What are the features of a stabilogram?
What is stabilogram diffusion analysis?
What is static vs. dynamic postural control?
What aspects of control theory can be used to describe postural control?

Admin
- Wait list (cap = 95)
- HW 1 on Compass
- Piazza
COP measurement

COP using force plates

Center of pressure (COP)

Ground reaction force (GRF)
Force plate gives you $\vec{F}$ and $\vec{M}$

and CoP location

Notice that $M_y = f(F_x \text{ and } F_z)$

$$M_y = F_x(z_{off}) + F_z(COP_x)$$

$$(COP_x)F_z = M_y - F_x z_{off}$$

$$COP_x = \frac{M_y - F_x z_{off}}{F_z}$$

(signs & local CS may vary!)
$$\text{COP}_y = \frac{M_x - z_{off} F_y}{F_z}$$

Quiet stance testing

"stand quietly"

- gaze at fixed target
- ~ 30s (not too short!)
- Multiple trials (e.g. 10)

Rule of thumb:
5 30s trials

- Output COP to evaluate postural sway
Postural sway

→ a measure of stability
Tool: Stabilogram

↓ track COP over time

AP displacement (mm)

ML displacement (mm)
Descriptive measures:

- Path length (total length of squiggle)
- Swept area: $\sum$ triangles
- Angular deviation from $AP$
- 95% conf ellip
COP over time

AP COP (mm)

Prieto 1996
Rocchi 2004
Doyle 2007, 2008

Also possible to look at frequency

papers will be placed on website
Effect of pregnancy on balance

Pregnant group:
n = 15
25-38 yrs
(31 ± 4 yrs)

Non-pregnant control group:
n = 15
26-39 yrs
(31 ± 4 yrs)

Testing frequency

Assessments per test session
- 10 trials, 30s, stand quietly with hands to side
- Traditional and SDA balance measures
- Preferred heel stance width
- Perceived sense of balance:
  - 0 ("normal") to 10 ("extremely unstable")
  - Fall incidences since last test session


Subject qualitative feedback

VAS = visual analog score
"Rate your pain"
Increasing stance width and perceived balance degradation are coupled with degradations in AP balance.

ML sway is modulated by stance width and experience residual effects postpartum.

Δ in AP + rad but not ML.

Why? ↑ stance width to stabilize.

Balance perception doesn’t return to baseline post-partum.
Postural control system (PCS)

- Sensory System
  - Vision
  - Vestibular system
  - Somatosensory (Proprioception, touch, pain, temperature)

- CNS\(^{(1)}\)
  - Brain & Spinal Cord
  - Feedback
  - Feedforward

- Musculoskeletal System
  - Muscles

---

Do march in place test system of nerve cells that responds to changes in internal state/surface of body.
Possible postural control system scenario for upright stance

Compensator \rightarrow \text{special filters that create a gain or phase shift}

Plant \rightarrow \text{process + actuator}
Stabilogram Diffusion Analysis (SDA)

"New" technique
- Sway is Stochastic
- Brownian motion random!

→ Random walk theory
- Non linear dynamics
- Multiple parameters characterize behavior
- No system memory
Random walk:
- mean displacement^2 is linearly related to time interval \(\Delta t\) by:

\[(\Delta x)^2 = 2D \Delta t\]

\(\Delta x\): mean displacement

D: measure of stochastic activity (jump frequency)
\[(\Delta \mathbf{j})^2 = 2D \Delta t\]
**SDA applied to COP**

**Schematic Representation of Stabilogram-Diffusion Plot**

- Short-Term Region
  - Critical Point: \((\tau_{rc}, <\Delta r^2>_c)\)
  - Slope: \(2D_{rs}\)

- Long-Term Region
  - Slope: \(2D_{rl}\)

**Time Interval (s)**

\(<\Delta r^2> \text{ (mm}^2\rangle\)

**Short-term D > long term D**

- Open-loop
  - (e.g. washing machine, light switch)

- Closed loop
  - (lots of e.g.s!)
**EquiTest®**: 18” x 18” dual forceplate with rotation and translation capabilities measure vertical forces exerted by the patient's feet; and a moveable visual surround.
- **Sensory Organization Test (SOT)**: somatosensory, visual and vestibular systems.
- **Motor Control Test (MCT)**: automatic motor system.

**Proprio 5000®**: multi-directional tilting platform to challenge balance. Single ultrasonic marker to record core stability.

Utility for assessing and measuring dynamic balance: under investigation