What is the ground reaction force and how is it measured?
What is postural control and sway and how is it quantified?
What is the center of mass vs. center of pressure?
What are the features of a stabilogram?
Recap: Anatomical Planes / Rotations

Median/Sagittal plane

Frontal/coronal plane

Transverse/horizontal axis

Transverse/horizontal plane
Two types of balance/postural control
Center of mass vs. center of pressure
COP measurement

COP using force plates

Center of pressure (COP)

Ground reaction force (GRF)
Force plate measurements

top

y

Z_{off}

bottom

z

---

2

4

3

1

x

y

z
Force plate measurement
Postural sway

Stabilogram: graphical output of postural sway – a measure of stability
COP over time

AP COP (mm)

time (s)
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

<table>
<thead>
<tr>
<th>weeks</th>
<th>0</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>16</th>
<th>20</th>
<th>24</th>
<th>28</th>
<th>32</th>
<th>36</th>
<th>40</th>
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<th>48</th>
<th>52</th>
<th>56</th>
<th>60</th>
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<tbody>
<tr>
<td>pregnancy</td>
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<td>postpartum</td>
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</table>
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.
Postural control system (PCS)

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

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

- **Musculoskeletal System**
  - Muscles

\(^{(1)}\) Central Nervous System
Possible postural control system scenario for upright stance
**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**
Robustness of the postural control system to mild impulsive perturbation

<table>
<thead>
<tr>
<th></th>
<th>Young adults</th>
<th>Middle-aged</th>
<th>Older</th>
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<tbody>
<tr>
<td>n</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Females</td>
<td>5</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Age (y)</td>
<td>22.9 ± 1.0</td>
<td>47.1 ± 1.2</td>
<td>75.6 ± 0.8</td>
</tr>
<tr>
<td>Age Range (y)</td>
<td>20 - 30</td>
<td>42 - 53</td>
<td>71 - 79</td>
</tr>
</tbody>
</table>

Robustness ≡ \( \frac{1}{\text{MaxSens}} \)

where MaxSens is from sensitivity function of the postural control system to a mild impulse force


Sample Nyquist plot

Wed: Gait cycle, walking