

What's new in prescribing balance intervention programs

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Objectives

- Understand the current evidence re: control of balance and posture, fall avoidance, assessment of balance, and emerging paradigms for prescription of balance training programs.
- Understand the assessment of patient/client impairments related to their specific balance related goals.
- Describe the factors to be used in choosing and tailoring an intervention program to best meet a patient/clients' balance related goals.
- Recognize and discuss how to measure and set the intensity, frequency and time components of a balance training prescription for an individual.

Fall injuries: 2015 costs for falls (Medicare) over \$31 billion

As U.S. population ages, number and costs of falls are likely to rise.

Millions of people 65 and older treated in ED's because of falls each year

800,000+ per year hospitalized because of a fall injury, most often a broken hip or head injury

Fall injuries are among the 20 most expensive medical conditions

Average hospital cost for a fall injury is over \$30,000

Costs of treating fall injuries goes up with age

Direct costs do not account for the long-term effects of these injuries such as disability, dependence on others, lost time from work and household duties, and reduced quality of life.



<https://www.cdc.gov/niosh/docs/2011-123/pdfs/2011-123.pdf>

“Up to 73% of individuals with stroke fall following their return to community living after discharge from rehabilitation.” (Weerdesteyn, et al. 2008)

“In the LEAPS study, 36% of participants had multiple falls with injury, 10% had a serious fall-related injury. 55.4% of all falls occurred in the first 3 months, at home.” (Tilson, et al. 2012)

50% - 70% of people with Parkinson’s Disease report more than 1 fall in a year.

**46% of people with PD reported falls in prior 3 months.
Of those with no prior fall, 21% reported falls.**

<http://ptnow.org/clinical-summaries-detail/parkinson-disease-pd#ViewComplete>

Focus on falls



Fall prevention Awareness day – September 22 (first day of Fall)

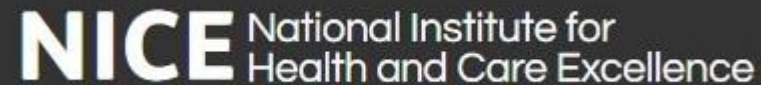
- <https://www.ncoa.org/healthy-aging/falls-prevention/falls-prevention-awareness-day/>

CDC – STEADI: Initiative for health care providers

- <http://www.cdc.gov/steady/index.html>



NICE (UK) <https://www.nice.org.uk/>



APTA -

- <http://www.ptnow.org/clinical-summaries-detail/fall-risk-in-communitydwelling-elders>
- <http://www.apta.org/BalanceFalls/>



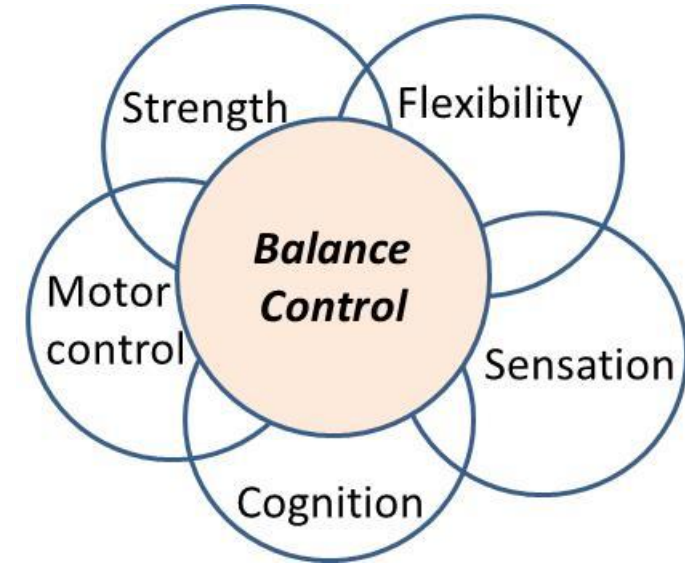
Control of posture. Balance. Fall resistance

Internal Variables:

- Sensory reception: somatosensory, visual, and vestibular
- Sensory processing: assign and weight meaning of environmentally available information
- Central Motor Planning/Control – choose and plan movements, including postural/balance components; pre-plan vs. response
- Peripheral motor execution (ROM, strength/power, endurance, cardio-vascular/respiratory)
- Others: executive function, attention, cognition, judgment

External Variables:

- Task demands *and* environmental context
- Support surface
- Visual conditions (optical flow/complexity, lighting)
- Distractions: navigation, obstacles, cognitive demands, divided attention



Factors to consider especially or differently for people with neurological diagnoses

Common impairments of neuromuscular conditions:

- Inadequate muscle activation
- Altered sensory reception and/or processing
- Altered sequencing/timing of muscle recruitment
- Altered cognition and/or executive function
- Altered available ROM
- Fatigue
- Pain

Other systems may also be affected

- Cardiovascular – CVA, inactivity,
- Respiratory - posture, inactivity
- Diabetes related sensory loss
- Autonomic NS involvement - orthostasis, pain

Common balance/posture specific issues:

- Reduced limits of stability
- Delayed/absent anticipatory postural adjustments
- Delayed/absent postural responses
- Posture/alignment

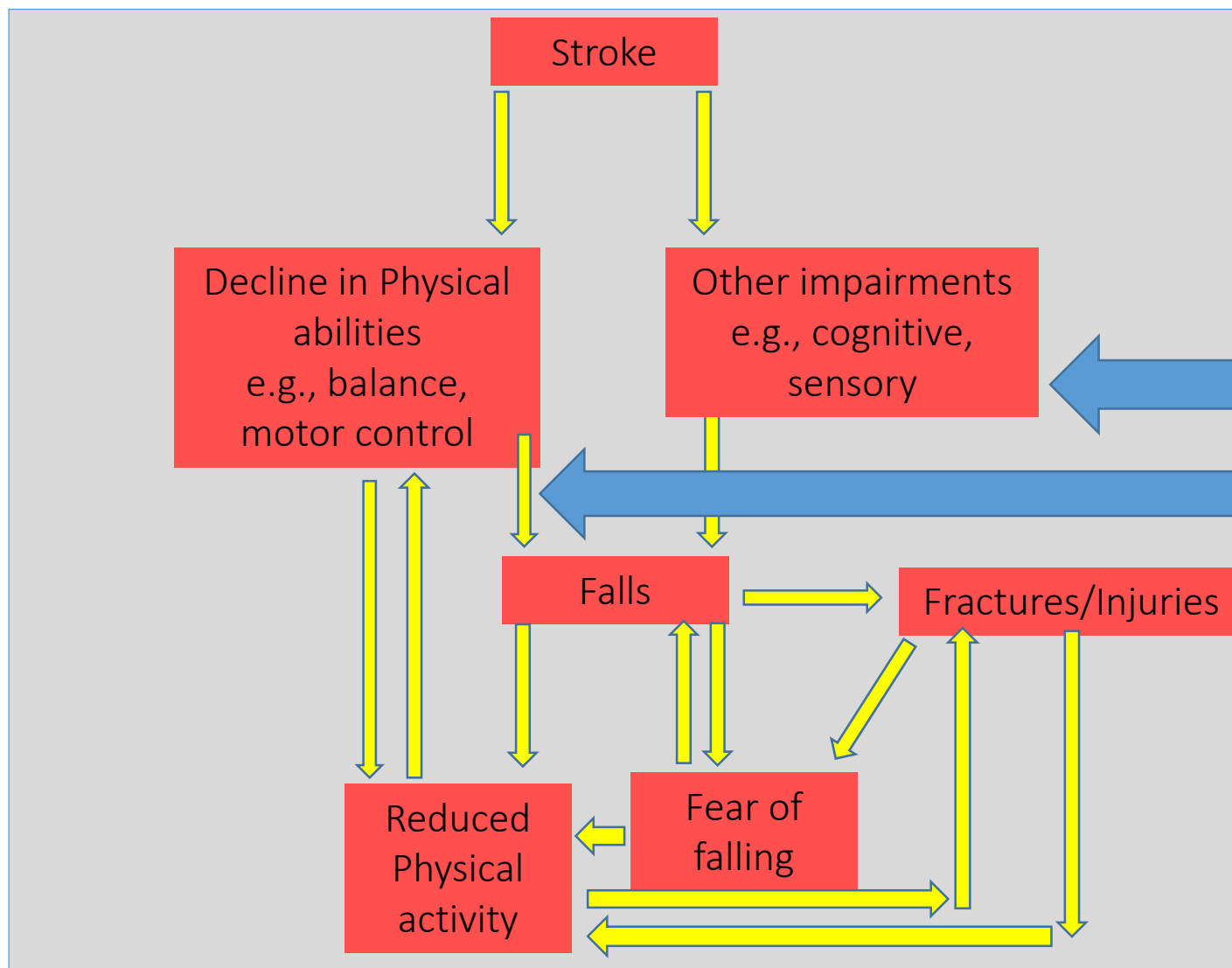
Factors to Consider:

- Heterogeneity within and among conditions
→ tailor approach
- Disease progression: Degenerative vs. “Static” vs. Improving
- Examination or treatment during a window of greater or lesser expected motor/functional recovery
- Impact/timing of medications
- Expected course of disease?

Interactions among risk factors, falls and consequence of falls for people who have had a stroke

Very similar for those with Multiple Sclerosis, ALS, Parkinson's Disease, dementia/mild cognitive impairment, other neurological diagnoses.

Details vary in these



Types of falls – one classification scheme

incorrect transfer or shift of bodyweight

“seemingly self-induced shifting of bodyweight causing the centre of gravity to move outside the base of support.... leaning too far from the base of support during walking or standing; failure to establish a stable final position during transferring or gait termination; excessive trunk sway; an improperly placed step during walking.”

trip or stumble

hit or bump

loss of support with external object

slip

could not tell

collapse or loss of consciousness

[Robinovitch et al., 2013]



internal perturbation

external perturbation

Types and causes of environmental falls

Perturbations may be:

- external to the person and unexpected → require reactive control
- created internally by the person's own movements → allows proactive control [Patla et al., 1993]

Walking most common activity associated with falls [Talbot et al., 2005; Robinovitch et al., 2013]

Interaction of environmental hazards and individual susceptibility, based on subject-specific gait characteristics [Connell & Wolf, 1997; Rubenstein, 2006]

Anxiety level, preferred walking pace and depression have been shown to be good predictors of the extent of fear of falling in community-dwelling older adults [Tinetti et al., 1990]

Vicious cycle → de-conditioning & mobility restrictions

Gait changes to ensure safety – not age-related decline

Development of improved interventions

“There may also be a non-linear pattern between mobility and falls associated with hazards. Household environmental hazards may pose the greatest risk for older people with fair balance, whereas those with poor balance are less exposed to hazards and those with good mobility are more able to withstand them. Reducing hazards in the home appears not to be an effective falls-prevention strategy in the general older population and those at low risk of falls. Home hazard reduction is effective if targeted at older people with a history of falls and mobility limitations. **The effectiveness may depend on the provision of concomitant training for improving transfer abilities and other strategies for effecting behaviour change.**” [Lord et al., 2006]

Reducing Hazards \rightleftharpoons **Balance/Mobility**



Falls
???



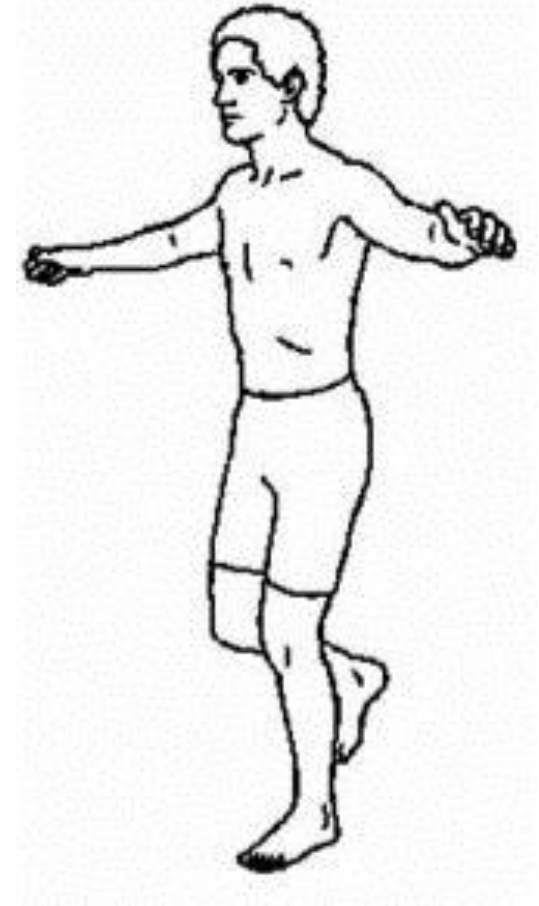
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Choosing and using outcome measures

- **Objectives:**
 - Understand the assessment of patient/client impairments related to their specific balance related goals.



Choosing the correct measures

- **Choose outcome measures that answer/quantify/identify what you need to know**
 - purpose of different outcome measures
 - categories of outcome measures – reactive or proactive ability, systems, physiology, psychosocial, cognitive/executive fnt
 - newer outcome measures



Full fall risk assessment needs to include:

- Falls history
- Medication review
- Orthostasis and cardiovascular exam
- Home/community assessment
- Cognition
- Psychosocial/emotional
- Incontinence assessment
- Balance confidence/perceived abilities
- Specific physical exam: sensory, visual, motor
- **BALANCE ABILITY**



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Avin K, Hanke T, Kirk-Sanchez N, McDonough C, Shubert T, Hardage J, Hartley G. Management of Falls in Community-Dwelling Older Adults: Clinical Guidance Statement From the Academy of Geriatric Physical Therapy of the American Physical Therapy Association. *PTJ*. 2015;95(6):815-834.

<https://www.nice.org.uk/guidance/cg161/chapter/1-Recommendations#preventing-falls-in-older-people-2> Accessed 10/17/16

Purpose of measure: Fall risk/balance assessment

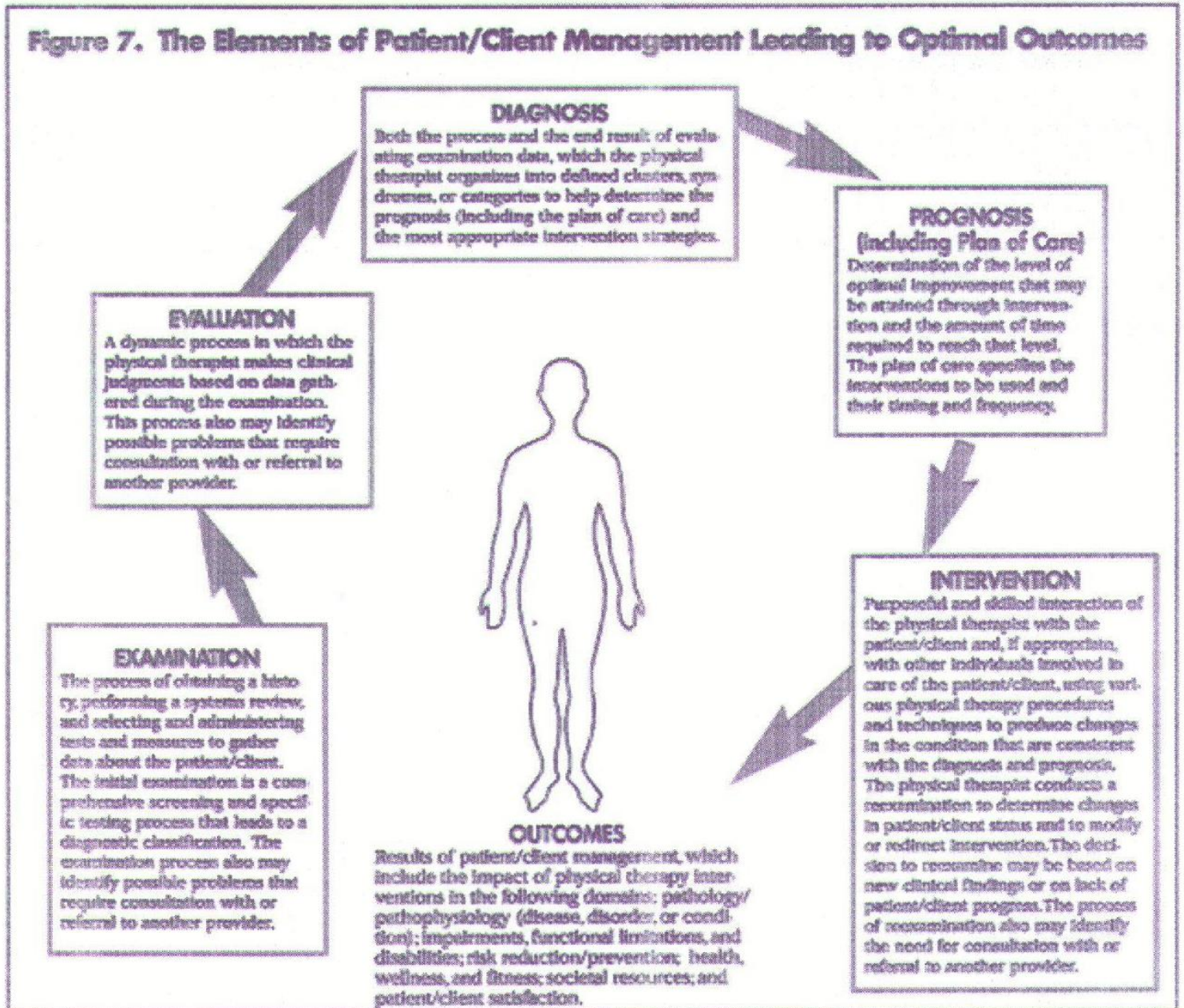


Allows both:

- Identification of modifiable risk factors
- Guides selection of interventions

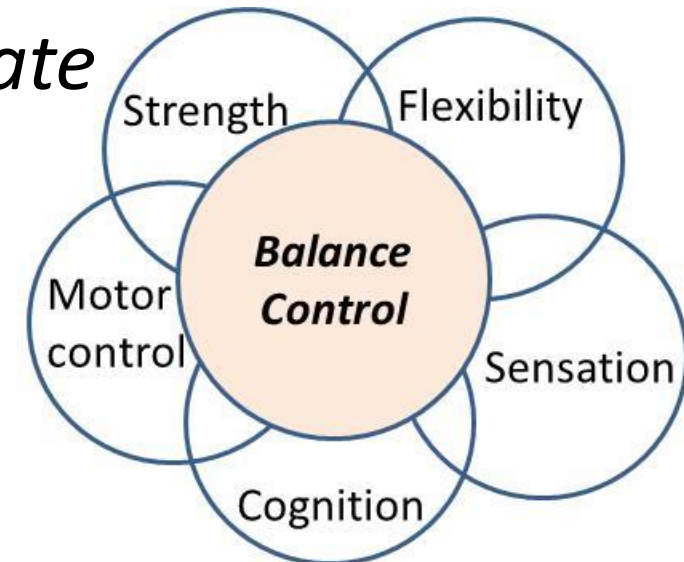
Outcome measures

- Examples:
 - *Berg*
 - *TUG*
- Is an outcome measure the same as a test, or examination tool?
- Perhaps use of term “outcome” is misleading



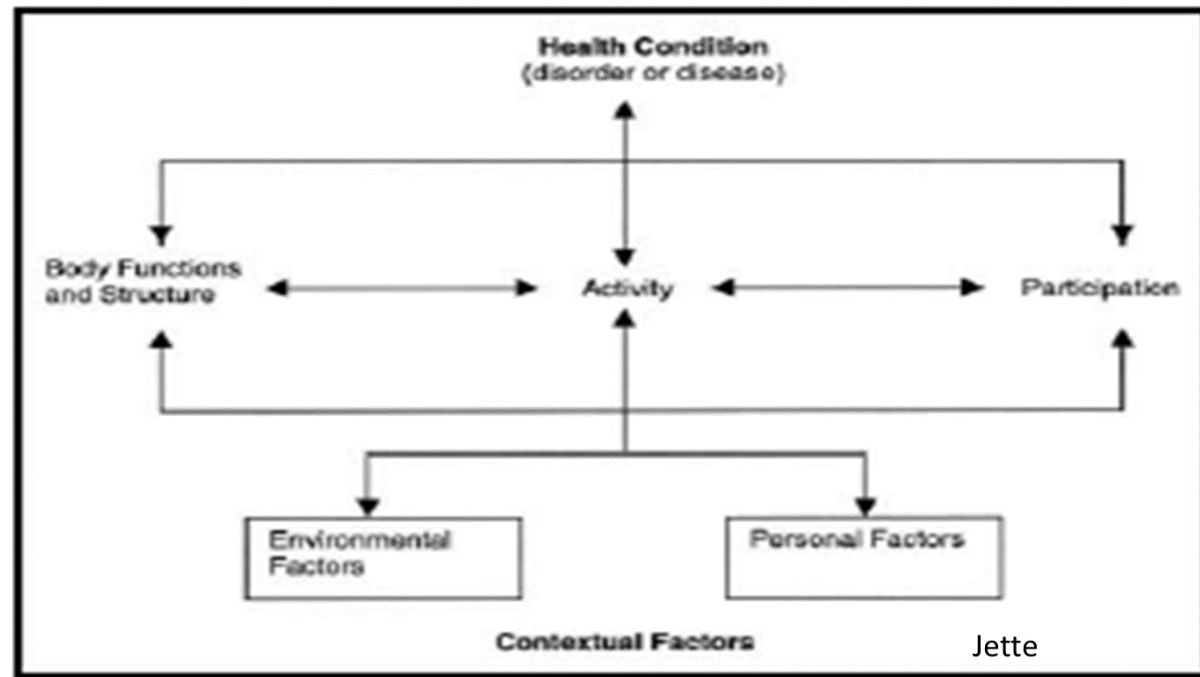
Measurement instruments

- What is the purpose of each measure you use
 - Prediction of fall risk (including showing improvement in fall risk as a result of intervention → an outcome)
 - i.e. Berg or TUG
- Figuring out why someone is falling: *an adequate measure must be chosen if it is to effectively guide treatment*
 - i.e. MMT, goniometry, sensory testing



Domain of Measurement Instrument: *Impairment BS/F, Activity, and/or Participation* WHY DOES THIS MATTER?

- IMPAIRMENT BS/F
 - What limits mobility/balance? What puts person at fall risk?
- ACTIVITY
 - Task analysis, modify tasks/envirom, practice/learn tasks/activities
- PARTICIPATION
 - Fear, access, safety



Other Considerations for Measure Selection

- Practice setting
- Time constraints
- Equipment needed
- Patient's initial level of performance and diagnosis prognosis: should balance get better or get worse?
 - Floor/ceiling effects
- Exam results
 - Past medical history and chief complaints
 - Impairments in body structure and function
- Balance specific measures
 - Balance is a complicated construct
 - A given test may miss important factors

Selecting an ideal balance specific measure: Measure must match patient's current/projected status

- Contains items assessing:
 - Impact of identified impairments
 - Both static and dynamic components of movement
 - Patient's ability to adapt to the environment such as varied sensory and cognitive demands
- Contains items that allow therapist to individualize treatment
 - Limits of stability
 - Verticality
 - Biomechanical constraints
 - Stability in Gait
 - Sensory orientation
 - Anticipatory postural adjustments
 - Postural responses

Clinical tests commonly used to assess fall risk and balance ability for people with specific neuro diagnoses: *Parkinson's Disease*

The best predictor of falling was having more than 2 falls in the previous year (sensitivity 68%, specificity 81%).

No evidence is available regarding the use of particular fall screens for people with PD. The American Geriatrics Society/British Geriatrics Society Clinical Practice Guideline on [Prevention of Falls in Older Persons](#) may be helpful

Outcome measures recommended for use in assessing balance ability:

- Functional Reach Test
- Berg Balance Scale
- Functional Gait Assessment
- BESTest
- Timed "Up & Go"

<http://ptnow.org/clinical-summaries-detail/parkinson-disease-pd#ViewComplete>

Clinical tests commonly used to assess fall risk and balance ability for people with specific neuro diagnoses: *Multiple Sclerosis*

- “Interventions should be tailored to specific areas of balance loss (eg, somatosensory, vestibular, visual, motor control) as well as specific tasks and activities that lead to balance loss.”
- “Endurance training may improve balance, as balance decreases when individual is fatigued.”
- Recommend outcome measures to assess balance ability:
 - Activities-specific Balance Confidence Scale
 - Berg Balance Scale
 - Functional Reach Test
 - Four Square Step Test
 - Dynamic Gait Index [<http://www.ptnow.org/clinical-summaries-detail/multiple-sclerosis-ms>]
- Poorer verbal memory predicted ↑ frequency of falls & risk of multiple falls. [D’Orio et al., 2012]
- Best fall predictors: balance/cognition, progressive MS, use of a mobility aid. [Gunn et al., 2013]

Clinical tests commonly used to assess fall risk and balance ability for people with specific neuro diagnoses: *Stroke*

TUG:

- Score of 15 seconds or less could be used to rule *out* high risk for falling
- Not useful in ruling *in* high risk patients
- “Non-linear relationship between mobility (assessed by TUG) and risk for falls which may be modified by other factors, both behavioral and environmental.”

BERG:

- Generally accepted that scores of less than 45 are indicative of balance impairment
- “While the reliability and validity of the scale are excellent, there are no common standards for the interpretation of BBS scores though there is an accepted cutoff point for the presence of balance impairment. “

<http://www.ebrsr.com/sites/default/files/Chapter%2020 Outcome%20Measures.pdf>

Measures of reactive balance control predicted falls for 6 mo. after assessment

[Mansfield et al., 2015]

Categories of balance specific measures

- **reactive ability**
- **proactive ability**
- **systems**
- **physiology**
- **psychosocial**
- **cognitive/executive function**

Measuring the variables that affect balance

Performance Based Balance Tests

Static: Quiet sitting/standing

Dynamic: Transitions and mobility

Sensory manipulation

Sensory, including vestibular, function

Functional/combination test batteries

Systems Assessments

Versus Functional Assessments more typically used as clinical tests of both balance ability and fall risk such as Berg or TUG

Balance Evaluation Systems Test (BEST) [Horak et al., 2009]:

- Focus on identifying balance systems affected/contributing to balance abilities.
- Helpful in guiding intervention

Physiological Balance Profile Approach (PPA) [Lord and Clark, 1996]:

- Focus on identifying physiological mechanisms underlying an individual's balance impairments;
- Not necessarily helpful in guiding interventions (not enough information)

BESTest and Mini BESTest

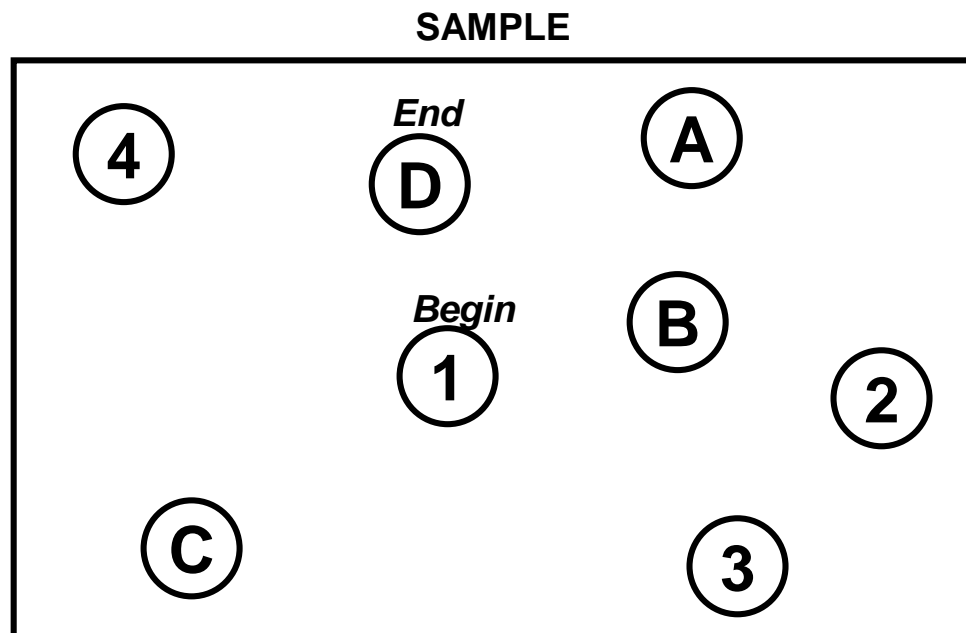
- 6 Balance Systems-Full BESTest
 - Biomechanical constraints
 - Stability limits/verticality
 - Anticipatory postural adjustments
 - Postural responses
 - Sensory orientation
 - Stability in gait
- 4 Systems Represented-Mini BESTest (Biomechanical constraints and stability limits were found to have less influence on dynamic balance)
 - Anticipatory postural adjustments
 - Postural responses
 - Sensory orientation
 - Stability in gait

Non-Physical Tests/Domains: *cognition predictive of fall risk*

Prospective, cohort study; role of domains of cognitive function in predicting balance and fall risk in adults with *neurological conditions in the rehab setting*:

Stroop Color Word Test and errors on Part B of the Trail Making Test were significantly associated with fall risk.

Composite scores of executive function, speed of info processing, visual memory → associated with increased likelihood of having better balance (Berg Balance Test score).



YELLOW BLUE ORANGE
BLACK RED GREEN
PURPLE YELLOW RED
ORANGE GREEN BLACK
BLUE RED PURPLE
GREEN BLUE ORANGE

Summary: best fall prediction by clinical measures

Older adults, healthy and those with various neurological conditions:

Of a number of physical and psychological-based measures, the three that best predicted falls prospectively were:

Activity Specific Balance Confidence Scale (ABC)

Fear of Falling Avoidance Behavior Questionnaire,

TUG

[Merrill et al, 2016]

Newer instrumented measures

Static Posturography – quantifying displacements of COP through force plates during quiet standing or using accelerometers to assess motion (sway) during quiet standing

Dynamic Posturography – as above but with external balance perturbations

Dynamic Posturography with sensory perturbations (Sensory Organization Test)

Provide information about balance ability and structures/systems involved

Drawbacks – equipment, time, space, cost, limited to specific tasks (mostly standing)

Wearable/portable sensors to quantify kinematics of mobility, gait, transitional movements

Clinical tests that have been instrumented with accelerometers or other portable or wearable sensors, e.g, postural sway, TUG, step initiation

Using accelerometers to assess gait and postural parameters during mobility tasks

Using smartphone to measure gait and postural parameters

Portable sensors- Kinect cameras - to assess gait and/or parameters of movements and mobility tasks, or clinical balance assessments

Tailoring program to goals

Objective

- Describe the factors to be used in choosing and tailoring an intervention program to best meet a patient/clients' balance related goals.

Evaluation/Assessment

Relate back to client's goals → Increase mobility and/or decrease falls/risk

- **underlying body system/function impairments**
- **→restorative vs. compensatory → or both combined**

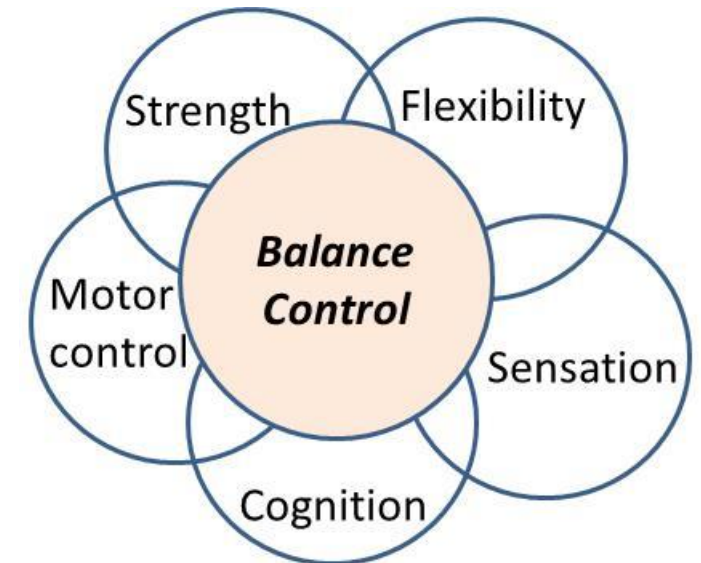
Tailoring program to goals: vary according to:

- Population
 - Fallers or fall prevention?
 - Athletes or older adults?
 - Various disabilities (stroke, PD, MCI, etc.)
- **Compensation vs. Restoration**
- Setting of exercise program
 - Home
 - Community
 - Care facility
 - Outpatient
 - Hospital
 - Combined



Most important: Goals still depend on assessment of areas to be addressed: LOOK AT ENGINEERING SLIDE

- Impairment based assessment
 - Strength
 - Endurance
 - Flexibility/ROM
 - Sensory
 - Strategies/motor control
 - Motor (ankle, hip, stepping strategies)
 - Sensory (vary vs. compensation)
- Functional balance demands
 - Proactive: Static \longleftrightarrow dynamic
 - Reactive



Falls Management Exercise (FaME) Skelton et al 2005, Gawler et al 2016

- Combined home and individualized group exercise program
- OTAGO exercises were core to both the home and group program
- However, progressed to more challenging balance exercises during the group sessions
 - balance specific, individually-tailored and targeted training targeting specific impairments as well as dynamic balance and training to improve righting responses to avoid a fall

Decide on your specific intervention: Dosage

- WHAT IS DOSAGE
 - Frequency of taking medication (F)
 - Amount of medication (I)
 - Time/duration of taking medication (T)
 - Type of medication (T)
- How is dosage different in physical therapy?
- Specifically, what about dosage related to balance interventions?



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Major problem: dosage

- FITT
 - Frequency
 - Intensity
 - Time
 - Type
- Applied broadly for locomotor training & strength training
- Why not balance?
- In order to be effective, balance exercise program must be:
 - Salient and Effective (Type matters)
 - Challenging (Intensity matters)
 - Manageable (Frequency matters)
 - Feasible & Tolerable (Time matters)
- How about TIFT principle for balance training?

Dosage: types of intervention

CONVENTIONAL

- Impairment based
 - Strength
 - Endurance
 - Flexibility/ROM
 - Sensory
 - Strategies/motor control
- Mixed
 - Explicit (strengthening ex + functional balance activities in OTAGO)
 - Implicit → functional activities often incorporate work on impairments, for example:
 - Strategies (AP weight shifting functional activity works on ankle strategy)
 - Strengthening (sit to stand functional activity works on strength)
- Proactive functional training
- Reactive functional training

CONTEMPORARY/ALTERNATIVE

- Dual-tasking
- Virtual Reality
- Dance
- Mind-Body Exercises (Tai-Chi & Yoga)
- Perturbation Training

Balance Interventions

- Impairments
 - Strength
 - ROM
 - Sensation
- Strategy
 - Ankle
 - Hip
 - Stepping
 - Movement patterns
- Functional Activities
 - Sitting
 - Sit <> stand
 - Standing
 - Gait



Attain sitting

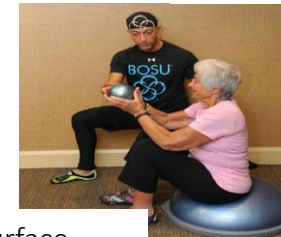


Maintain sitting

Move within BOS



Move Outside BOS



Change sitting surface



Change standing BOS



Change standing surface



Weight shift via reaching



Self perturbations – kicking, stepping

Facilitating Strategies

Development of effective task-specific sensory and motor strategies for maintaining balance

- Motor strategies

- Ankle – small range, slow velocity shifts
 - Weight Shifting, standing on foam/compliant surface
- Hip – larger, faster motions
 - Rocker board, reaching up/down/lateral, small perturbations
- Stepping – outside BOS
 - Larger perturbations

- Sensory strategies

Sensory strategies must include the ability to organize and select the most appropriate sensory inputs

- Vary sensory information (add or change)
 - Visual
 - Somatosensory
 - Vestibular
- Sensory compensation

Systematic reviews and meta-analyses

- Large number completed
 - 50+ since 2009 (Rimland et al 2016 --)
- Vary according to
 - Population: fallers (or not), older adults, various disabilities (stroke, PD, MCI, etc.)
 - Setting of exercise program: home, community, care facility, outpatient, hospital
 - Outcomes assessed: falls, fear of falling, fall injuries, clinical and/or instrumented balance measures
 - Type of exercise intervention

Rimland et al 2016

- Excellent current review examining falls prevention research broken down according to these categories
- Part of EU funded project
 - ONTOP (Optimum evidence-based Non-drug Therapies in Older People)
 - A part of SENATOR (Software ENgine for the Assessment & optimization of drug and non-drug therapies in Older peRsons)

Systematic Reviews (Stroke)

The Effect of Balance Training on Balance Performance in Individuals Poststroke: A Systematic Review - **Lubetzky-Vilnai and Kartin (2010)**

- Reviewed 22 studies
- Inclusion: At least 1 standing balance intervention and 1 balance outcome
- Divided into Acute, Subacute and Chronic phases of stroke

The Effects of Exercise-Based Rehabilitation on Balance and Gait for Stroke Patients: A Systematic Review - **An and Shaughnessy (2011)**

- Reviewed 17 studies
- Inclusion: RCT, one outcome focused on balance or gait function
- Exclusion: Use of robotics or Virtual reality

What is the Evidence for Physical Therapy Post Stroke? A Systematic Review and Meta-Analysis - **Veerbeek et al (2014)**

- Reviewed 4 specific areas within balance:
 - Sitting balance training
 - Standing balance training without biofeedback
 - Standing balance training with biofeedback – force and position feedback
 - Balance training during various activities

Need for change??

Physical activity and regular exercise have been shown to improve balance, prevent falls, and maintain physical function in older individuals *(Lord SR 2003)*

Traditional exercise has not been readily adopted by older persons due to barriers:

- fear of falling
- health problems
- motivation

(CohenMansfield, Marx& Guralnik, 2003; Lees, Clark, Niggs & Newman, 2005)

Type

Will have determined the goal tasks/activities: “what” the client needs to be able to do

Goals/need –

adequate postural control for activities, gait
fall prevention/response to perturbations

Based on results of examinations and assessment
specific components of balance to address
specific tasks and conditions

Underlying impairments addressed separately or as part of balance training

SAID: Specific Adaptation to Imposed Demands

Alternative therapies

Dual-tasking/Cognitive Motor Therapy

Virtual Reality

Dance

Mind-Body Exercises (Tai-Chi & Yoga)

Perturbation Training

Dual-task training

Training method which requires a person to perform two tasks concurrently and the efficiency of performance of both is compared.

Principles

Improving automation of motor task by repetitive practice.

Motor automation reduces the attentional requirements of motor tasks, thus capacity to perform simultaneous cognitive tasks.

Stresses functional capacity during ADL, optimizes functional independence.

Reducing cognitive-motor interference

Reduced dual-task cost (computed as $[(\text{Dual task} - \text{Single task}) / \text{Single task}]$)

Higher costs indicate worse performance under dual task conditions

Neuroplastic changes in the cortex

Increased activation in the **default mode network** (corresponds to task introspection and active in the absence of focused task performance) and the **central executive network** (active while performing executive function).

CMT in Older Adults

Review by Shoene 2014

- 37 studies were included.
- Conventional interventions used under DT conditions:
 1. Step training
 2. Balance board training
 3. Balance board plus aerobic training
 4. Multi component programs with low challenge of balance
 5. Aerobic programs
- Main outcomes focussed: Balance, Fall questionnaires, Mobility, Reaction time, Dual-task Cost.
- Results:

Interactive cognitive-motor interventions can improve physical and cognitive fall risk factors in older people, but that the effect of such interventions on falls has not been definitively demonstrated.

Interactive cognitive-motor interventions appear to be of equivalent efficacy in ameliorating fall risk as traditional training programs

CMT in Older Adults

- With aging, limited processing capacity to perform the task
- Reduction in cognitive functions:
 - ❑ executive functioning
 - ❑ attention
 - ❑ processing speed (Salthouse TA 1996, Hedden T 2004)
- Age related over-activity of executive networks in the prefrontal cortex during motor planning which slows motor responses (Marika Berchicci 2013)
- Impaired cognitive functions increase the fall risk (Hsu CL 2012)
- Combined training of cognitive and physical functioning leads to better results than isolated cognitive or physical exercises in older people (Theill N 2013, Silsupadol 2009).
- **CMT improves coordinated motor performance by increasing efficiency of executive control during more complex tasks** [Shoene 2014]

CMT in Stroke Survivors

- Effective in subacute & chronic stroke.
- Positive impact on balance and gait and dual-task performance.
- High dosage, short duration found to be effective in training dual-task performance
- Cognitive task performance effects rarely studied
- Dual-task cost rarely examined

Outcome variables affected:

- Gait Variables:
 - stride length, time, velocity
 - performance on distracted gait speed
- Balance and mobility
 - BBS
 - FR, TUG
 - Limits of stability as measured on LOS and SOT.
 - Step reaction time
- **Physical activity**
- Fear of fall and fall rate
- Cognitively: Executive functioning, divided attention.

Virtual Reality

Principles

- **Feedback**
 - Intrinsic – Auditory, visual, somatosensory and proprioceptive
 - Extrinsic – Knowledge of results & Knowledge of Performance
- **Multisensory stimulation** - Simulates real-life.
- **Motor learning principles:** Task-related training, repeated practice, variable practice.
- **Interactive** and game like → Motivation and compliance.
- **Neuroplastic changes** in the cortex: Shift from bilateral (pre-training) to ipsilateral (post-training) activation of the primary sensory-motor cortex.



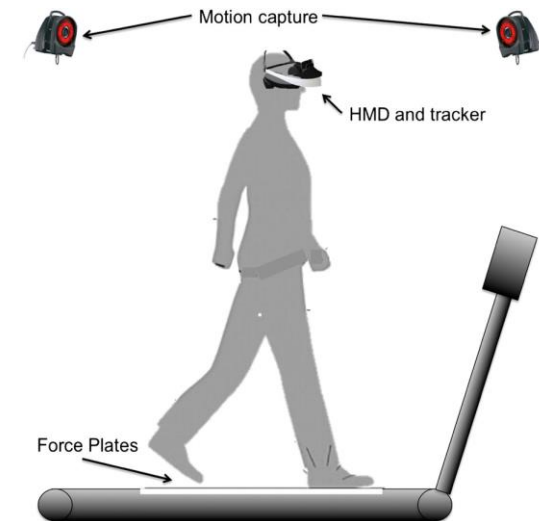
Review article by Laufer 2014

- Seven studies involving 21,668 people were included.
- Interventions: 23 trials studied exercise or physical therapy interventions
 - 4 studies: Wii-based exercise vs no exercise
 - 3 studies: Wii-based training vs alternative exercise programs
- **Main outcomes focussed:** Functional balance performance, postural sway, fall risk questionnaires, fear of falling questionnaire, fitness, muscle strength and cognitive performance and depression.
- **Results:** Wii-based exercise programs may serve as an alternative to more conventional forms of exercise aimed at improving balance control.



Review article by Molina 2014

- Thirteen studies were included.
- Mostly used Interventions:
 - Nintendo Wii gaming console (8 studies)
 - Computers games (two studies)
 - Dance video game with pad (two studies)
 - Balance Rehabilitation Unit (1 study)
- **Main outcomes focussed:**
 - Balance: BBS (5 studies)
 - mobility-related physical functioning measures: TUG (7 studies)
- **Results:** Evidence to support the effectiveness of using exergames for improving physical functioning in older adults remains inconclusive.



Outcomes affected:

- Virtual reality showed significant improvement in:
 - mobility related physical functioning
 - balance (static and dynamic) :TUG and BBS
 - gait parameters (walking speed)

- Positive changes in:
 - muscle strength
 - lowered reaction time
 - less body sway
 - physical activity levels.

- Only two studies, studied falls as the outcome measures. (showed reduction in fall risk and number of falls).

- Virtual reality allows for good program adherence.

Virtual Reality in stroke survivors

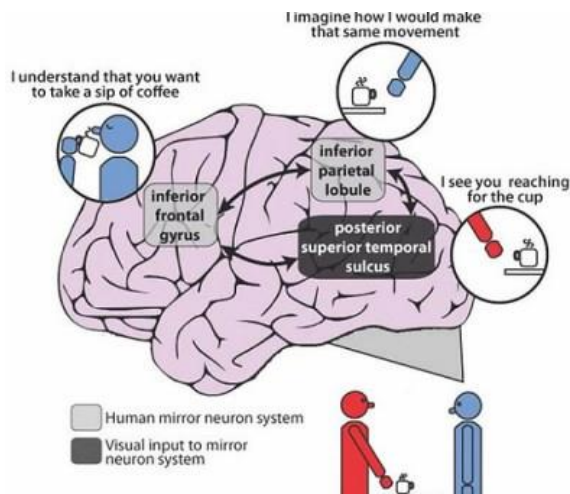
- Effective in Acute, Subacute and Chronic stroke.
- Conclusions:
 - Positive impact on balance and gait recovery.
 - Immersive VR more effective than non-immersive
 - Multimodal approach combining VR and conventional rehab more effective.
 - A minimum of 10 sessions to be effective.
 - Higher number of repetitions and longer training times are more beneficial (>1 hour).
 - Only few studies assessed transfer to community ambulation. Nevertheless positive results has been attained
- Most studies do not report follow-up more than one month.
- Most studies do not examine “cognitive load” of the tasks/games



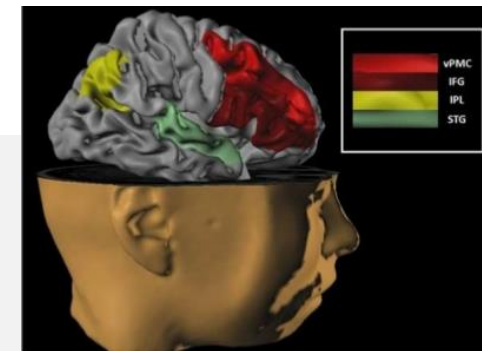
Dance Therapy

Principles

- **Motor learning principles:** focus on trunk control, facilitates continuous center of pressure excursion, voluntary stepping strategies, increased single stance control, whole-body coordination, and somatosensory awareness.
- **Provides and promotes:**
- *Sensory feedback*
- *Variability of practice* -range of speeds, rhythmic variation and spontaneous multidirectional changes.
- *Coordination of multiple limb segments:* synchronized to a rhythmic stimulus
- *Cognitive challenges:* learn sequence of motor actions
- *Social integration:* → Motivation and compliance



Cortical plasticity - activation of “Mirror Neurons” - Action Observation Network (during observation & actual performance of dance) (G Batson et al 2014)



Dance Therapy in Older Adults

Review - Fernandez-Arguelles 2014

- 7 studies
- IC: Older adults >60 years of age with no disabling disease.
- **Outcome measures:** balance, gait, dynamic mobility, strength, and flexibility
- **Interventions:**
 - Ball room dancing
 - Dance based exercise
- **Results:**
 - Positive effects on the risk of falling related to: balance, gait and dynamic mobility, strength and physical performance
 - However, unable to confirm that dance has significant benefits on these factors based on the scientific evidence.

Review -Hwang 2015

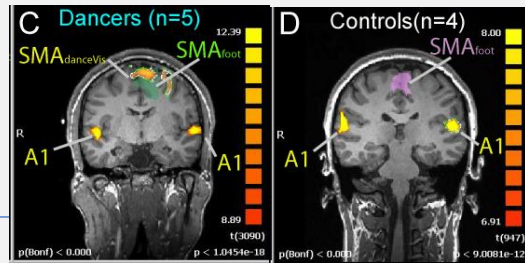
- 18 articles published from 2004 to 2013
- IC: Older adults with average age =52-87 years.
- **Outcome measures:** Flexibility, muscle strength and endurance, balance, cvs endurance, cognitive function, body composition.
- **Interventions:**
 - 5 used contemporary (improvisation and the Lebed method.)
 - 4 used cultural (Greek, Turkish, Korean, Cantonese, line dancing)
 - 1 used pop
 - 2 used jazz
 - 6 used Ball room dancing (foxtrot, salsa, tango, bolero, swing, polka, cha-cha, waltz, merengue)
- **Frequency and duration of session:** 1-4t/W, for 6weeks- 8 mnths, 45mins to 2 hours.
- **Results:** Dance, regardless of its style, can significantly improved strength, endurance, balance, and functional fitness in older adults.

Outcomes Affected

- Dance therapy induces significant improvement in:
 - balance control
 - postural stability
 - muscle strength and endurance.
- Effect of dance on frequency of falls and fear of falling has not been yet studied.
- Sherrington (2008) recommended that twice weekly for minimum 25 weeks is the minimum protocol time as an effective exercise dose.
- Only 2 studies have shown long term follow up (6 and 8 months).
- More studies need to evaluate effective dosage.
- Future focus on conducting more RCTs, with more sample size, with more duration of follow up.

Dance Therapy in Neurologic populations

Reference	Sample Characteristics	ET Rx	C Rx	Dosage	Outcomes	Result
Duncan & Earhart et al 2012	N: 62	Community-based Adapted Tango dance class	No	1 H, 2W for 12 months	<ul style="list-style-type: none"> MDS-UPDRS-3 MiniBESTest; 6MWT; Gait velocity comfortable and fast and dual task, Nine-Hole Peg Test (9HPT) 	<ul style="list-style-type: none"> 6MWT, walking velocities, upper extremity function improved in ET group*
Hackney et al 2007	N: 19	Tango class	Exercise classes	1H for 2/W for 13 weeks	<ul style="list-style-type: none"> ABC FES Geriatric Center Morale Scale (Depression); FRT One Leg Stance Test; Walking velocity 	<p>Within groups</p> <ul style="list-style-type: none"> Both groups ↑ in all outcome measures. ET > C. <p>Between groups</p> <ul style="list-style-type: none"> Fall self efficacy in ET* ABC in ET *



- Has been very effective in other neurological conditions (e.g., Parkinson disease, Multiple Sclerosis) for improving balance, gait, cardiovascular fitness, community ambulation and falls.
- Early stage of research to find effectiveness on Stroke.
- Tending towards being effective in chronic stroke.
- Preliminary evidence shows positive impact on balance, gait recovery and community ambulation (Madeleine E et al 2012., Kathleen Michael et al 2009., Savitha Subramaniam et al 2015)
- Multimodal approach combining dance and VR more effective.

Mind Body Exercises - Tai Chi & Yoga

- **Multimodal mind-body exercise forms:** combination of postures, breathing, and meditation utilized together
- **Provides sensory feedback**
- **Provides motor control:** weight shifting, body rotation and awareness of alignment, enhances core stability
- **Demands motor planning** for performing a sequence of movements very precisely.
- **Activation and reorganization** of neuromuscular patterns
- Improves accuracy of **joint positioning** and better **proprioception**
- Improves **attention:**
 - reduced cognitive-motor interference,
 - increased anterior cingulate cortex activation at rest with Yoga/Tai-Chi practice suggest improved executive attention.

YOGA: *strike a pose*



Tai Chi Therapy in Older Adults

Review by Verhagen A et al 2003

- Seven studies were included, with in total 505 participants, of whom all but 27 were healthy seniors, age between 53 and 96 years.
- Interventions:
 - modified Yang style Tai chi, varying from 10 to 24 forms
- Main outcome
 - Falls
- Results
 - Beneficial effect of TCC on falls are noted. More RCTs are required to evaluate the effect of TCC in fall prevention and to evaluate other health care benefits.

Outcomes Affected

- Tai chi has been very effective in older adults.
- Extensive studies have been done for effect of Tai chi in older adults.
- Significant improvement in :
 - number of falls, fear of falls (CFES) and risk of falls in older adults.
 - functional balance (sway meter, step test, BBS)
 - mobility (functional reach)
 - lower limb strength
 - cardiovascular parameters.
- Increase in total exercise time and increased sense of ability to do exercise.
- Improvement in the self perceived physical well being (PWI-CV)

Does Tai-Chi Practice reduce fall-risk?

Case

- SE - 57 y/o male with right hemiparesis had stroke due to intracerebral hemorrhage since 5 years and 10 months. He did not show cognitive impairment MoCA 26/30. He used AFO and cane for ambulation. Presented with a score of 47/56 on BBS, 12.53s on TUG, and 81.25% on ABC. His regular walking speed was 1.27 m/s, covered 280m on 6 MWT and showed impairment of right lower extremity with score of 5/7 and 1/7 for leg and foot CMSA respectively.

Yoga Therapy in Older Adults

Review article by Youkhana, 2016

- 6 studies
- Older adults with age > 60 years
- Intervention included:
 - Physical yoga (excluding meditation and breathing exercises alone)
- Outcome measures:
 - Berg balance scale (3 studies), one leg standing (1 study), Mobility tests-sit to stand and gait speed tests (3 studies) and short physical performance battery (2 study).
- Results:
 - Yoga interventions resulted in small improvements in balance in yoga versus control participants (SMD 0.40, 95%CI 0.15–0.65) and medium effect on mobility in yoga versus control participants (SMD 0.50, 95% CI 0.06–0.95) in people aged 60+ years.

Outcomes Affected:

- Yoga therapy has shown significant improvement in:
 - Balance and Mobility as measured by BBS, TUG.
- The maximum studies have followed up for 8 to 14 weeks, only one study has a follow up till 24 weeks.
- Long term effects of yoga in older adults not yet studied and needs further research
- Also the optimum dosage (volume, intensity, frequency) of yoga therapy for effective results has not been established.
- No study has considered falls as a outcome measure. However, only one study has taken fear of falls and it shows reduction in the fear of fall.

Tai-Chi & Yoga Practice in Neurological populations

- Early stage of research tending towards being effective in chronic stroke.
- Positive impact on balance, gait recovery and community ambulation.
- Studies are in progress to find effect on acute and sub-acute stages of stroke (Zhang Y et al., 2014)
- Would be more appropriate as a preventive and a complimentary method for stroke rehabilitation.
- Has been very effective on young and healthy older adults.

YOGA: *strike a pose*



Limitations – Alternative Therapies

- Very few studies have correlated the significant improvement in the balance test scores to decrease in fall risk and community ambulation levels.
- **Challenges for VR use:**
 - Immersive VR side effects (e.g., sweating, nausea, headaches, disorientation and balance disturbances).
 - Proficiency in computer skills
 - Infrastructure needs - expensive equipment, inadequate communication infrastructure (for tele-rehabilitation in rural areas), and patient safety concerns
- **Challenges for mind-body approach use:**
 - Specialized instructors and certifications required for mind-body exercises
 - May require extensive training before effects can be seen.

Prevention of Falls

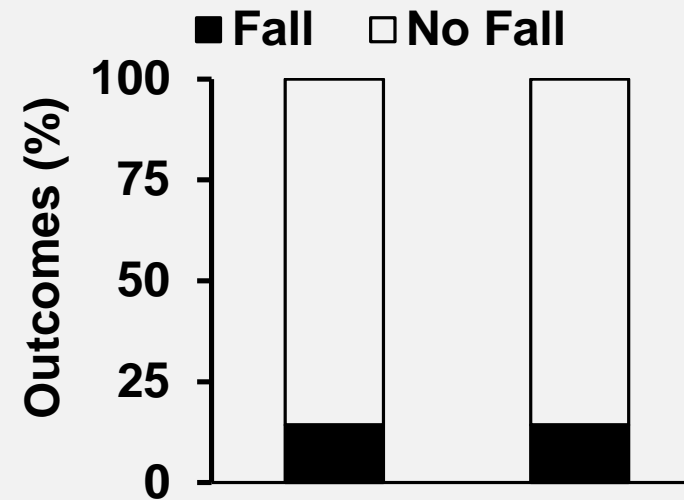
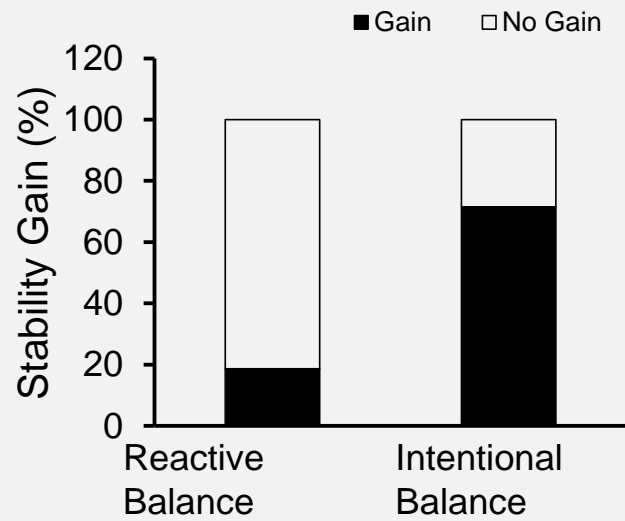
- Strength Training
- Balance and Coordination
- Combined training
- Virtual reality training
- Dual-task training
- Tai Chi
-
-
-
- Adaptive perturbation training



Does Task-specific balance training improve reactive responses and reduce fall-risk?

Case

- Ms. TH - 58 y/o female with left hemiparesis due to ischemic stroke experienced 11 years back. Currently ambulating with a cane and wears an AFO. She presented with mild cognitive deficit (MoCA 25/30). The clinical balance assessment revealed a score of 44/56 on BBS, 13s for TUG, 64.37% on ABC. She has lower extremity impairment with a score of 5/7 and 2/7 on CSMA leg and foot score respectively. Her walking speed was 0.95 m/s, walked 261m on 6 MWT.



Although intentional balance improved no change in reactive balance and falls

Principles of Perturbation training

Based on Principles of Motor learning: (Mansfield A 2007)

- Task specific learning
- Variability of practice:
 - ❑ Initial block practice: Perturbations presented in separate blocks to facilitate initial acquisition of adaptation to the novel task
 - Early adaptation – progressive adaptive gains
 - Later phase – Limited gains or reaches steady state
 - ❑ Carry over effect: Overlearning during later phase of learning leads to carryover effect
 - ❑ Later random & varied practice: To promote generalizability in later phase (e.g mix perturbation directions or perturbed and non-perturbed trials)
 - ❑ Booster sessions: To facilitate retention of training
- Instructions: Directs learner's attention to pivotal aspects of skill
- Individualisation: Training should match individuals rate of adaptation



Review by Mansfield A et al 2015

- 8 studies with 404 participants
- Inclusion criteria:
 - RCT, written in English
 - Focused on perturbation-based balance training among older adults (>60 years) or individuals with neurological conditions
 - Collected falls data post training (prospectively)
- Exclusion criteria:
 - Cross over design
 - studies using postural perturbation for rehabilitation of single joint
 - studies examining within session adaptations
- Outcome measures:
 - Proportion of fallers
 - Fall rate
- Results: PBT appears to reduce the likelihood and frequency falls among people at increased risk for falls
- Overall effect for fall rate (rate ratio 0.54) was lower than reported in previous meta-analyses of general balance training in older adults (rate ratios 0.65– 0.86)
- Perturbation-based balance training might be more effective than conventional balance training

Frequency and duration

Often used as proxy for exercise intensity, especially “time on task”

(e.g., Maughan et al, 2012)

Evidence/conventional wisdom is that 3x/week is needed for effectiveness

Balance training is a motor learning (re-learning) task

Repetitions necessary for motor learning = 100's to 1000's for people
post stroke

Limited by, among others:

ability to attend therapy that often

ability of providers to provide therapy that often

performance of home program that often

tolerance, fatigue, boredom/engagement.....

Frequency and duration

*Analysis of dose-response relationships in healthy adults over 65
(Lesinski et al 2015)*

Examined training frequency, duration, and period

Training period: 11–12 weeks

Frequency of 3 sessions/week

Total number of 36–40 training sessions

Duration of 31–45 min for single training session

Total duration of 91–120 min of training/week

THE MEDROL PACK APPROACH!!!

High Frequency –High duration – tapering paradigm

Design:

Test	Pretest					Prog. 1					Prog. 2					Prog. 3					Post-test
Session	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Week	Week 1					Week 2					Week 3				Week 4			Week 5		Week 6	

Interventions



Cognitive motor Training

Wii-fit games

Bubble Balancing
Table Tilt
Soccer Heading
Tightrope walking
Light Run
Basic Step



Cognitive tasks

Digit Recall
Category Fluency
Word list Generation
Mental Arithmetic
Repeated Letter
Analogy

Conventional Balance Training

Stretching Exercises

Strengthening Exercises

Lunges
Squatting
Thera band Exercises

Proprioception Exercises

Single Limb Stance
Tandem Standing
Standing on Foam ,Tilt board

Treadmill Walking

Squatting Thera band exercise



Tilt board



Treadmill



A VACCINATION APPROACH!!!

Single Session + Booster doses

Perturbation Training

Duration

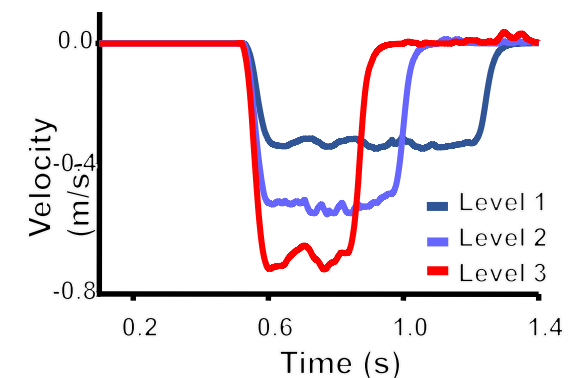
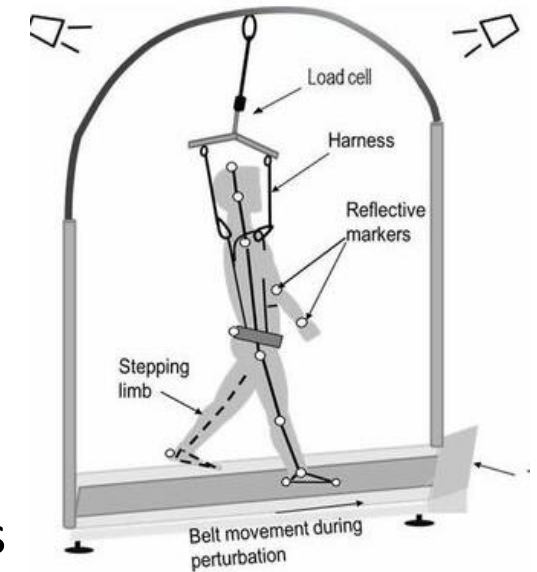
- Repetition (Within session)
 - Adding more trials doesn't improve acquisition
 - More repetition improves retention

Frequency

- Repetition (Between session)
 - Adding booster sessions (less intensity/repetition/duration) enhances retention

Intensity

- Challenge/Threat
 - Velocity
 - Acceleration
 - Distance



Debbie Espy, PT, PhD

Cleveland State University
Program in Physical Therapy



Dosage: Intensity

TIFT

Improvement in the “what” you are training indicates a need to increase the difficulty of the task until the client can manage the goal task

Theoretical hierarchies of balance task difficulty to progress program

static → dynamic

slower → faster

larger → smaller BOS

and more

proactive → reactive

smaller → larger reach or motion

add dual task

Dosage: Intensity

Exercise must be prescribed at the correct intensity to be beneficial

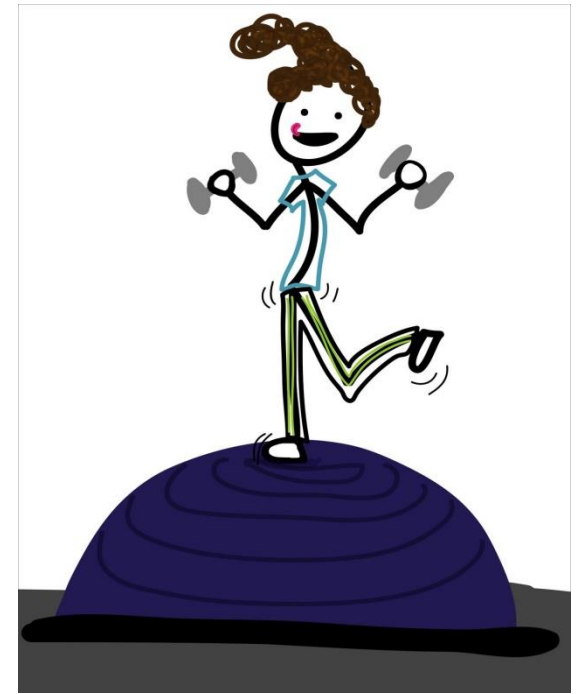
Too low – no to little benefit – waste of time

Too high – unsafe, can't perform, frustration/discouragement

What challenges balance in one individual is not necessarily what is difficult for another

Context matters – all the components that challenge balance systems

There is no measure of intensity for balance exercise



Major problem: measurement of intensity

In other exercise modes (e.g., strengthening, aerobic conditioning, stretching), initial load and modifications to the load (harder/easier) are determined by the person's ability to manage the load

- % one rep max then increase when not fatigued after sets
- run at a given speed within a given heart rate
- RPE → increase speed or incline to stay at that level
- Pain with movement/stretch to a certain ROM
- %VO₂ max

There is no good measure of intensity in balance exercise, instead people use:

- Time on task or number of reps (Time)
- Times per week (Frequency)
- Hierarchies of theoretical difficulty level (Type)

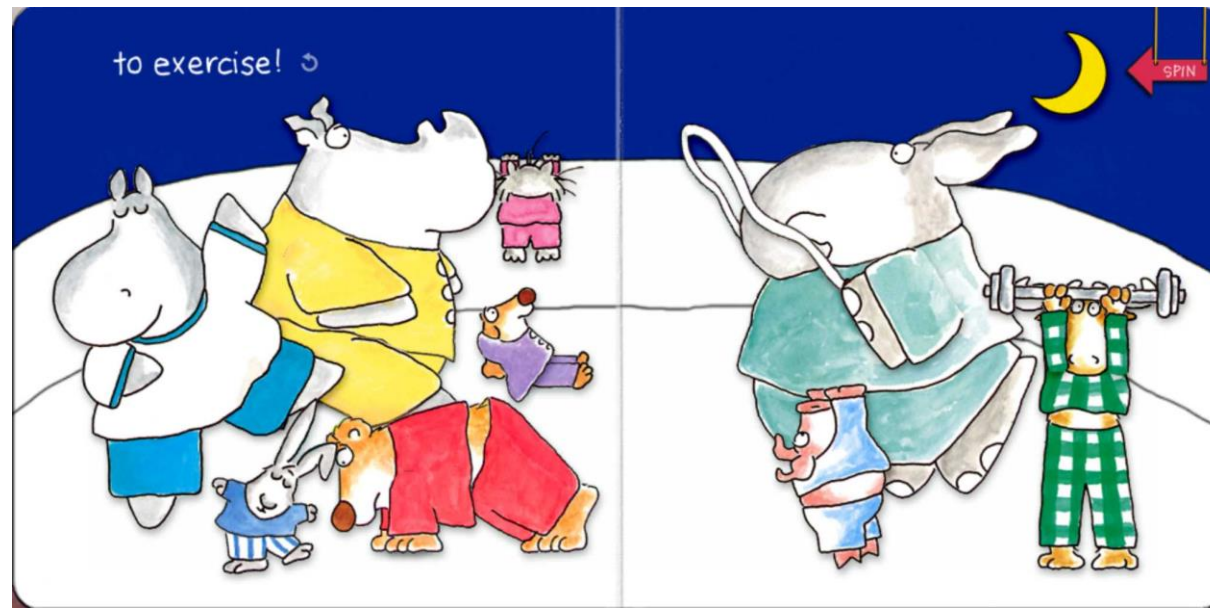
(Baker et al 2007, Haas et al 2012, Farlie et al 2013)



Dosage: Intensity

“In determining optimum level of challenge of balance exercises, recommendations commonly relate to the difficulty of the balance task, rather than to the *intensity of the activity relative to the ability of the individual...*” from a systematic review of randomized trials of balance training exercises (Farlie et al 2013)

20 kg is heavier than 10 kg and 6 minute miles are faster than 9 minute miles.....but 20 kg and 6 minute miles may or may not be the appropriate intensity for a specific individual



Dosage: Indicators

Indicators to increase or decrease difficulty of exercise tasks:

- Ability/inability to perform task correctly/number of errors
- Ability/inability to perform # of reps required.....
-within the time required/appropriate speed of movements
- Pain, anxiety, fear
- Client feels the task is too easy

May also be indicators to increase or decrease the repetitions or frequency instead modifying the particular task

Home vs. Supervised

Home program vs. in clinic or with therapist–

- supervision possible – monitor safety, vital signs, etc
- correct/guide for correct performance – i.e., can do more challenging tasks
- assist as needed – safety, avoid falls or injury, and to allow more difficult activities to be practiced
- structure and progress tasks optimally
- client's ability to understand

Can't necessarily, feasibly accomplish the number of repetitions necessary for motor learning in just clinic visits

Context of home – environment in which they will need the skills after all

Pathology Specific Considerations

Stroke – sensory, perceptual, learning, motor considerations, potential advantages of aerobic level exercise as well

Parkinson's Disease – altered motor and procedural learning, blocked practice/more reps, potential advantages of aerobic level exercise as well

MS - fatigue

Guilliane Barre, Post-Polio, Chronic Fatigue, ALS – risk of fatigue and risk of overworking motor units/muscles

Others.....

Other Systems Involved

Balance training tasks may pose challenges also to other body systems; balance program dosage (reps, frequency, intensity) may be limited by one or more of these rather than balance difficulty:

Cardiovascular

Cardiopulmonary/respiratory

Muscular overwork, fatigue

Skeletal system/osteoporosis

Cognitive fatigue, ability to maintain attention

Assessment of Client Responses to Activities

Immediate/online – with the client during and just after the activities

- understanding of task

- ability to complete correctly, safely

- pain, discomfort, fear, anxiety

Delayed –

- how they felt later – after the supervised program

- feedback about how the home exercises went

Adjust Accordingly

Increase/decrease reps,

Increase/decrease frequency,

Increase/decrease difficulty of (similar) tasks

Move to “harder” or “easier” class of tasks

Change environment

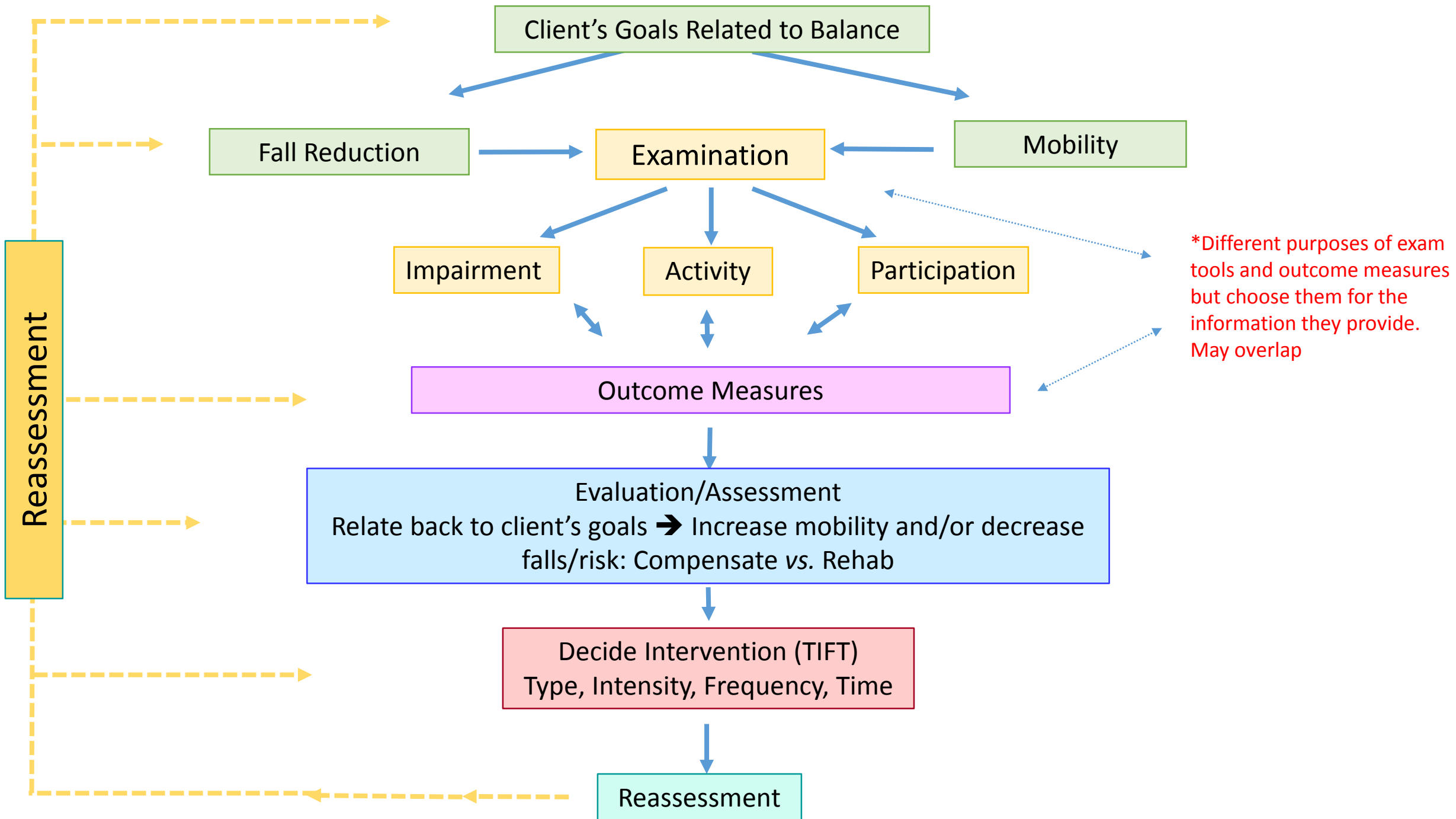
Adjust Accordingly

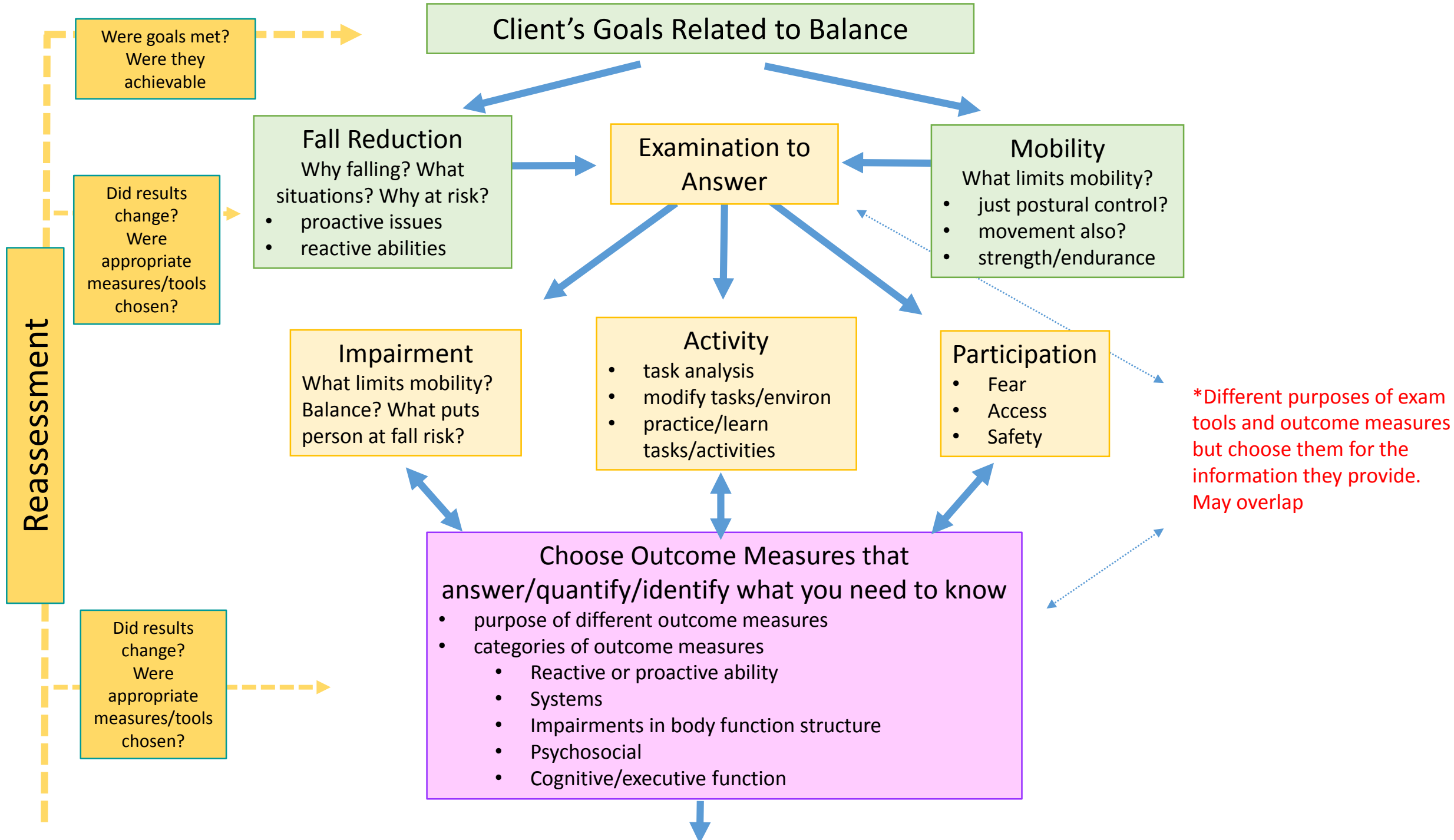
One option: use RPE/Borg/VAS type scale to assess and modulate ex program.

Completely Stable <i>Standing/sitting undisturbed on solid ground</i>	1
Steady <i>Balance does not feel challenged, but may have some body movements</i>	2
	3
Unsteady <i>Feels like work to keep balanced, but still do not need to step</i>	4
	5
Mildly Unbalanced <i>Feels like I might/ could have to take a step OR reach for support to maintain balance</i>	6
Moderately Unbalanced	7
Unbalanced <i>Feels that even the smallest or sudden movements will cause a fall</i>	8
Very Unbalanced	9
About to Fall <i>Extremely challenged; have to step AND/OR grab support to keep balance</i>	10

Figure 1. The Rate of Perceived Stability Scale

Rate of Perceived Stability (Espy 2015)





Reassessment

New exam/outcome measures? Was your assessment correct

Evaluation/Assessment

Relate back to client's goals → Increase mobility, decrease falls/risk

- underlying body system/function impairments
- → restorative vs. compensatory → or both combined

Optimally/adequately performed?
Based on new exam/assessment – chosen correctly?

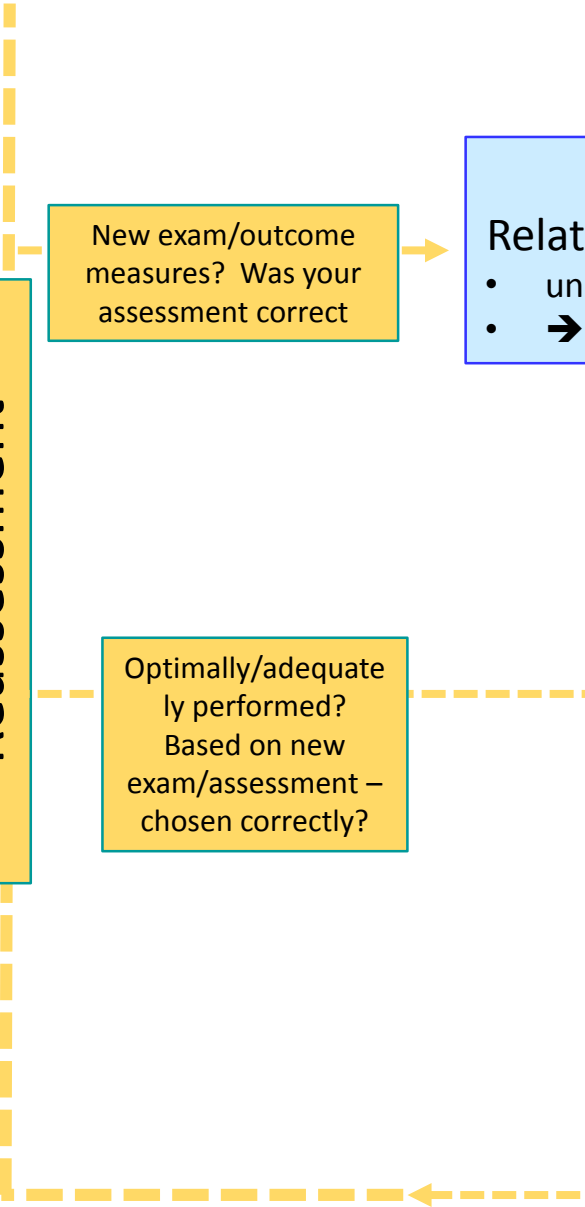
Decide Intervention (TIFT)

Type, Intensity, Frequency, Time

- Type – to best address client goals and identified impairments/risk factors
- Intensity – too easy? too hard?
- Frequency/Time – what does evidence say, what can/does client tolerate/do

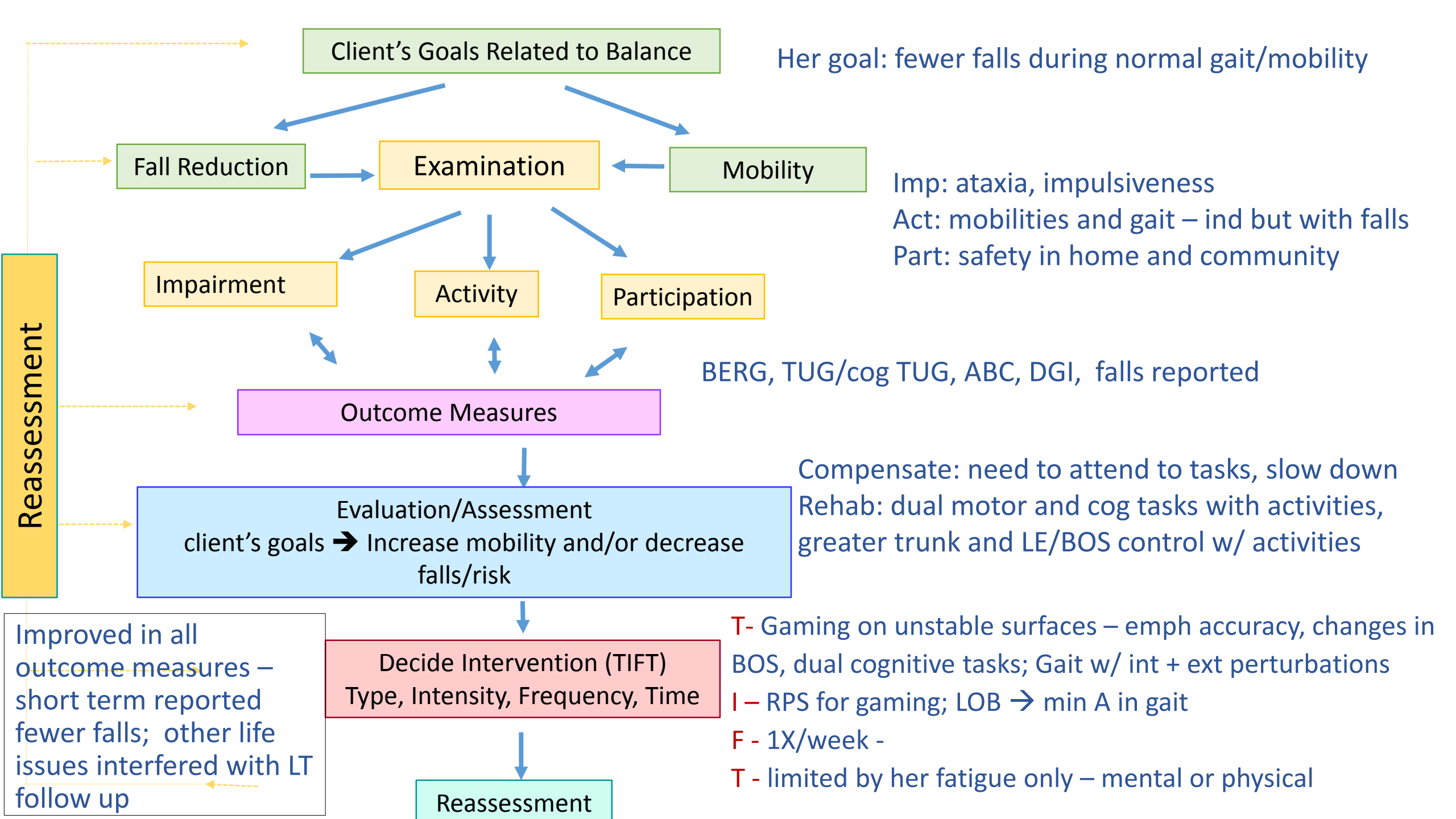
Reassessment

- Having positive or negative impact
- Impacting the way you expected (change in impairments, meeting goals, changes in outcome measures)
- Right intervention? Done correctly? Right dose? Too much/too little



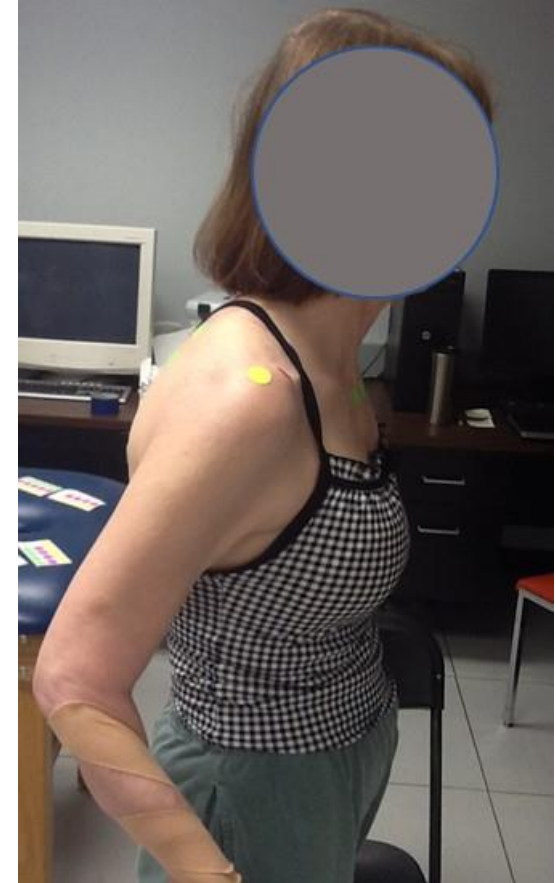
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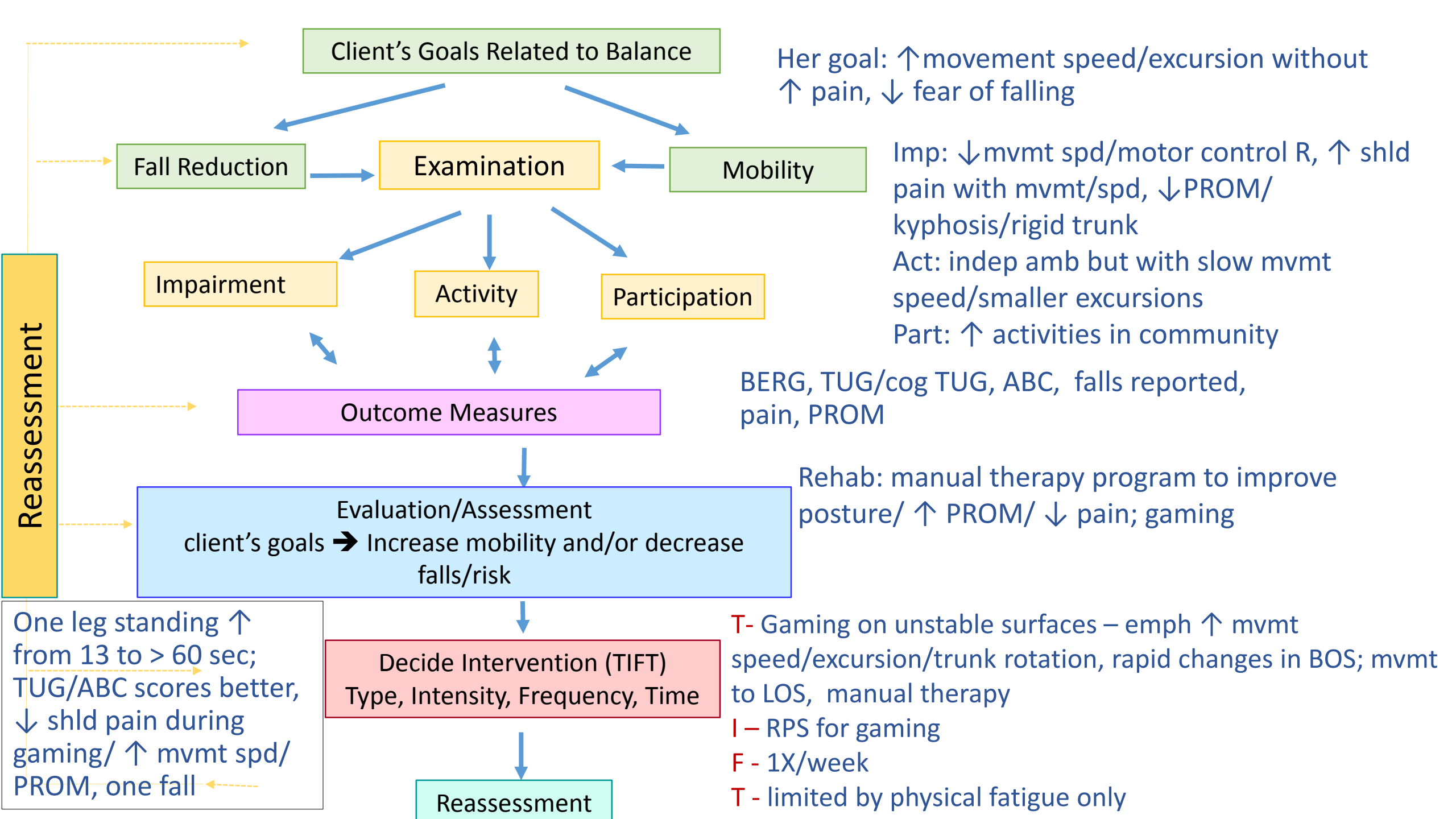
- 59 yo, female, R Cerebellar CVA - 7 yrs ago
 - Ind community amb. Job is dog sitting/walking
 - Reports falls ~ 1/week → “usually with normal movements”
 - No ROM, sensory or strength limitations
 - Significant impairments in B coordination UE and LE; Ataxia of trunk and extremities
 - Walks and moves overly quickly and ballistically
 - Impulsive with speech, movements, decisions.....
-
- BERG 51/56, (one foot in front, on one leg)
 - TUG 8.4; Cog TUG 9.6
 - ABC 62.8% (stand on toes, stand on chair, escalator, icy sidewalks)
 - Gait and mobility ataxia increases with 2nd motor or cognitive task



B.

- 70 yo, f; L CVA, 9 yrs ago
- Berg 56/56; TUG 12.12, cog TUG 15.44; ABC 88% (stand on chair, icy sidewalks); h/o falls several severe falls remotely
- Independent ambulator but slow and deliberate with movement: ↓ trunk rotation, ↓ wt shift within LOS, ↓ mvmt speed/excursion
- Trunk rigid/kyphotic, painful R shoulder with impingement/adhesive capsulitis, ↓ PROM
- Limits activities due to fear of falling, slow speed of mvmt





Open to floor for questions.....