

Exercise for Impaired Balance

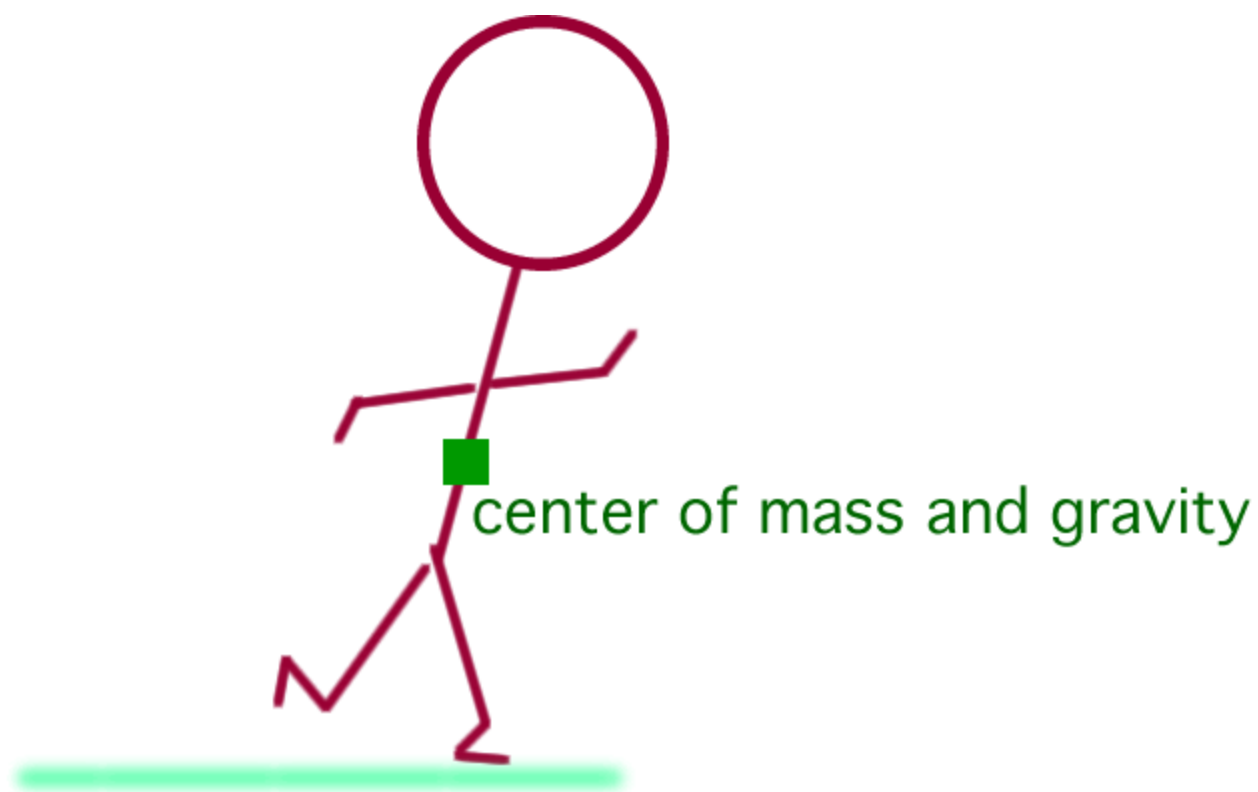
Key Terms and Definitions

Balance

- Balance, or postural stability, is a generic term used to describe the dynamic process by which the **body's position is maintained in equilibrium**.
- Equilibrium means that the body is either at rest (**static equilibrium**) or in steady-state motion (**dynamic equilibrium**).
- Balance is greatest when **the body's center of mass (COM) or center of gravity (COG) is maintained over its base of support (BOS)**.

Center of mass

- The COM is a point that corresponds to the
- **center of the total body mass** and is the point at which the body is in **perfect equilibrium**.
- It is determined by finding the weighted average of the COM of each body segment



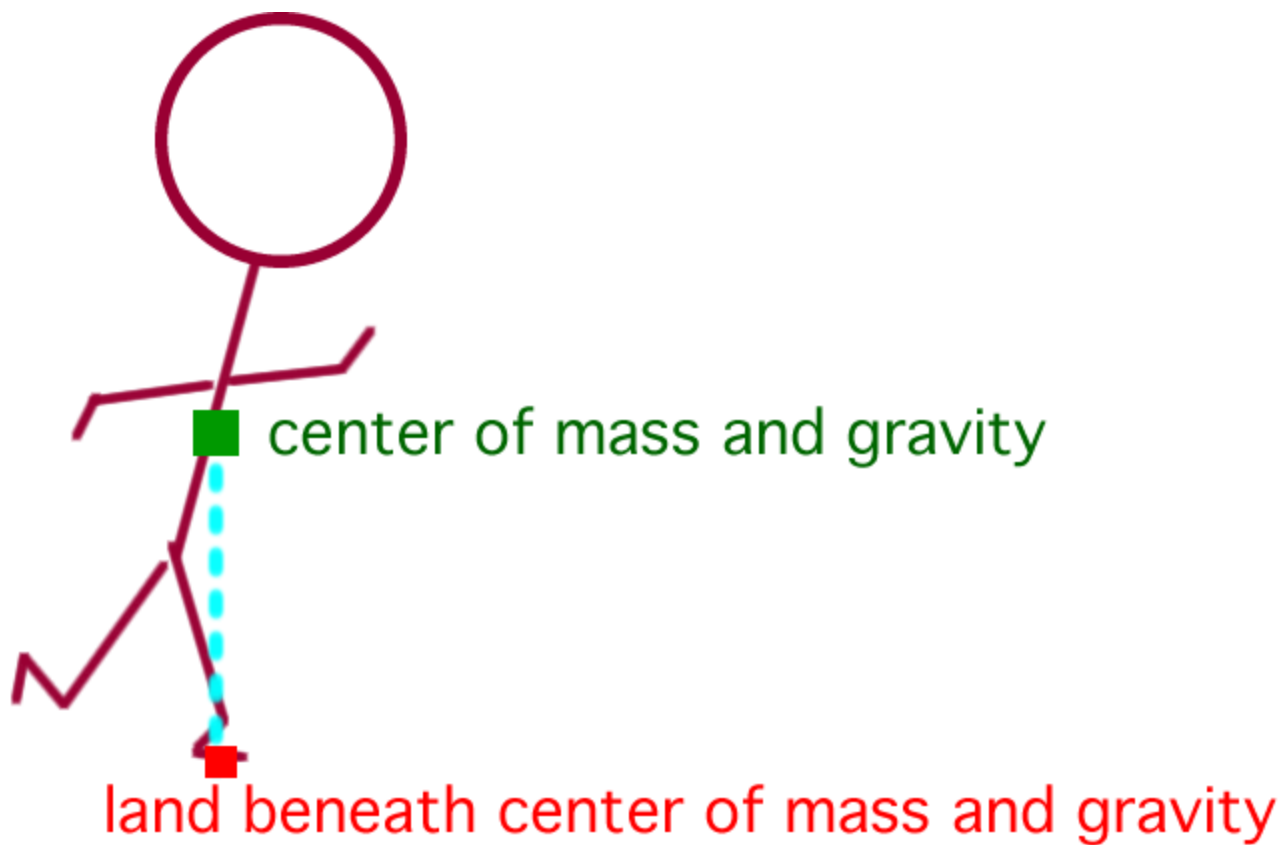
center of mass and gravity

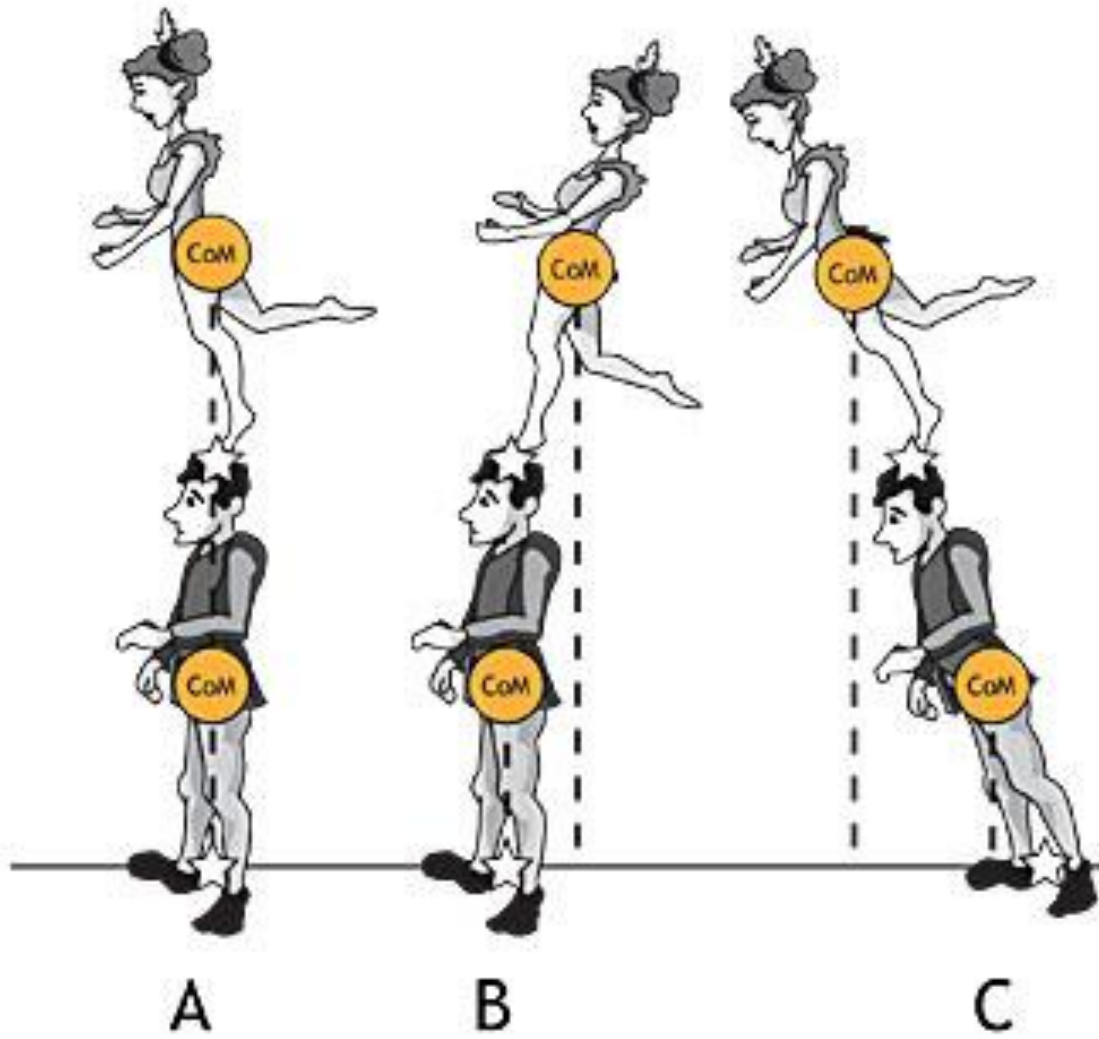
Center of gravity

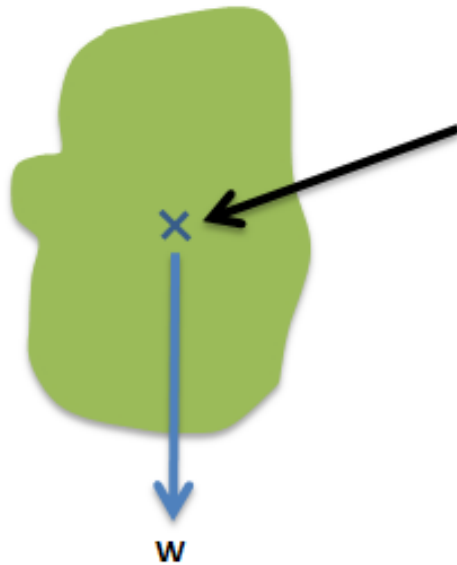
- *The COG refers to the vertical projection of the center of mass to the ground.*
- In the anatomical position, the COG of most adult humans is located slightly anterior to the second sacral vertebra or approximately 55% of a person's height.



Comparison of Factors Affecting Location of Center of Gravity in the Human Body Relative to Load being Carried





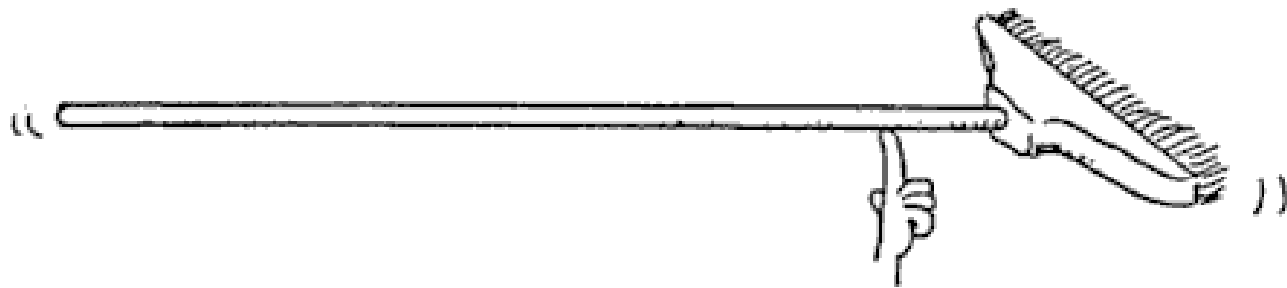


Center of Mass

(This would also be **center of Gravity** since the object is in uniform gravitational field)



balance point
=
centre of mass
=
axis of rotation

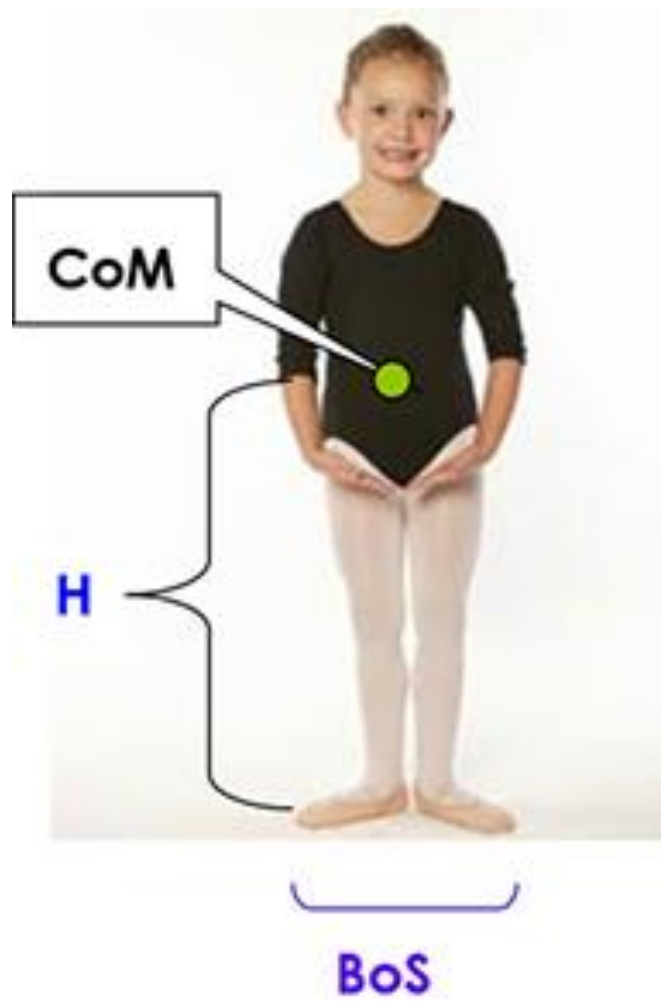


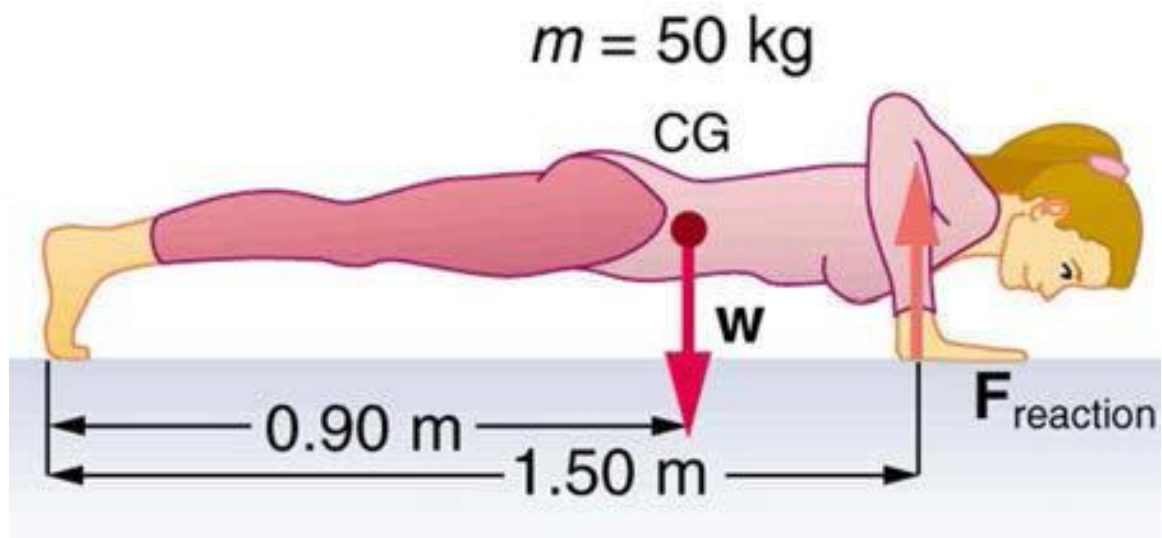


(a)

(b)

(c)





Momentum

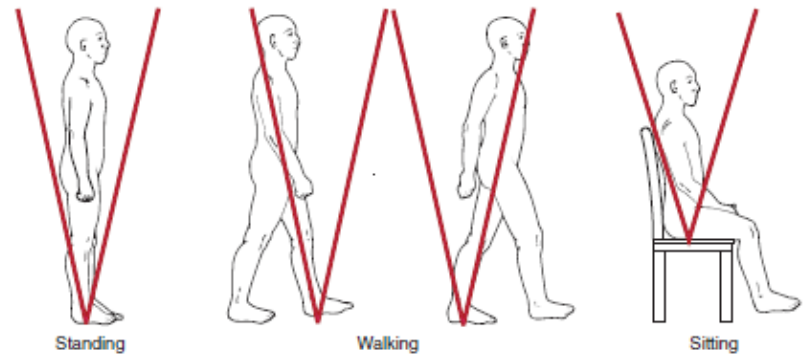
- *Momentum is the product of mass times velocity.*
- Linear momentum relates to the velocity of the body along a straight path, for example, in the sagittal or transverse planes.
- Angular momentum relates to the rotational velocity of the body.

Base of support

- The BOS is defined as the perimeter of the contact area between the body and its support surface; foot placement alters the BOS and changes a person's postural stability.
- A wide stance, such as is seen with many elderly individuals, increases stability, whereas a narrow BOS, such as tandem stance or walking, reduces it.
- So long as a person maintains the COG within the limits of the BOS, referred to as the limits of stability, he or she does not fall.

Limits of stability

- “Limits of stability” refers to the sway boundaries in which an individual can maintain equilibrium without changing his or her BOS
- These boundaries are constantly changing depending on the task, the individual’s biomechanics, and aspects of the environment.

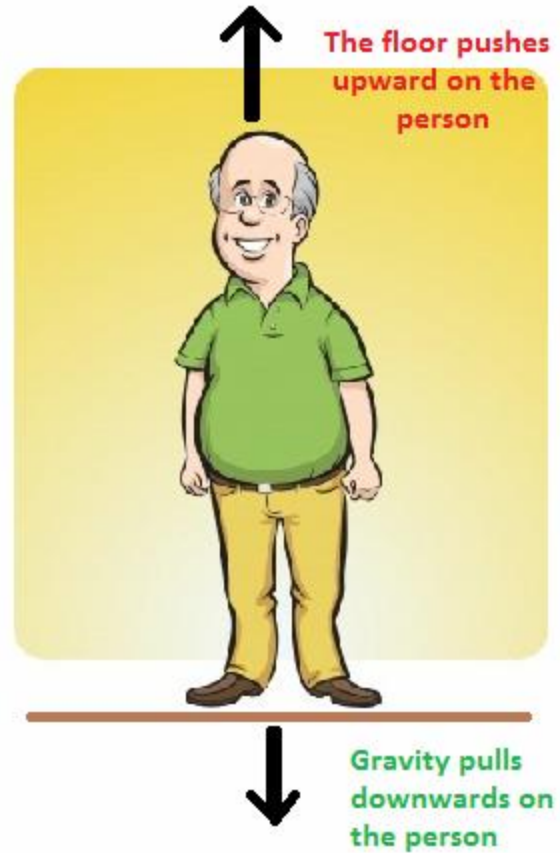


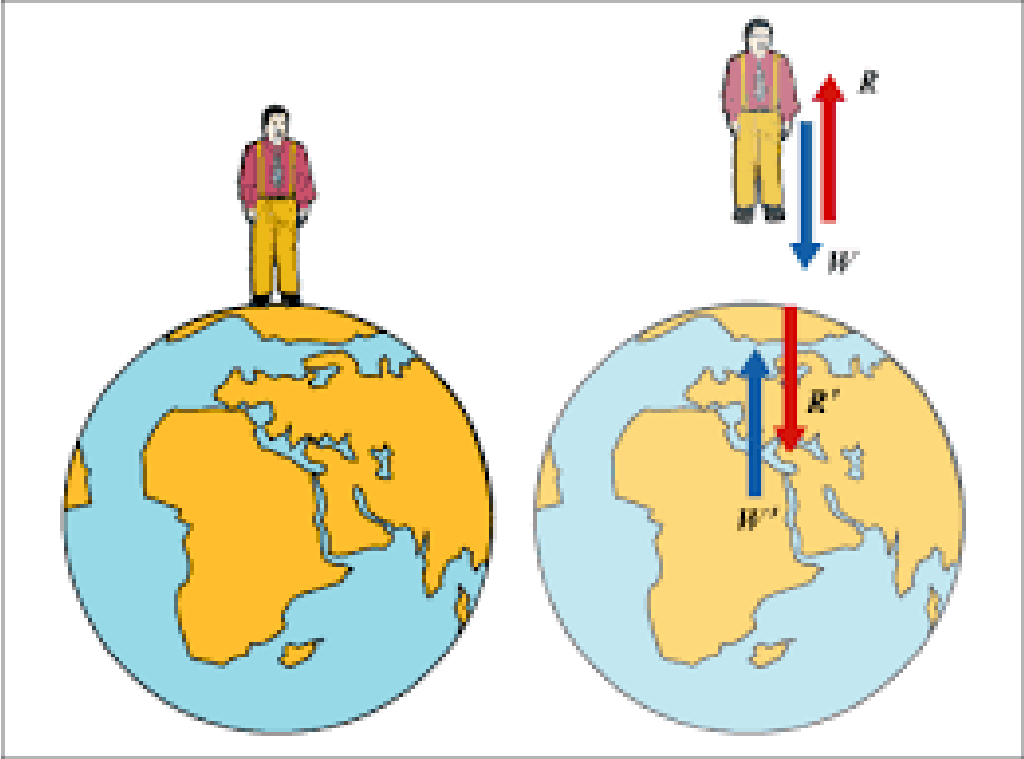
JRE 8.1 Boundaries of the limits of stability while standing, walking, and sitting.

Ground reaction force and center of pressure

- *In accordance* with Newton's law of reaction, the contact between our bodies and the ground due to gravity (action forces) is always accompanied by a reaction from it, the so-called ground reaction force

The forces on the person are balanced



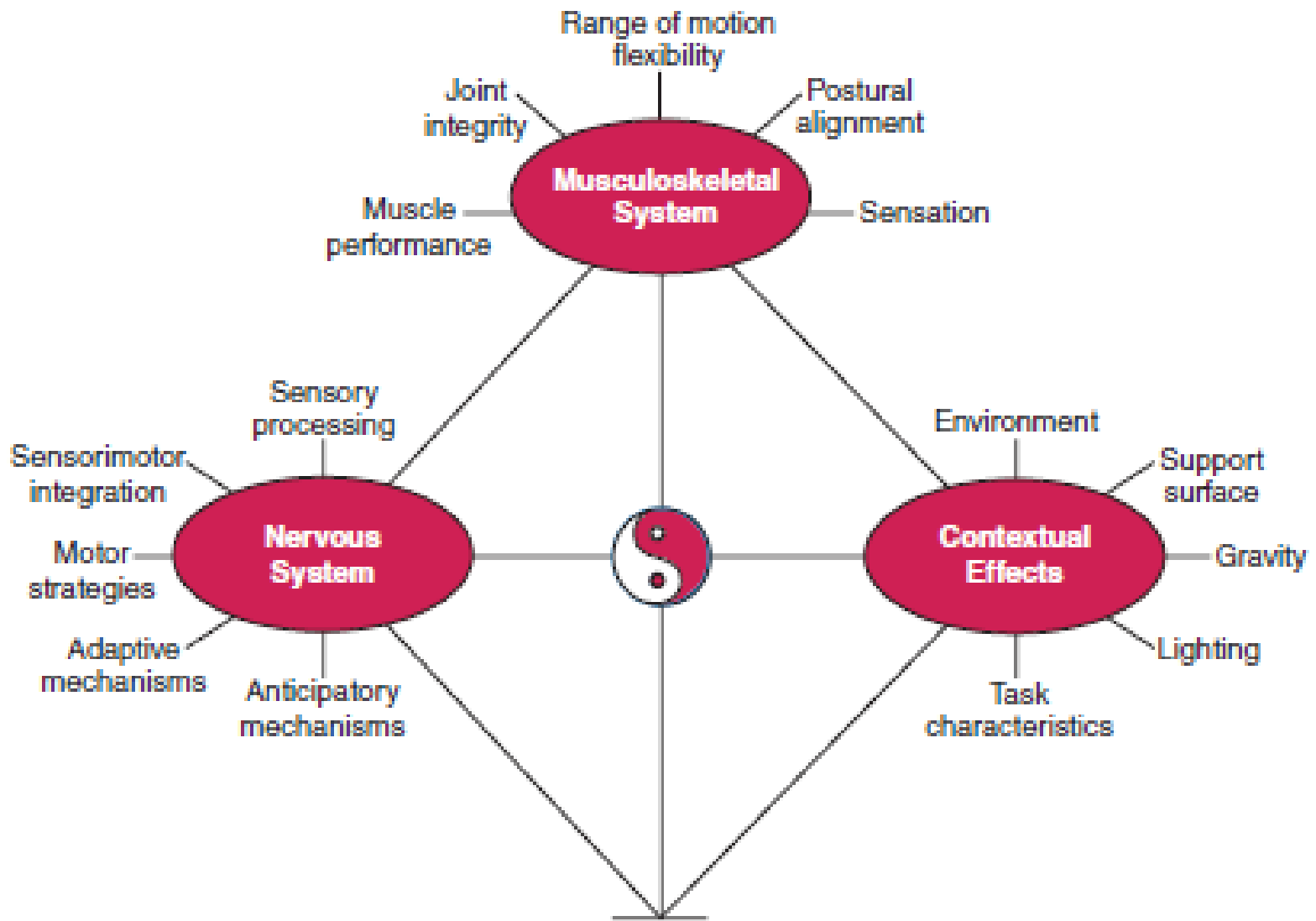


- The center of pressure (COP) is the location of the vertical projection of the ground reaction force.
- It is equal and opposite to the weighted average of all the downward forces acting on the **area in contact with the ground**.
- If one foot is on the ground, the net COP lies within that foot.
- When both feet are on the ground, the net COP lies somewhere
- between the two feet, depending on how much weight is taken by each foot. When both feet are in contact, the COP under each foot can be measured separately.
- To maintain stability, a person produces muscular forces to continually control the position of the COG, which in turn changes the location of the COP. Thus, the COP is a reflection of the body's neuromuscular responses to imbalances of the COG.
- A force plate is traditionally used to measure ground reaction forces (in Newtons [N]) and COP movements
- (in meters [m]).



Balance Control

- Balance is a complex motor control task involving the detection and **integration of sensory information** to assess the position and motion of the body in space and the execution of appropriate **musculoskeletal responses** to control body position within the context of the **environment and task**.
- Thus, balance control requires the interaction of the **nervous and musculoskeletal systems and contextual effects**



Interactions of the musculoskeletal and nervous systems and contextual effects for balance control.

Nervous system

- The *nervous system* provides the **(1) sensory processing** for perception of body orientation in space provided mainly by the visual, vestibular, and somatosensory systems; **(2) sensoriomotor integration** essential for linking sensation to motor responses and for adaptive and anticipatory (i.e., centrally programmed postural adjustments that precede voluntary movements) aspects of postural control; and **(3) motor strategies** for planning, programming, and executing balance responses.

Musculoskeletal system

- **Musculoskeletal contributions** include postural alignment, musculoskeletal flexibility such as joint range of motion (ROM), joint integrity, muscle performance (i.e., muscle strength, power, and endurance), and sensation (touch, pressure, vibration, proprioception, and kinesthesia).

Environmental system

- *Contextual effects that interact with the two systems (sensory and motor) are the **environment** whether it is closed (predictable with no distractions) or open (unpredictable and with distractions), **the support surface** (i.e., firm versus slippery, stable versus unstable, type of shoes), **the amount of lighting**, effects of gravity and inertial forces on the body, and **task** characteristics (i.e., well-learned versus new, predictable versus unpredictable, single versus multiple tasks).*

Motor Strategies for Balance Control

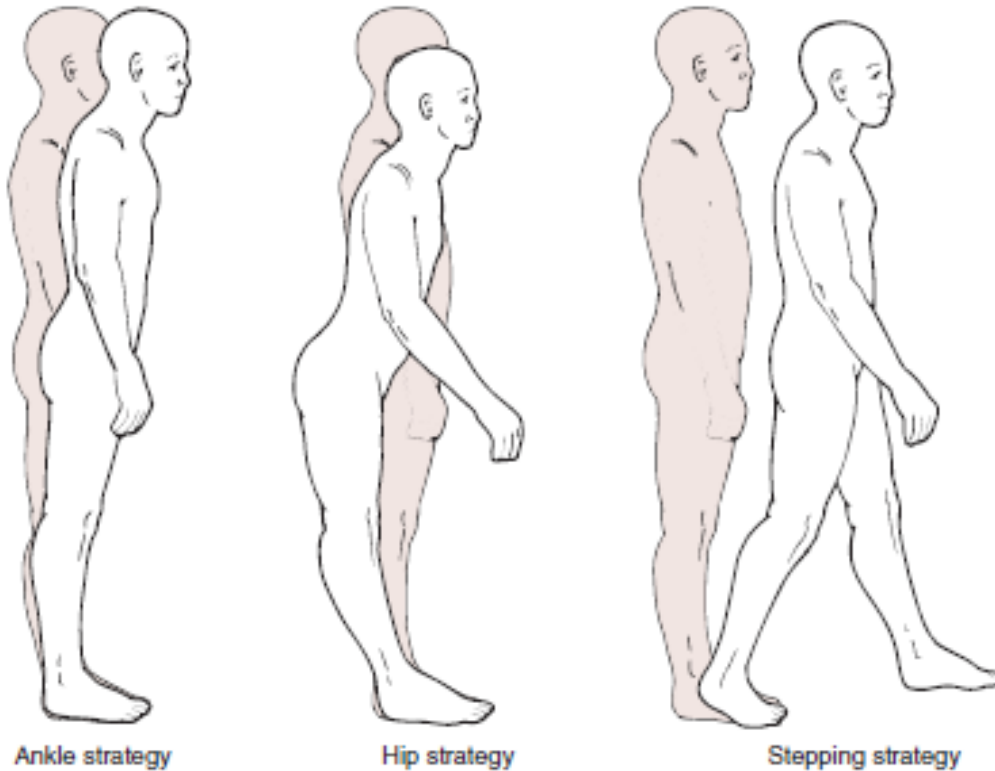


TABLE 8.1 Characteristics of the Three Movement Systems for Balance Control Following Perturbations

Characteristic	Reflex	Automatic	Voluntary
Mediating pathway	Spinal cord	Brain stem/subcortical	Cortical
Mode of activation	External stimulus	External stimulus	External stimulus or self-stimulus
Comparative latency of response	Fastest	Intermediate	Slowest
Response	Localized to point of stimulus and highly stereotyped	Coordinated among leg and trunk muscles; stereotypical but adaptable	Coordinated and highly variable
Role in balance	Muscle force regulation	Resist disturbances	Generate purposeful movements
Factors modifying the response	Musculoskeletal or neurological abnormalities	Musculoskeletal or neurological abnormalities; configuration of support; prior experience	Musculoskeletal or neurological abnormalities; conscious effort; prior experience; task complexity

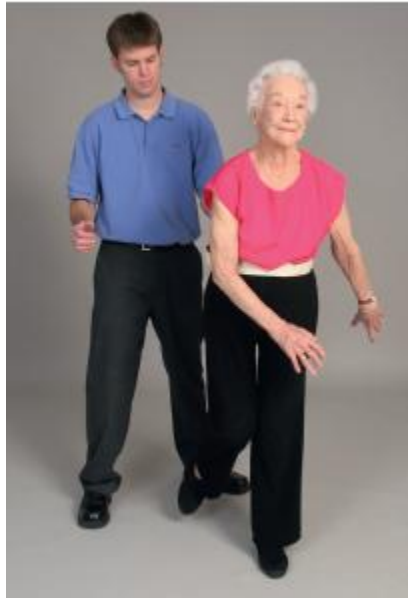
Management of Impaired Balance

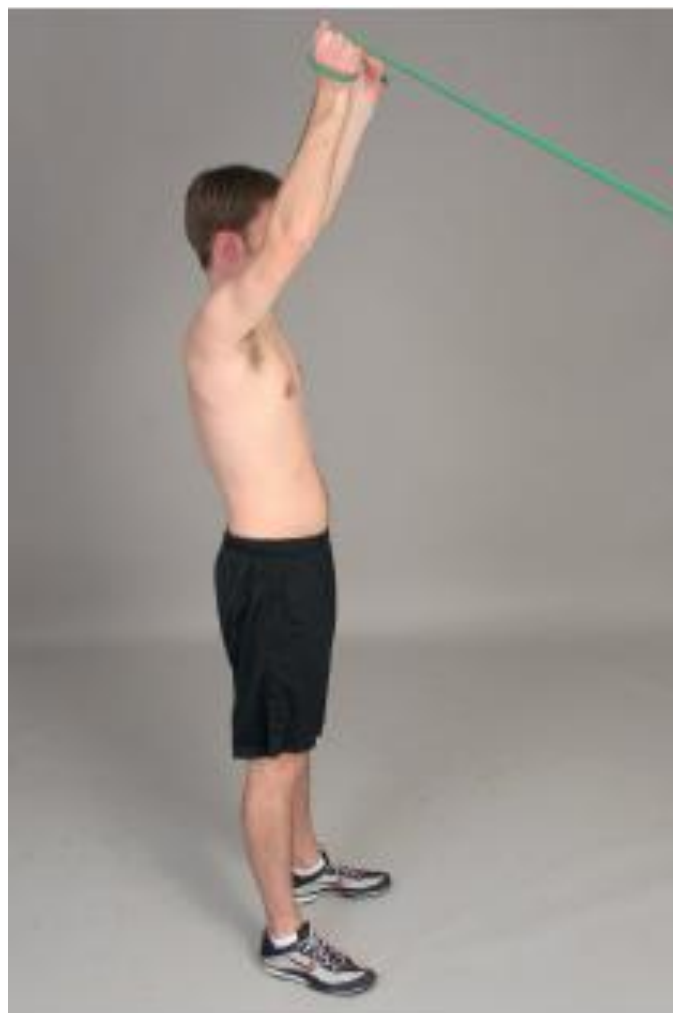
Examination and Evaluation of Impaired Balance

TABLE 8.3 Balance Assessments and Interventions

Category of Assessment	Clinical Tests/Measures	Interventions If Deficits Present
I. Balance*		
Static	Observations of patient maintaining different postures; Romberg Test ¹¹⁰ ; sharpened (tandem) Romberg ¹¹⁰ ; Single-Leg Stance Test ¹⁵⁴ Stork Stand Test ⁷⁴	Vary postures Vary support surface Incorporate external loads
Dynamic	Observations of patient standing or sitting on unstable surface or performing postural transitions and functional activities; Five-times-sit-to-stand Test (5 × STS) ³²	Moving support surfaces Move head, trunk, arms, legs Transitional and locomotor activities
Anticipatory (feedforward)	Observations of patient catching ball, opening doors, lifting objects of different weights; Functional Reach Test ³⁷ ; Multidirectional Reach Test ¹¹¹ ; Star Excursion Balance Test ¹¹⁴	Reaching Catching Kicking Lifting Obstacle course
Reactive (feedback)	Observation of patient's responses to pushes (small or large, slow or rapid, anticipated and unanticipated); Pull Test ¹⁰¹ ; Push and release Test (PRT) ⁷² ; Postural Stress Test ¹⁶⁴	Standing sway Ankle strategy Hip strategy Stepping strategy Perturbations
Sensory organization	Clinical Test of Sensory Integration on Balance Test (CTSIB) also called the "Foam and Dome" Test ¹³⁵	Reduce visual inputs Reduce somatosensory cues
II. Balance during functional activities*	Tinetti Performance-Oriented Mobility Assessment (POMA) ¹⁴⁴ ; Timed Up and Go Test (TUG) ¹¹⁸ ; Berg Balance Scale (BBS) ¹⁰ ; Four Square Step Test (4SST) ³³ ; Dynamic Gait Index (DGI) ¹³⁷ ; Functional Gait Assessment (FGA) ¹⁶⁷ ; Community Balance and Mobility Scale ⁶⁵ ; High Level Mobility Assessment (HiMat) ¹⁶⁰ ; Dizziness Handicap Inventory (DHI) ⁷³	Functional activities Dual or multitask activities (e.g., walking with secondary cognitive or motor task)
III. Safety during gait, locomotion, or balance*	Observations; home assessments; Activities-Specific Balance Confidence (ABC) Scale ¹²⁰ ; Falls Efficacy Scale ¹⁴⁵	Balance within stability limits; environmental modifications; assistive devices; external support

Balance Training



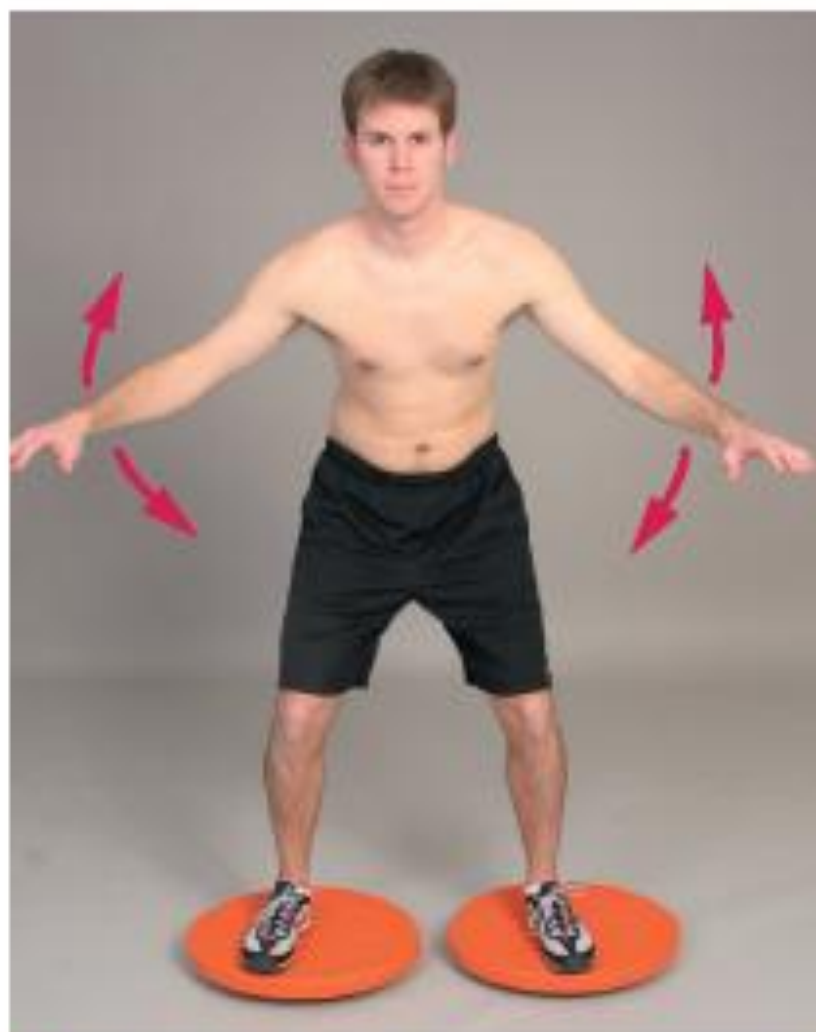




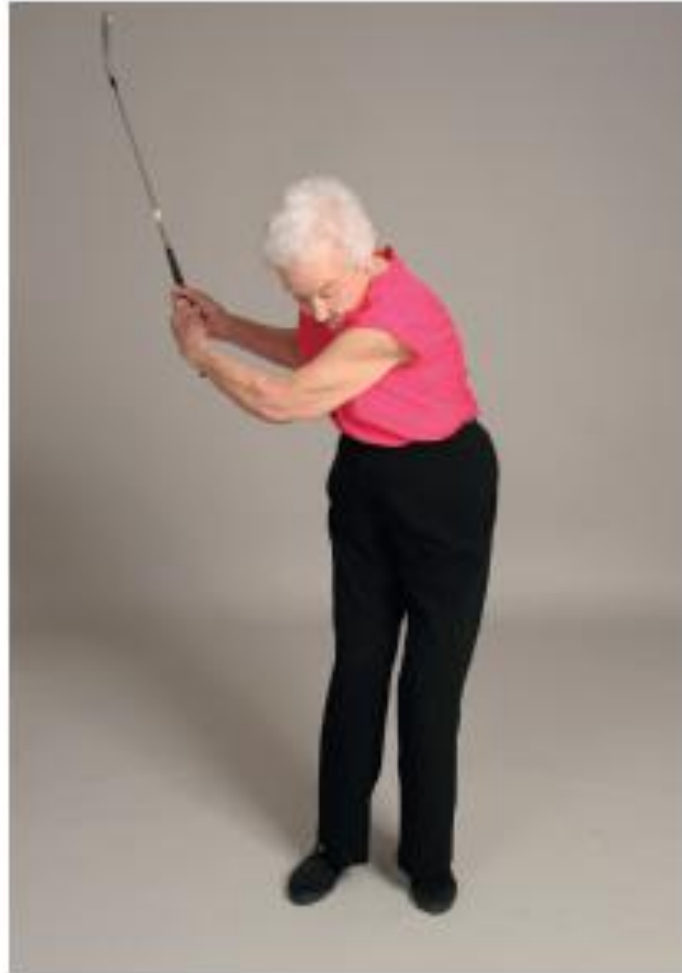
RE 8.13 Balance while standing and catching a ball.



FIGURE 8.14 Balance while standing on wobble boards.



JRE 8.15 Balance while standing on wobble boards with arm movements.



RE 8.19 Functional balance during a golf swing.



E 8.20 Rising up on toes to strengthen plantarflexors.







BOX 8.4 The Otego Home Exercise Program⁴⁴

Lower Extremity Strengthening*

With person sitting in a hard, straight-back chair:

- Perform 5 minutes of active, gentle warm-up exercises to minimize soreness.
- Add appropriate ankle cuff weight and have patient perform unilateral knee extension.
- Repeat for the opposite leg.

With person in standing, use a counter or heavy furniture to support as needed.

- Add appropriate ankle weight and have patient perform unilateral knee flexion. Repeat for the opposite leg.
- Adjust cuff weight if necessary and have patient perform unilateral hip abduction. Repeat for the opposite leg.
- Raise up on toes to strengthen ankle plantarflexors.
- Rock back on heels for ankle dorsiflexors.

*Each exercise is to be done slowly (e.g., 2–3 seconds to lift the weight and 4–6 seconds to lower the weight) and through the full functional range of motion. The goal is to perform each exercise for two sets of 10 repetitions.

Balance Training**

- Knee bends—10 repetitions
- Backward walking—10 steps, 4 times
- Walking and turning around—Make figure of “8,” 2 times
- Sideways walking—10 steps, 4 times
- Tandem stance—10 seconds
- Tandem walk—10 steps, 2 times
- Heel walking—10 steps, 4 times
- Toe walking—10 steps, 4 times
- Sit to stand—5 stands with two hands, 5 stands with one hand or 10 stands with two hands, 10 stands with one hand, 10 stands with no support, 10 stands with no support repeated

**The easiest level for the balance exercises is to use two hands for support. Progression to harder levels (to one hand support and no hands for support) depends on the ability to complete the targeted number of repetitions or amount of time using smooth, controlled movements. To progress to exercises without holding onto support, the instructor must be confident that the person can safely recover balance using lower-body strategies such as stepping.

BOX 8.5 Balance Exercise Program Incorporating St

Week 1

Flexibility exercises (5 repetitions, 15-second hold)

Hamstring stretch

Gluteus maximus and hip flexor stretch

Gastrocnemius and soleus stretch

Paraspinal stretch

Strengthening exercises (baseline determination of preferred elastic-band strengths for lower limb exercises—1 repetition maximum)

Lower limb muscles (elastic band: 1 set of 8–10 repetitions for each leg)

Quadriceps (sitting and straight-leg raises)

Hamstrings

Gluteus maximus

Gluteus medius

Upper limb muscles (5–10 repetitions)

Push-ups

Abdominal muscles (5 repetitions)

Curl-ups with arms behind head

Instruction in body mechanics for:

Standing

Sitting

Lying

Lifting

Reaching

Carrying

Arising from floor

Ascending/descending stairs

Baseline walking evaluation (determine maximum comfortable distance)

Week 2

Week 2

Flexibility exercises (as above)

Strengthening exercises: lower limb muscles (elastic band: 1 set of 10 repetitions, each leg), upper limb muscles (10 repetitions), abdominal muscles (5–10 repetitions)

Postural exercises (10 repetitions, 10-second hold)

Head and neck

Trunk

Coordination exercises

Reciprocal leg movements (10 repetitions, eyes closed)

Bridging (10 repetitions)

Sitting/standing (5 repetitions)

Braiding exercises (2 repetitions)

Reciprocal ankle motion (10 repetitions)

Rung ladder: forward stepping (2 repetitions)

“Survival” maneuvers

Floor recovery exercises—“how to get up if you should fall”

Week 3

Flexibility exercises (5 repetitions, 20-second hold)

Strengthening exercises: lower limb (2 sets of 10 repetitions), upper limb (push-ups, 10–15 repetitions), abdominals (curl-ups, 10–15 repetitions)

Postural exercises (15 repetitions, 10-second hold)

Coordination exercises (repetitions increased)

Survival maneuvers: practice (floor recovery/stairs)

Endurance walking (0–6 minutes, comfortable pace)

Week 4

Flexibility exercises (5 repetitions, 25-second hold)

Strengthening exercises: lower limb (2–3 sets of 10 repetitions), upper limb (push-ups, 15 repetitions), abdominals (curl-ups, 15 repetitions)

Postural exercises (20 repetitions, 10-second hold)

Coordination exercises (repetitions increased)

Reciprocal legs (eyes closed)

Braiding (no holding, eyes open)

Rung ladder (forward, side, and backward stepping)

Survival maneuvers: practice (floor recovery/stairs)

Endurance walking (3–8 minutes, comfortable pace)

... - -

Week 5

Flexibility exercises (5 repetitions, 30-second hold)

Strengthening exercises: lower limb (3 sets of 10 repetitions), upper limb (push-ups, 15–20 repetitions), abdominals (curl-ups, 15–20 repetitions)

Postural exercises (25 repetitions, 10-second hold)

Coordination exercises: as above with increased repetitions, plus:
Braiding (no holding, eyes closed)

Reciprocal ankle dorsi/plantar flexion (25 repetitions)

Survival maneuvers: practice (floor recovery/stairs)

Endurance walking (6–10 minutes, comfortable pace)

Week 6

Flexibility exercises (5 repetitions, 30-second hold)

Strengthening exercises: lower limb (3 sets of 10 repetitions), upper limb (push-ups, 20 repetitions), abdominals (curl-ups, 15–20 repetitions)

Postural exercises (25 repetitions, 10-second hold)

Coordination exercises (as above with increased repetitions)

Endurance walking (8–12 minutes, comfortable pace)

Survival maneuvers: practice (floor recovery/stairs)

Thank you