Objectives

1. Participants will identify aspects of the postural control system.
2. Participants will recognize postural control changes that occur in older adults.
3. Participants will become familiar with novel therapies to improve postural control in older adults.
4. Participants will choose and rationalize which novel therapy would be most useful as an intervention utilizing case scenarios.

The Problem: Falls

• 1 out of 3 people over 65 fall each year
  • Increases to 50% over the age of 80 years

• Falls are the leading cause of both fatal and non-fatal injuries in older adults

• The direct medical costs were $31 billion

CDC
How do people fall?

• Most frequent cause – slips and trips while walking
• Usually involves multiple factors
• Most often occurs in own home

• Li et al., 2006, CDC 2017

What happens when people fall?

• About 1 in 5 (20% or more) sustain moderate to severe injuries that can impair mobility and increase risk of early death
• Those over 75 who fall are 4-5 times more likely than those <75 to be admitted to LTC after a fall
• Over 95% of hip fractures are caused by falls (often falling laterally)

• CDC

Other issues

• Less than half of older adults who fall will talk to their healthcare provider about it (CDC)
• Many who fall, even if uninjured, become afraid of falling.
  • Restricted mobility
  • Fear of falling
    • (Jagten, 2002)
Intrinsic Etiology of Fall or Imbalance and Model for Postural Control

All of these things change with age and/or post CVA (Horak, 2006)

- Vision
- Vestibular
- Somatosensory
- Neuromuscular
- Cognition
- Postural Control
- Dynamic balance
- Fear of falling
- Hearing
- Age

Extrinsic Risk Factors of Falls

- Environment
  - Inside
    - Lighting, decline...
  - Outside
    - Support surface, obstacles, divided attention
- Demands of task
  - Familiarity
  - Distractions
- Footwear
- Time of day
- Devices

Assistive Devices

- Issues with assistive devices
  - 4x greater risk factor of falling.
  - De Mettelinge, 2015
- FIT
- Using regularly
What is “Balance” or Postural Control?

- **Complex interactions between** (Horak & Macpherson, 1996; Horak, 2006):
  - Sensory and motor systems involving perceptions of stimuli
  - Responses to changes in the body’s position in the environment
  - Maintenance of the body’s center of mass within the base of support

  – not merely Falling vs. not falling

**Sensory Systems in Postural Control**

- **Sensory systems**
  - provide input to the CNS to maintain and regain balance within and outside the LOS to prevent falls

- **Most prevalent systems**
  - Somatosensory
  - Visual
  - Vestibular

- **Systems use feed forward and feedback mechanisms to interpret and integrate the body’s position in space in order maintain posture and balance**

---

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Mean Relative Risk Ratio (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucous membrane</td>
<td>4.4 (1.5-10.3)</td>
</tr>
<tr>
<td>History of falls</td>
<td>3.0 (1.7-7.0)</td>
</tr>
<tr>
<td>Gait deficit</td>
<td>2.9 (1.3-5.6)</td>
</tr>
<tr>
<td>Balance deficit</td>
<td>2.7 (1.6-5.4)</td>
</tr>
<tr>
<td>Use of assistive device</td>
<td>2.6 (1.4-4.6)</td>
</tr>
<tr>
<td>Visual deficit</td>
<td>2.5 (1.6-3.5)</td>
</tr>
<tr>
<td>Arthritis</td>
<td>2.4 (1.9-2.9)</td>
</tr>
<tr>
<td>Impaired activities of daily living</td>
<td>2.3 (1.5-3.1)</td>
</tr>
<tr>
<td>Depression</td>
<td>2.2 (1.7-2.9)</td>
</tr>
<tr>
<td>Cognitive impairment</td>
<td>1.8 (1.0-2.8)</td>
</tr>
<tr>
<td>Age 65 or older</td>
<td>1.7 (1.1-2.6)</td>
</tr>
</tbody>
</table>

For patients with no risk factors, fall risk is 8%.
For patients with 4 or more risk factors, fall risk is 78%*
Somatosensory System in Postural Control

- Provide information on the relative orientation and movement of the body in space through (Lundy-Ekman, 2013; O’Sullivan et al., 2013):
  - Muscle and joint and tissue proprioceptors that detect movement
  - Light touch and pressure from body parts in contact with support surfaces
    - Just light touch (from any body part) improves balance (Martinell, 2015)

Visual System in Postural Control

- Perceives body orientation and movements as well as changes in the environment

Vestibular System in Postural Control

- Detects linear and angular movement of the head to stabilize eye movement via the vestibulo-ocular reflex
- Assists in regulation of muscle tone for postural control through the vestibulo-spinal reflex (O’Sullivan et al., 2013)
Vestibular outputs very rapidly influence eye, head, and postural reflexes

- Vestibulo-ocular reflex
  - Eye velocity compensates for head velocity
- Vestibulo-colic
  - Head position maintained despite body movements
- Vestibulospinal
  - Postural changes in response to vestibular signals

Sensory Reweighting

If one system is unavailable or inaccurate

<table>
<thead>
<tr>
<th>Sensory System</th>
<th>Contribution to Balance Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestibular</td>
<td>17%</td>
</tr>
<tr>
<td>Visual</td>
<td>33% 32% 23%</td>
</tr>
<tr>
<td>Proprioception</td>
<td>50% 68% 100%</td>
</tr>
</tbody>
</table>

Sensory Changes with Age

- Multiple physiological changes occur with age to the sensory systems that affect postural control (O’Sullivan et al., 2013)
  - Somatosensory
    - Impairments with age of muscle spindle function, distal sensation (Swash & Fox, 1972), and joint proprioception (Wingert, Welder, & Foo, 2014)
  - Visual
    - Vision declines with age (Lee & Scudds, 2003)
  - Vestibular
    - Decline in vestibular function sensing head position and movement (Herdman, Blatt, Schubert, & Tusa, 2000)
Sensory Reweighting and Impairment

- Even with reweighting each system contributes unique information to postural control (O'Sullivan et al., 2013; Peterka, 2002)
  - An impairment in any one system will likely decrease balance

- Consider Older adults (Horak, 2006; O'Sullivan et al., 2013)
  - Prone to deficits in the sensory systems that control posture
  - Vision often declines with age
  - Chronic diseases such as diabetes may cause decreased sensation in the feet

Posture Decreases
Center of mass, limits of stability

Postural Awareness decreases

- Postural Awareness is impaired in older adults with balance deficits
  - Impaired trunk flexion proprioception (Goldberg, Hernandez, & Alexander, 2005)

- Perception of vertical posture is significantly impaired (Barbieri, Gisot, & Pérennou, 2010)
  - Older adults demonstrate twice the amount of backward shift of vertical posture

- If perception of vertical posture or trunk flexion is already impaired, the ability to maintain balance may be affected.
Motor Aspects of Postural Control

• The CNS takes feedback from the sensory systems and initiates responses to maintain posture that are task and environment specific

• These responses are conscious and unconscious alterations to maintain balance in the context of an activity

• Reactions vary (O’Sullivan et al., 2013)
  • Simple stretch reflexes
  • Specific movement strategies

Postural Strategies

• Constantly used during daily activities in anticipation or reaction to movement
  • Anticipatory postural control or adjustments (APAs) (Lundy-Ekman, 2013)
    • ability to adjust posture prior to a voluntary movement in order to maintain balance
    • body’s response to outside forces acting on the body, including a perturbation, slip, trip, or fall
    • Can further be classified as ankle, hip, and change in support strategies

• To be effective, all these strategies require adequate muscular strength, muscular power, coordination, timing, and amplitude (Horak, 2006; Izquierdo et al., 1999; Maki & McIlroy, 2006)

Reactive Motor strategies

• Ankle strategies
  • Shifting COM forward and back
  • Response to a small disturbance within UGS

• Hip strategy
  • Shifting COM by flexing or extending at hips
  • Response to larger and faster disturbances of COM
  • On when classing an foot length is less than length of feet

• Suspension strategies
  • “I dip, you dip, we dip”

• Change in support strategies
  • Usually termed stepping strategy
  • Movement of lower or upper limbs to make new contact with support surface
  • Movement of lower or upper limbs to make new support surface
  • Can be used in response to foot, change in postural perturbations
  • Lower limbs can be involved in catching self with falls

• During normal balance, combinations of strategies are used
Neuromotor Changes with Age

- Neuromotor function is affected with age through a decline in (Doherty, 2003):
  - Strength
  - Muscle mass
  - Power
  - Reaction time
  - Neuromuscular activation

- Biomechanical Changes

Anticipatory and compensatory postural control changes with age

- APAs and CPAs have both been shown to be impaired among older adults (Kanekar & Aruin, 2014)
  - Increase in postural sway (Era et al., 2006) and muscular latencies with perturbations and sway are also evident with age (Lin & Woollacott, 2002)

- Aging and reactive posture control - older adults exhibit (Kanekar & Aruin, 2014):
  - Increased sway
  - Delayed anticipatory muscle activity
  - Greater compensatory muscle activity

Strategies for strategies?

- Older adults use inappropriate CPAs (Kanekar & Aruin, 2014)
  - When visual and somatosensory inputs are manipulated (Manchester, Woollacott, Zederbauer-Hylton, & Marin, 1989):
    - older adults use hip and stepping strategies for smaller balance perturbations
    - compared to younger adults, who use ankle strategies

Though APAs are delayed and less affective, the ability to activate muscles in anticipation to movement is still preserved
Postural control CAN BE improved in Older Adults

Interventions have successfully improved postural control among older adults

Current Interventions

• Exercise
  • Can improve many of the factors related to limited mobility (strength, power, balance, endurance)  
    (De Vries et al., 2012; Pahor et al., 2014)

• Balance training – at least 50 hours over 6 months
  • (Shubert, 2011; Sherrington, 2011)
Balance Retraining

• Target the neuromuscular systems that control balance through various levels of challenge.
• Begin with controlling the center of gravity (COG) over the base of support (BOS).
• Progress by challenging the regulation of balance and postural stability specifically engaging visual, vestibular, somatosensory and cognitive systems.
• Elicit postural reactions and ankle, hip and step strategies by altering stimuli, surfaces, secondary tasks to mimic functional activities.

APTA, 2007

Gait Training

• Include all the components of gait in addition to:
  • Appropriate and accurately adjusted assistive devices, and
  • Challenge and advance with changes in surfaces/terrain, elevations, time/rhythm, distance, physical load, attention, postural transition (start, stop, direction), and amount of support.

APTA, 2007

Combined Balance and Stepping Training

• Working on dynamic balance and stepping responses through structured practice.
  • Focus on speed of step initiation and appropriate toe clearance and step length.
  • Narrowing base of support
  • Bilateral to tandem to unipodal
  • External challenges to balance
  • Moving upper extremities and bouncing and catching ball
  • Narrowing base of support while responding to challenge
  • Semitandem while catching ball
  • Increase the complexity of ambulatory tasks
  • Changing direction

Nosalim et al, 2006
Other CBST Examples

• Walking backwards
• Changing speed
• Walking with reduced base of support
  • Walking on beam
• Turning
• Bending
• Stepping on and off curbs
• Stepping over obstacles

Nnodim et al, 2006

Otago Exercise Program

• Goals
  • Increase strength, balance, and endurance
  • Produce lifestyle change to integrate strength and balance training at least 2 hours per week
• 8 week program delivered over 52 weeks
  • 4-5 visits with a physical therapist
    • Including monthly phone calls for a year
  • 17 exercises total (strengthening with cuff weights, more traditional balance exercises)
  • Therapist evaluates adult and selects appropriate exercises from the 17
  • Adult completes exercise for 30 mins, 3 times a week
• Walking program prescribed, if participant is strong enough to walk
  • 30 minutes, 3 times a week
• https://www.med.unc.edu/aging/pts/exercise-program

Multisensory integration

• 81% who received tailored home health therapy (specific to deficits but inclusive of multisensory integration) improved the number of mCTSIB conditions they could complete (Whitney, Marchetti, Ellis, & Otis, 2013)
  • Modified clinical Test of Sensory Interaction on Balance (mCTSIB)

• If your patient has peripheral neuropathy
  • Work on visual and vestibular
    • Eyes closed, dark glasses, changing surfaces – to maximize use of visual and vestibular
Vestibular issues

- Older adults with unexplained dizziness benefit from balance rehab AND vestibular rehab
  - Gaze stability exercises
  - Most often VOR x 1 is done
  - Should incorporate head movement and gaze stabilization ex with other balance activities

- Jung et al., 2009; Klatt et al., 2015
Vestibular exercises

- Reference websites
  - Vestibular rehabilitation by physical therapy nation
    - https://www.youtube.com/playlist?list=PLsuA8PP9QZOy8B4ps9BoD5BHPIwU
  - Michigan Medicine
    - https://www.youtube.com/user/UMHealthSystem/search?query=vestibular

Reactive or volitional step training

- Perturbation training
- Step training

Perturbation Training/Reactive Training

- Perturbation training is aimed to increase an individual's anticipatory and compensatory postural reactions
- Perturbation training may improve postural control by translating motor learning to similar tasks (Rue & Oun, 2003)
- The goal is to destabilizes the patient's COM
- Perturbation training improves reactions to postural perturbations in older adults
- Decrease in falls associated with trips
- Programs that have a variety of perturbation modalities may result in a greater reduction of falls compared to programs with single perturbation modalities (Mansfield et al, 2010)
Multi-target stepping program/volitional step training – compared to walking decreased falls and injuries
Yamada, 2013

Reactive or volitional step training
Okubo, 2016

• Meta-analysis
• Improve balance recovery, reaction time, balance and gait but not strength.
• Some studies showed improved cognitive measures
  • Especially when conducted with distractors and choice stepping
• Reduce rate of falls by 52%
• Reduce proportion of fallers by 49%

Reactive or volitional step training
Okubo, 2016

• Greater fall reduction effect of step training compared to general training due to task specificity
• During trips, slips and lateral falling, quick stepping in forward, backward and sideways directions are required.
  • The repetitive task-relevant exercises may generate stored motor programmes that can be accessed when anticipatory or reactive postural threats are detected.
• In contrast, significantly increased lower extremity muscle strength resulting from 16 weeks of resistance training has been shown to not transfer to better responses to laboratory-induced trips, suggesting specificity of necessary functional muscle coordination
Reactive or volitional step training
Okubo, 2016

• Suggestions from meta analysis:
  • Step training should be a major component of exercise fall prevention interventions.
  • This training could be either volitional or reactive but should be performed in an upright position and undertaken in response to environmental challenges which mimic common fall situations such as stepping onto a target, avoiding an obstacle or responding to a perturbation.
  • Reactive step training which requires a perturbation module and full body harness is not readily available BUT volitional step training can be applied to various settings including community exercise classes or an individual’s home.

Task Specific Training

• Single task training involves functional tasks such as standing, walking, and transfer
  • Practice what you want them to improve at in varying environments
    • Example - Different height chairs with different dimensions and cushions...

• Practicing the actual motor skill of avoiding a fall following loss of balance
  • Has show to decrease fall risk in frail older adults and Parkinson patients

Types of Dual Task Training

• Body stability plus manipulation
  • Standing on a compliant surface holding a glass of water
  • Tandem standing with rapid alternating hand movement
  • Standing and reaching in all directions
  • Throwing and catching a ball while standing

• Body transport plus manipulation
  • Walking, walking backward, walking sideways, walking under dim light
    • Doing these while holding a mug or basket
    • Doing these while tossing a ball
    • Counting while walking
  • Cognitive

Silsupadol et al, 2006 and Grabiner et al, 2012
Power or High Velocity Training

- Muscle power and contraction velocity have been shown to have greater influence on functional performance, especially low intensity tasks
- Lower muscle power is an indicator for greater fall risk and balance problems
- When threats to balance occur, a rapid muscle response must happen to maintain postural stability
- Note – “Power” training tends to be high(er) load and high velocity on concentric
- High velocity training is high velocity on concentric but DOES NOT have to be high load

Orr et al, 2006

High velocity/speed training and older adults

- Power/mm weakness r/t to balance (systematic review, Orr, 2010)
  - *Subjects in review did not have known pathologies
- “Power” training
  - Generally demonstrates improved power and function compared to traditional resistance training
    - At 40-70% 1 RM (Marques, 2013)
  - Inconsistent evidence of power training improving balance in general (systematic review, Orr, 2008)
  - Suggestion – do not use as sole intervention

High velocity training

- Older adults 20 weeks high velocity unweighted vs high velocity weighted
  - Same exercises on Kaiser machines
  - 2x/wk
- Results:
  - Unloaded high-velocity training increased functional fitness and power the same as loaded training.
    - Consider when time/space is limiting factor.

Gray, Binns, 2005
Yoga

- Youkhana (2016)
- Systematic review and meta-analysis showed yoga was beneficial to improve balance and mobility in older adults

Tai Chi

- Has been shown to improve balance and decrease falls in older adults (multiple articles and CDC)
  - May not be appropriate for frail older adults
  - Low, 2008; Stevens et al., 2010;

- Improves telomere activity (Duan 2016)

Community-based Dance improves Function and balance

- Argentine Tango
  - 2 hr/wk x 10 wks
  - Improvements in walking speed and sit to stands greater than or equal to a walking group
  - McKinley et al., 2008

- Salsa
  - 2x/wk x 8 wks for 1 hr each
  - Improved parameters of gait, but not leg power
  - 93% adherence to program
  - Granacher, 2012

- Even one time a week of dance can benefit balance
  - Bough et al., 2013
Assistive Devices and Falls

- 262 older adults who used canes and walkers were surveyed (Luz, 2015)
  - 68% had never had a home safety eval
  - 50% were never properly trained on how to use an AD

- 75% who fell WHERE NOT USING THEIR ASSISTIVE DEVICE AT THE TIME!
  - This resulted in a higher proportion of injury and need for surgery compared to those who fell using their ADs
  - Reasons given for non-use
    - Forgot
    - AD made them feel old
    - Not easily accessible
    - Low perceived risk of fall or injury without device
  - EDUCATE your patients.

Effects of footwear on balance

- So why not have patient come with their usual different footwear? Including dress shoes and slippers?
- Make sure they can do functional tasks in all of their usual footwear before d/c

Falls and Environment

- Environmental factors contribute up to 41% of risk factors associated with falls among the elderly
  - The residential environment poses the highest risk; such as,
    - Inadequate lighting
    - Slippery floors
    - Absence of handles in bathroom or tub
  - Assessing the residential environment is important when trying to reduce fall risk

- *Feasibility?
  Yoo et al, 2015
Check for safety booklet, free from CDC

Balance-based torso-weighting
BalanceWear

• Balancewear therapy (BWT) is a non-exercise intervention designed to improve postural control that results in same-day improvements in balance and mobility among people with multiple sclerosis (Gorgas et al., 2015; Hunt et al., 2014; Widener, et al, 2009a; 2009b).

Developed by Cindy Gibson-Horn, PT
MotionTherapeutics, Inc.

What is the basis of Balancewear????

• The function of the trunk musculature is important for maintenance of posture, mobility, and recovery from loss of balance (Horak, 1989, 1996, 2006)

• The goal of BW: to improve anticipatory and compensatory postural adjustments (APAs and CPAs) to trunk perturbations by strategic torso weighting
  • Thereby improving balance and mobility.
  • Weighting is individualised at <2.5% of body weight
Balance Based Torso Weighting

- After 5 days of balance wear, older adults improved in SPPB score
  - Vincenzo et al., 2016

- Publications pending
  - Improvement in fall risk measured by TUG, gait speed ... over 4 months
  - Improvement in adults who wore balancewear 4 hours daily vs. not and regularly exercised

Motor Imagery

- Ability to imagine future events and estimate consequences
- With aging, ability to represent intentions and successfully plan actions declines
- Compared to younger adults (mean age of 22) older adults (66 years) were not able to accurately estimate their reach vs their actual functional reach
  - Older adults tend to overestimate

Gabbard and Fox 2013

Motor Imagery Practice

- Clear and effective script of instructions
  - Early practice stages
  - Watch and feel your hand and fingers reaching and grasping the mug. How will you grasp the mug and how fast will you move as not to spill its contents?
  - Goal setting
  - First person internalizing
    - Ask participant to consider the consequences if they miss-plan. Where would they fall?
  - Concentrate on the effector
    - Arm/hand when reaching for object

Gabbard and Fox 2013
Motor Imagery Practice Cont.

- Focus on visual cues
  - Focus on the endpoint
- Reinforcement on kinesthetically feeling execution of movement
  - Feeling self perform the action
- Combine physiotherapy with mental practice
  - Practicing actual movements, subjects gain understanding of their capabilities and develop movement endurance
- Mental practice combined with actual physical practice is shown to be better
- Progress from simple to more complex actions

- Practice 15-60 minutes, 3 times a week for 4 weeks

Gabbard and Fox 2013

Motor Imagery Benefits

- Improved strength
- Improved speed in arm pointing capacity
- Increased range of motion of the hip joint
- Improved postural control

- Things to consider
  - Challenging or unfamiliar actions are more difficult to imagine than familiar ones
  - Improvements from motor imagery practice may be higher when imagery is used at the initial or cognitive phase of motor skill acquisition.

Dickstein and Deutsch, 2007

The Balance Evaluation Systems Test (BESTest)

Differentiate Balance Deficits Fay Horsk, Diane Whitley, James Frank, Physical Therapy 88(5), 2009

www.BESTest.us | (Horsk, Whitley et al. 2009)
The Mini-BESTest showed the highest AUC (0.84) compared with the BESTest (0.74), BBS (0.69), and TUG (0.35), suggesting that the Mini-BESTest had the highest accuracy in identifying older adults with a history of falls. At the cutoff score of 16 (out of 28), the Mini-BESTest demonstrated a posttest accuracy of 85% with a sensitivity of 85% and specificity of 75%. The Mini-BESTest had the highest posttest accuracy, with the others having results of 76% (BESTest), 60% (BBS), and 65% (TUG).

Yingyongyouda, 2016

Treatment Suggestions

- Impairment
  - Somatosensory
  - Vestibular
  - Visual

- Decreased anticipatory postural control
Treatment Suggestions

- Impairment
  - Decreased reactive control

Treatment Suggestions

- Decreased power
  - 5/5 strength

Treatment Suggestions

- Impairment
  - Fear of falling
Treatment Suggestions

- Impairment
  - Stops walking when talking
  - Worse function while performing two tasks at the same time

### Table 1: Exercise sitting, standing, and walking at basic, moderate, and advanced levels in the balance training program.

<table>
<thead>
<tr>
<th>Basic</th>
<th>Moderate</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting</td>
<td>Sitting in a circle and passing</td>
<td>Walking in a circle and throwing a ball, placing feet on table, placing feet on waist of a different person</td>
</tr>
<tr>
<td>Sitting in a circle and passing</td>
<td>Walking in a circle and passing a ball, placing feet on table, placing feet on waist of a different person</td>
<td></td>
</tr>
<tr>
<td>Sitting in a circle, stopping</td>
<td>Walking in a circle and passing a ball, placing feet on table, placing feet on waist of a different person</td>
<td></td>
</tr>
<tr>
<td>Sitting in a circle, throwing</td>
<td>Walking in a circle and passing a ball, placing feet on table, placing feet on waist of a different person</td>
<td></td>
</tr>
<tr>
<td>Sitting in a circle, stopping</td>
<td>Walking in a circle and passing a ball, placing feet on table, placing feet on waist of a different person</td>
<td></td>
</tr>
<tr>
<td>Sitting in a circle, throwing</td>
<td>Walking in a circle and passing a ball, placing feet on table, placing feet on waist of a different person</td>
<td></td>
</tr>
</tbody>
</table>

*Exercises available for participants with consequences.*

### Table 2: Exercise starting in floor, moderate, and advanced levels in the balance training program.

<table>
<thead>
<tr>
<th>Floor</th>
<th>Moderate</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting on a chair, sitting on floor</td>
<td>Walking on a balance board, placing feet on waist of a different person, adding mental or cognitive task</td>
<td>Walking on a balance board, placing feet on waist of a different person, adding mental or cognitive task</td>
</tr>
<tr>
<td>Sitting on a chair, sitting on floor</td>
<td>Walking on a balance board, placing feet on waist of a different person, adding mental or cognitive task</td>
<td>Walking on a balance board, placing feet on waist of a different person, adding mental or cognitive task</td>
</tr>
<tr>
<td>Sitting on a chair, sitting on floor</td>
<td>Walking on a balance board, placing feet on waist of a different person, adding mental or cognitive task</td>
<td>Walking on a balance board, placing feet on waist of a different person, adding mental or cognitive task</td>
</tr>
</tbody>
</table>

*Exercises available for participants with consequences.*
Table 3. Exercises walking at basic, moderate, and advanced levels in the balance training program.

<table>
<thead>
<tr>
<th>Level</th>
<th>Basic</th>
<th>Moderate</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise</td>
<td>Walking on flat surface</td>
<td>Walking on balance board</td>
<td>Walking on balance board</td>
</tr>
<tr>
<td></td>
<td>Moving around on balance board</td>
<td>Maintaining balance on balance board</td>
<td>Maintaining balance on balance board</td>
</tr>
<tr>
<td></td>
<td>Walking forward at a fast speed</td>
<td>Walking forward at a slow speed</td>
<td>Walking forward at a normal speed</td>
</tr>
<tr>
<td></td>
<td>Turning on flat surface</td>
<td>Turning on balance board</td>
<td>Turning on balance board</td>
</tr>
<tr>
<td></td>
<td>Walking on flat surface reversing</td>
<td>Walking on balance board reversing</td>
<td>Walking on balance board reversing</td>
</tr>
<tr>
<td></td>
<td>Walking on balance board reversing</td>
<td>Walking on balance board reversing</td>
<td>Walking on balance board reversing</td>
</tr>
<tr>
<td></td>
<td>Walking on flat surface reversing</td>
<td>Walking on balance board reversing</td>
<td>Walking on balance board reversing</td>
</tr>
<tr>
<td></td>
<td>Walking on balance board reversing</td>
<td>Walking on balance board reversing</td>
<td>Walking on balance board reversing</td>
</tr>
<tr>
<td></td>
<td>Walking on flat surface reversing</td>
<td>Walking on balance board reversing</td>
<td>Walking on balance board reversing</td>
</tr>
<tr>
<td></td>
<td>Walking on balance board reversing</td>
<td>Walking on balance board reversing</td>
<td>Walking on balance board reversing</td>
</tr>
</tbody>
</table>

Table 4. Examples of added motor and cognitive tasks (dual- and multi-task activities) included in the training program.

- Motor tasks:
  - Moving arm, leg, head, or trunk (heaving, turning)
  - Bouncing and alternating clothing
  - Juggling a balloon
  - Throwing and catching a ball
  - Carrying a glass of water, a tray with several glasses of water, or a large ball
  - Rolling a Ping-Pong ball on a tray
  - Closing eyes

- Cognitive tasks:
  - Counting or subtracting by three or seven from a given start number
  - Reading a newspaper, identity or aloud
  - Naming categories of flowers, animals, countries, cities, names, etc.
Vestibular and balance rehab

Klatt, 2015

<table>
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<th>Table 8:</th>
<th>Gait Progression</th>
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<td>Exercise</td>
<td>Slow</td>
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<tr>
<td>Franks, C. D.</td>
<td>No Head Movement</td>
</tr>
<tr>
<td>Franks, C. D.</td>
<td>10° head Movement</td>
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<tr>
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<td>No Head Movement</td>
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<td>10° head Movement</td>
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There are more in the article!

Vestibular and balance rehab, VOR Progression,
Klatt, 2015

<table>
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<th>Table 9: Vestibular-Ocular Reflex Progression</th>
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<td>Initial</td>
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References

References Continued