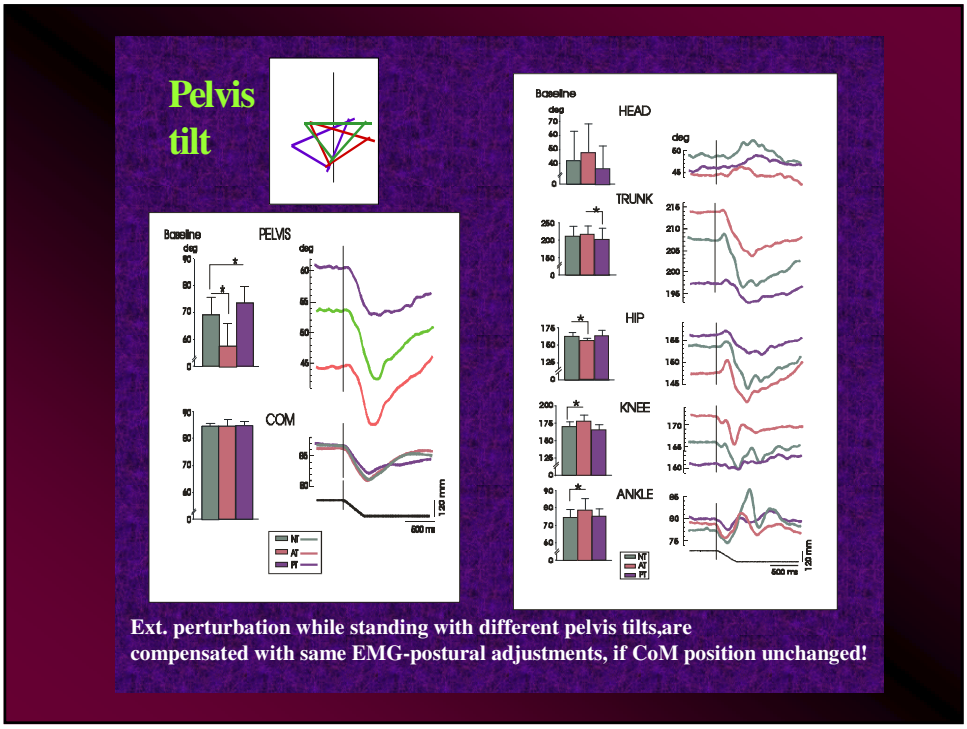


Diagram of the hydraulically activated platform used to perturb the balance of standing subjects. The platform may be translated in the antero-posterior direction or rotated about an axis collinear with the ankle joints (reproduced from ref. 109 with permission from The American Physiological Society).

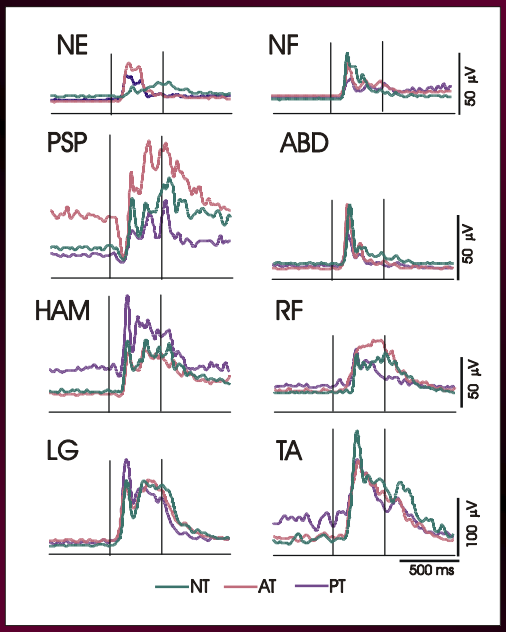
Compensatory postural adjustments to surface perturbation (Horak and Nashner 1986)



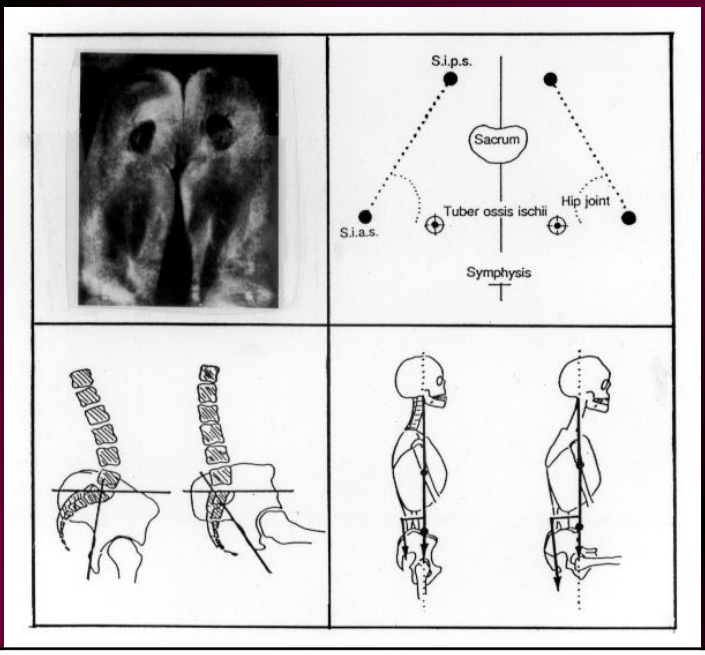


EMG

Mean of mean
10 subjects
5 trials each

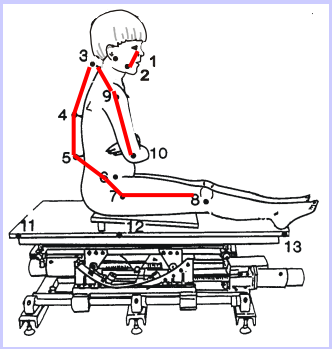


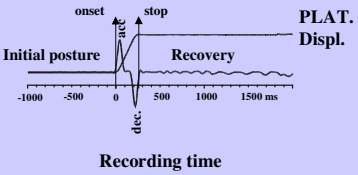
Sitting – diffferent support base conditions than standing



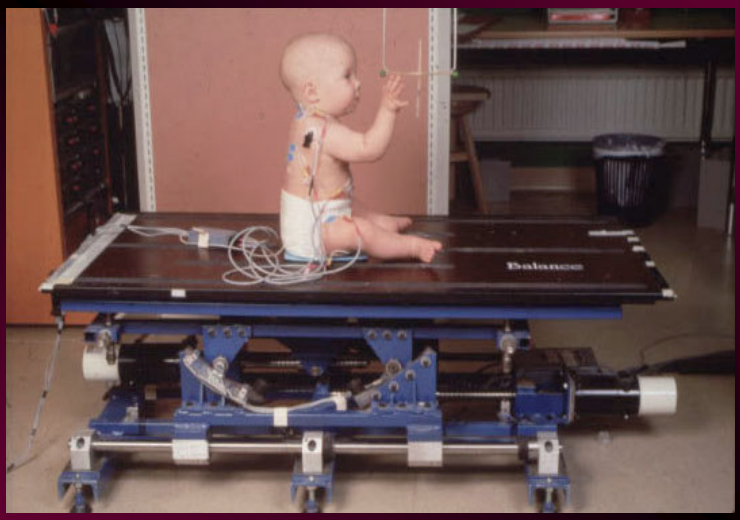
PLATFORM TRANSLATION

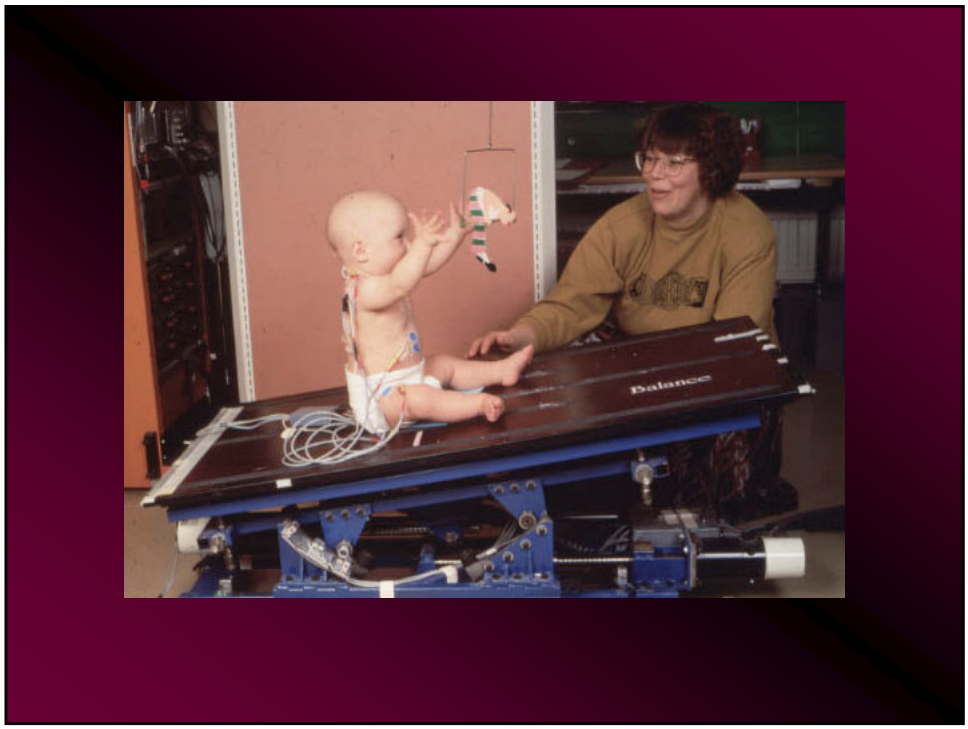
6 cm : 24 cm/s

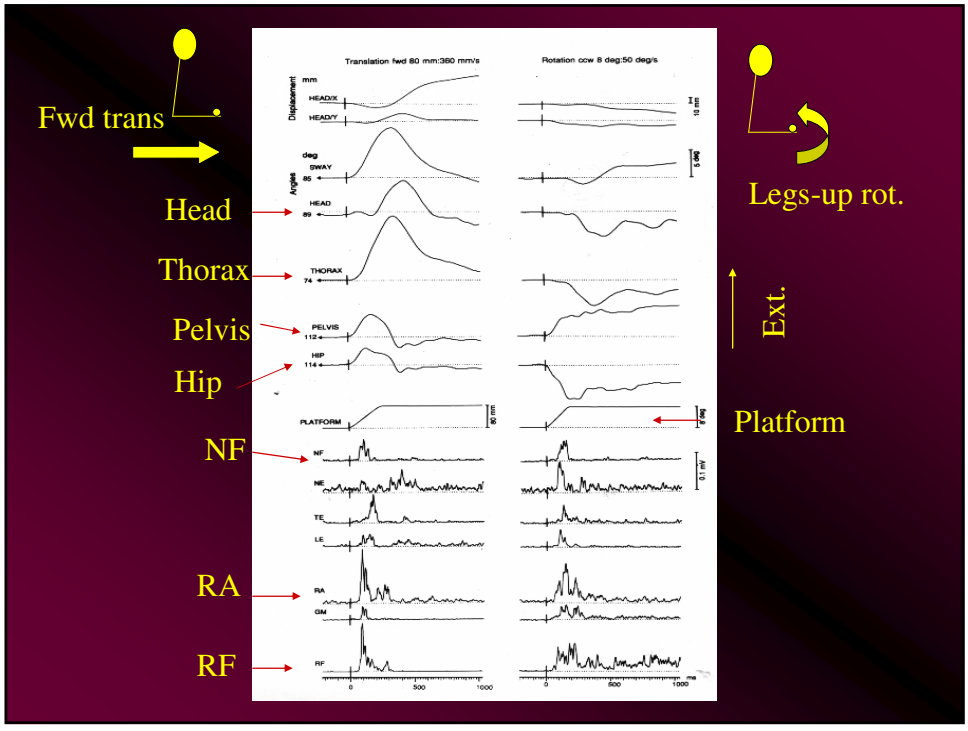


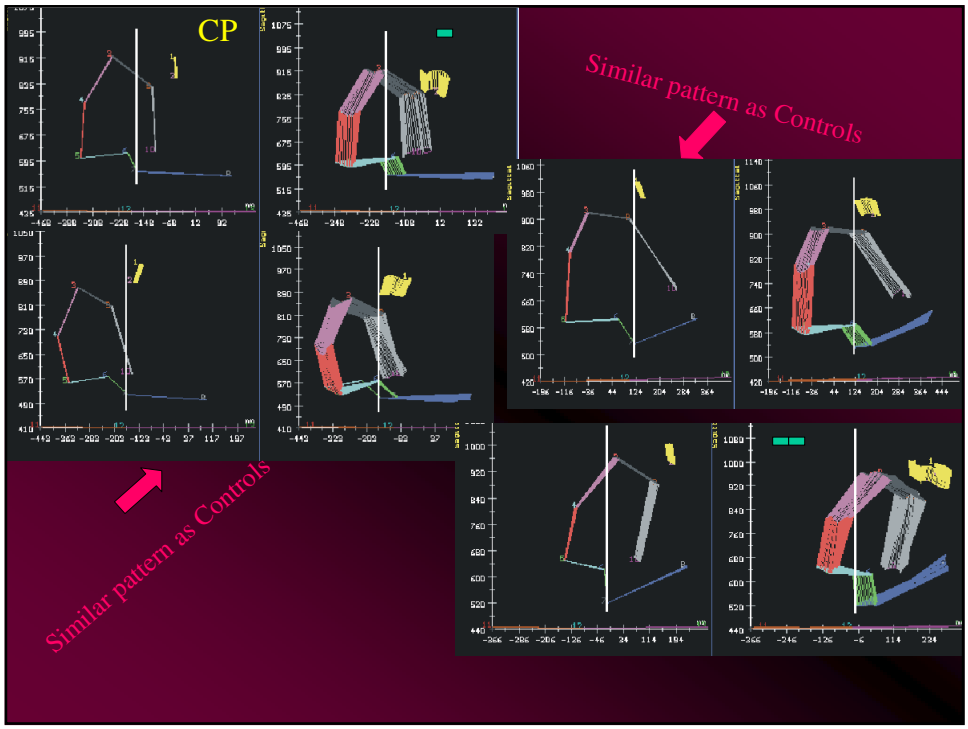


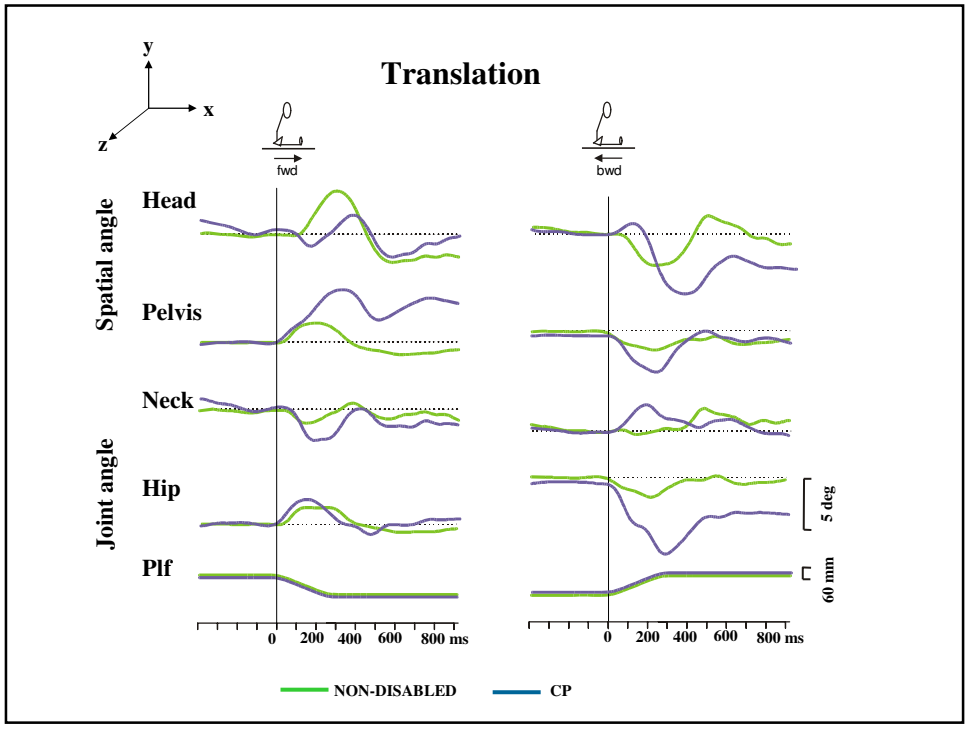
Recording time

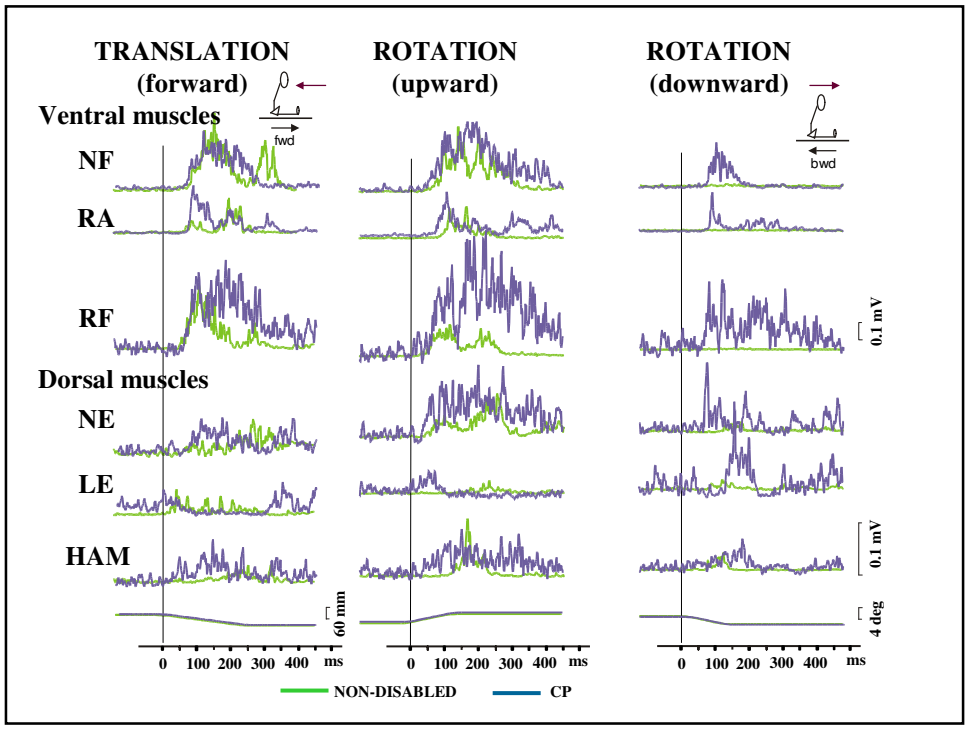


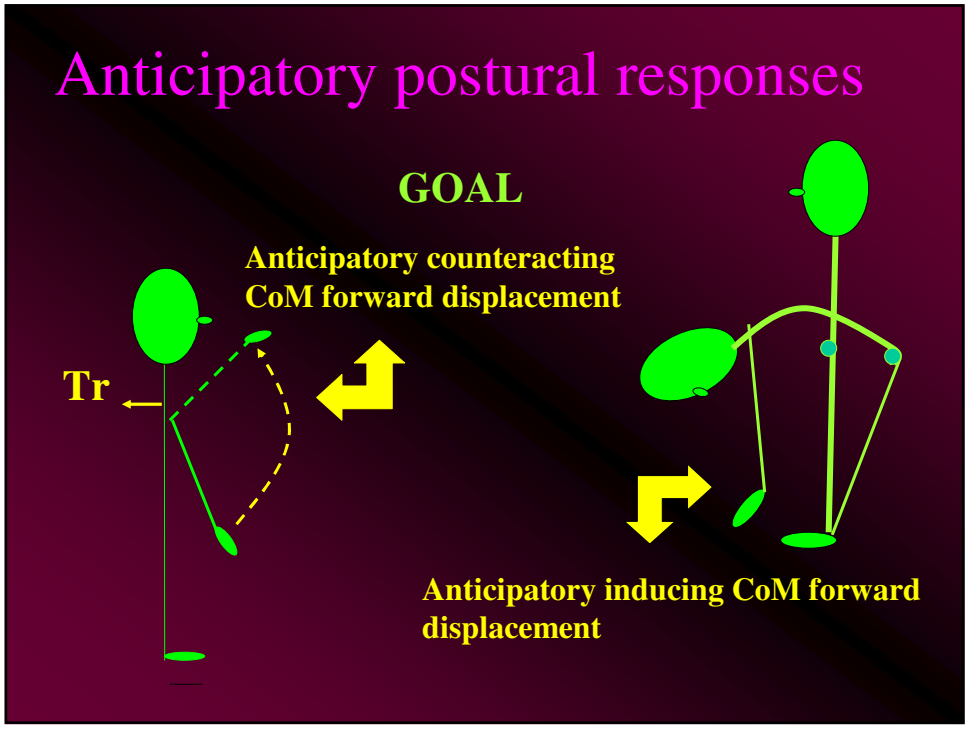

Balance

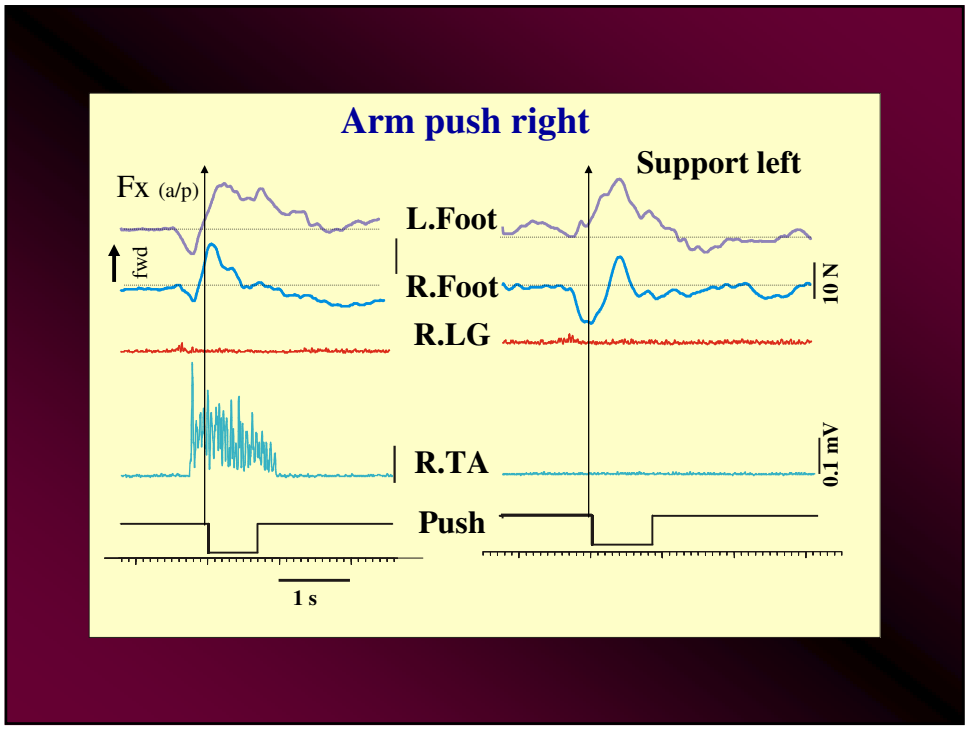

Fwd trans
Head
Thorax
Pelvis
Hip
NF
RA
RF
Translation fwd 80 mm:360 mm/s
Rotation ccw 8 deg:50 deg/s
Displacement
Angles
HEAD/X
HEAD/Y
SWAY
HEAD
THORAX
PELVIS
HIP
PLATFORM
NF
NE
TE
LE
RA
GM
RF
Legs-up rot.
Ext.
Platform


CP
Similar pattern as Controls
Similar pattern as Controls


Translation
y
x
z
fwd
bwd
Head
Pelvis
Neck
Hip
Plf
Spatial angle
Joint angle
5 deg
60 mm
0 200 400 600 800 ms
0 200 400 600 800 ms
NON-DISABLED
CP


TRANSLATION
(forward)
ROTATION
(upward)
ROTATION
(downward)
Ventral muscles
fwd
bwd
NF
RA
RF
Dorsal muscles
NE
LE
HAM
0.1 mV
0.1 mV
60 mm
4 deg
0 100 200 300 400 ms
0 100 200 300 400 ms
0 100 200 300 400 ms
NON-DISABLED
CP

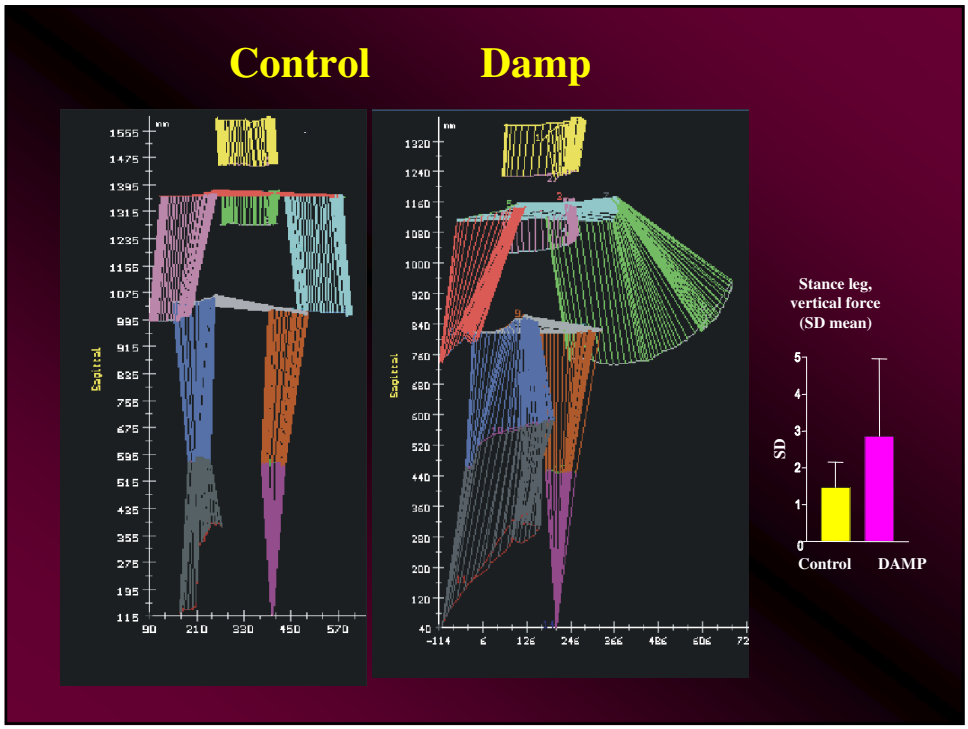

Anticipatory postural responses
GOAL
Anticipatory counteracting
CoM forward displacement
Tr
Anticipatory inducing CoM forward
displacement

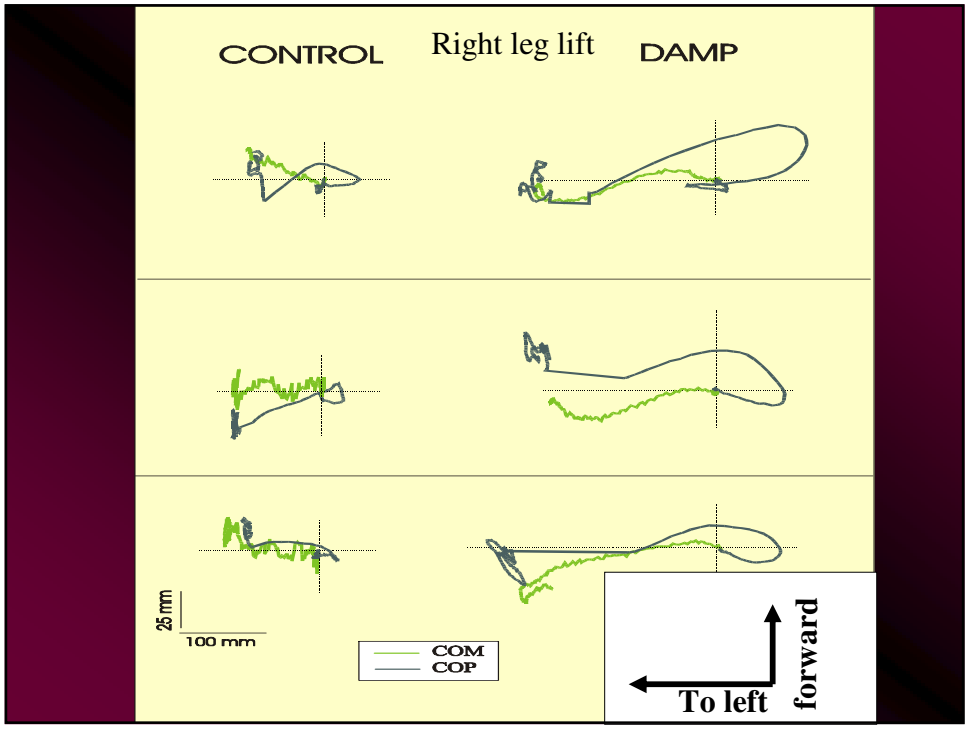


Anticipatory postural adjustments

Bimanual load-lifting task

(Bouisset and Zattara 1987)

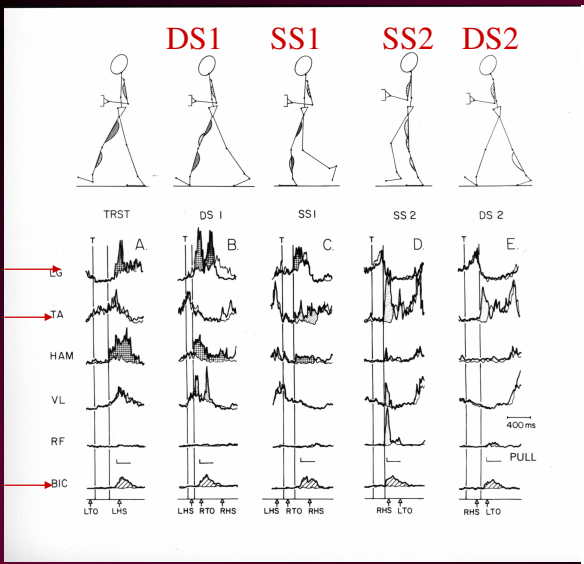

Control
Damp
Stance leg, vertical force (SD mean)
SD
Control
DAMP


CONTROL
Right leg lift
DAMP
25 mm
100 mm
COM
COP
To left
forward

Set-up
Handle
pull
while
walking

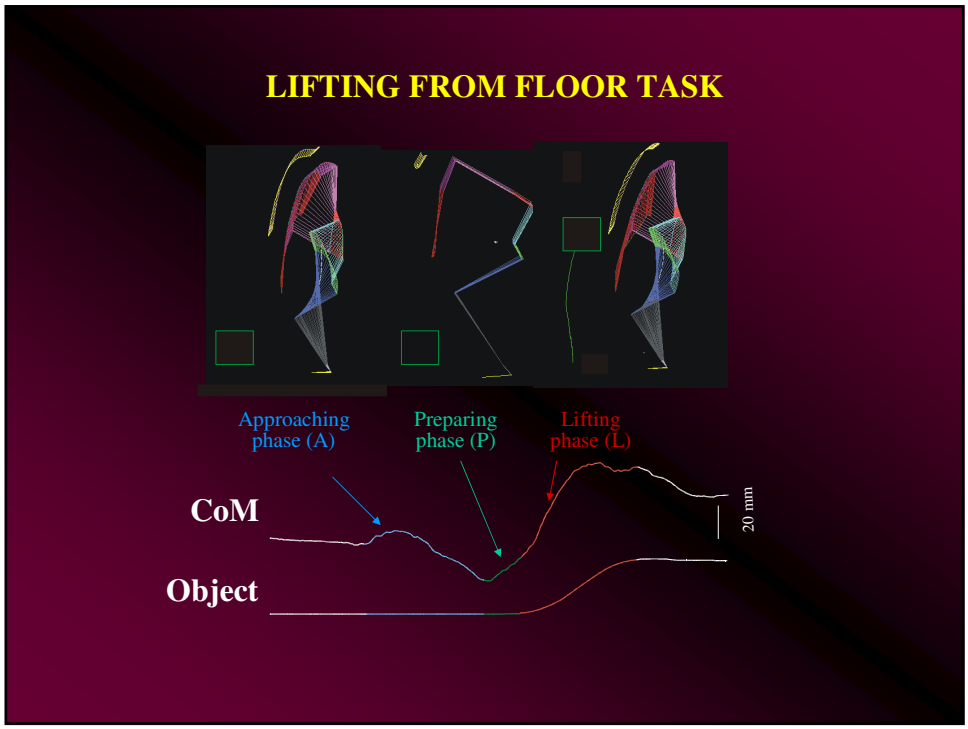
Handle pull while walking

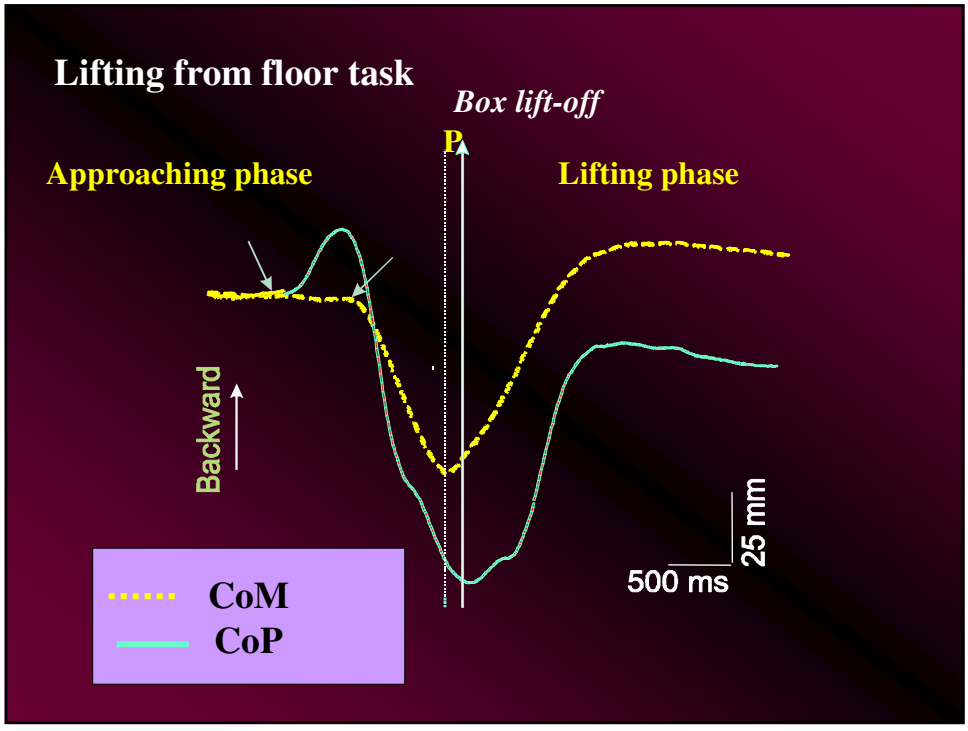
Adults



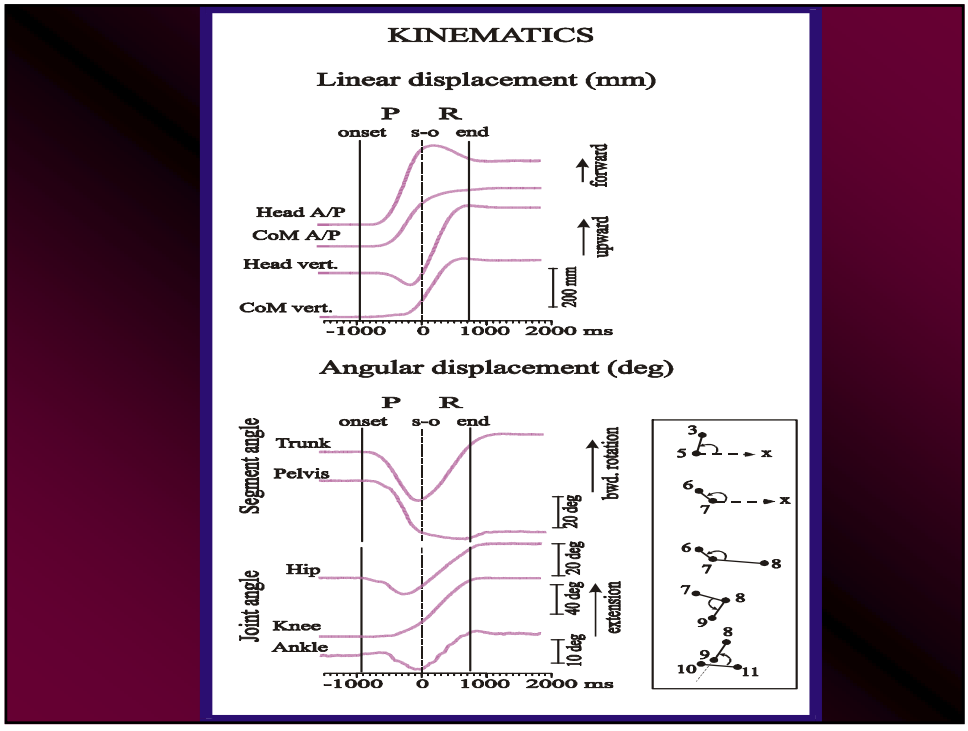
LG
TA
Bic

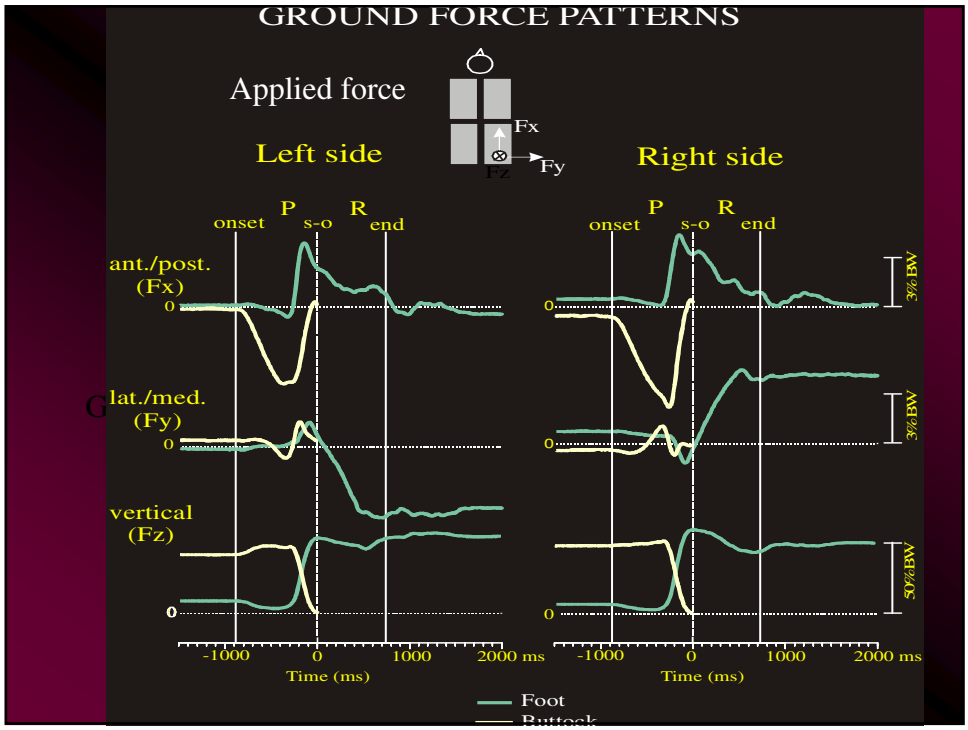
Same task, different postural adjustments due to changed support surface conditions!


LIFTING FROM FLOOR TASK
Approaching phase (A)
Preparing phase (P)
Lifting phase (L)
CoM
Object
20 mm


Lifting from floor task
Box lift-off
P
Approaching phase
Lifting phase
Backward
25 mm
500 ms
CoM
CoP

SIT-TO-STAND, SIT-TO-WALK TASK





POSTURAL CONTROL

Involves multidimensional sensorimotor integration by the CNS

Postural Orientation

Postural Adjustments

GOAL

To stabilize oneself in space

Regaining, anticipating CoM displacement