What is Balance?  
Balance has been defined as the ability to maintain center of mass (COM) within the base of support (BOS). Balance involves the interaction of multiple systems and is comprised of the following, depicted by the Systems Model of Postural Control:

Factors that influence balance:  
**Sensory Organization**: Somatosensory input (tactile and proprioceptive input), visual input, vestibular input  
**Central Set**: Cerebellar-cortical loop that adapts based on prior experience and basal ganglia-cortical loop that optimizes the response based on current conditions  
**Motor Coordination**: sensory integration, movement strategies, automatic postural responses, feedback/feed forward control  
**Environmental Organization**: type/texture of contact surface and configuration of surroundings  
**Musculoskeletal System**: strength/range of motion, height/weight/body habitus, deficits/impairments  
**Goal/Task Orientation**: nature of the activity
Automatic Postural Responses = Balance Strategies\textsuperscript{5, 6}

Automatic Postural Responses: non-volitional, occur 80-120 milliseconds after instability is perceived and consist of stabilizing muscle activation to maintain balance equilibrium.

There are four types of automatic postural responses, also known as balance strategies: ankle strategy, hip strategy, suspensory strategy and step strategy. The three strategies addressed in research are below:

<table>
<thead>
<tr>
<th>Balance Strategy</th>
<th>Occurs when</th>
<th>Muscles involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankle (Head movements in-phase with hips)</td>
<td>Perturbation is slow and low amplitude. Contact surface is firm.</td>
<td>Paraspinals Hamstrings Gastrocnemius</td>
</tr>
<tr>
<td>Hip (Head movements out-of-phase with hips)</td>
<td>Perturbation is fast or large amplitude. Contact surface is unstable.</td>
<td>Quadriceps Abdominals Paraspinals Hamstrings</td>
</tr>
<tr>
<td>Step (New BOS is created)</td>
<td>Perturbation is fast or large amplitude or when the other strategies fail.</td>
<td>All LE/trunk mm. to take a step and maintain balance.</td>
</tr>
</tbody>
</table>

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ANKLE STRATEGY

![Ankle Strategy Diagram](image)

HIP STRATEGY

![Hip Strategy Diagram](image)
Research

Falls prevention is a prevalent area of focus in physical therapy, not only for older adults but for those with neurological conditions as well. Perturbation-based training is an intervention that focuses on making neuromuscular adaptations to autonomic postural responses to improve fall prevention.

Findings:
- Perturbation based training (PBT) appears to both reduce the likelihood of being a faller and reduce the frequency of falling among people at increased risk of falls.
  - PBT= the training of postural corrective responses/automatic postural responses.
- The overall effect for fall rate after PBT (rate ratio=0.54) was lower than reported in previous meta-analyses of general balance training for falls prevention in older adults (rate ratios=0.65-0.86).
  - General balance training= resistance training/lower extremity strength training, stretching, static sensorimotor training.
- PBT causes multi-segmental and context-specific adaptations, depending upon the characteristics of the trained postural strategy.

Limitations:
- No common or consistent protocol (direction of perturbations, intensity of perturbations, frequency of perturbation, duration of perturbation, method of perturbation, optimal dosing etc.) or terminology in the research.
- Unable to truly blind research participants.
- Limited to no research comparing perturbation methods or attempting to standardize methods.

Perturbation Intervention Techniques:

<table>
<thead>
<tr>
<th>Intervention Technique</th>
<th>Description</th>
<th>Strategy Elicited</th>
<th>Training Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treadmill-based</td>
<td>Done in a partial body weight support system on a moving treadmill. Therapist performs perturbations as patient is walking or change in treadmill speed elicits step strategy.</td>
<td>Step</td>
<td>No optimal dosing has been determined. The range is from a single session of 24 perturbation to several weeks of training consisting of over a thousand perturbations. All dosing options have shown to bring about improvements in reactive balance control and fall prevention.</td>
</tr>
<tr>
<td>Overground walking</td>
<td>Therapist provides external perturbation as patient walks over level ground. Therapist guarding with gait belt.</td>
<td>Step</td>
<td></td>
</tr>
<tr>
<td>Platform based</td>
<td>Moving platforms elicit targeted balance strategy. Performed with partial body weight support system or gait belt.</td>
<td>Step</td>
<td></td>
</tr>
<tr>
<td>External Perturbations</td>
<td>Administered by therapist providing “push/pull” to elicit desired balance strategy. Done with therapist guarding, with or without gait belt.</td>
<td>Ankle, Hip, and Step</td>
<td></td>
</tr>
</tbody>
</table>
**External Perturbation Lab: Implementation in Clinic**

**Script:** “I will be testing/training your balance system. You may feel like you’re going to fall but I will not let you fall.”

If you are testing **ankle/hip strategy:** “Please do not take a step, and do not let me move you.”

If you are testing **stepping strategy:** “You may take one step, but please return as quickly as possible to the starting position.”

**Environment:** level ground, unsteady surface (airex pad, yoga mat, bosu), anterior/posterior/frontal plane wedge (predispose anterior/posterior/frontal plane LOB)

**Balance Strategy Assessment:**

To test **ankle and hip strategy:**
- Start on a level surface sitting in front of the patient on a rolling stool with a plinth behind the patient, cupping their iliac crest with both hands (thumbs on ASIS, fingertips on posterior iliac crest).
- State the script above and slowly increase anterior/posterior/frontal plane perturbations testing if their ankle/hip strategy is:
  - **Sufficient:** able to maintain COM in BOS without excess sway
  - **Insufficient:** unable to maintain COM in BOS resulting in LOB or step
  - **Delayed:** able to maintain COM in BOS with excess sway and additional time
- Note the direction (anterior/posterior/frontal plane right or left) of their deficit.

To test **stepping strategy:**
- Start on a level surface sitting in front of the patient on a rolling stool with a plinth behind the patient, cupping their iliac crest with both hands (thumbs on ASIS, fingertips on posterior iliac crest).
- State the script above and slowly increase anterior/posterior/frontal plane perturbations testing if their stepping strategy is:
  - **Sufficient:** able to establish a new BOS with one step and quickly return starting position
  - **Insufficient:** unable to establish a new BOS resulting in LOB/multiple steps using both feet
  - **Delayed:** able to establish new BOS with 1-2 steps with one foot and return to starting position with additional time
- Note the direction (anterior/posterior/frontal plane right or left) of their deficit.

**Balance Strategy Intervention:**
- Based on balance strategy assessment findings, target delayed or insufficient strategies by either:
  - Focusing on the perturbations (increasing duration and intensity in that direction) that elicit this response on level ground or unsteady surface.
  - Setting up the environment to predispose that type of LOB with a wedge or unsteady surface.
- Can be documented as bouts of time or number of perturbations in a certain direction.


