

MODULE 7b

FATM EXERCISE STRATEGIES PART II

Learning Objectives:

1. Explain appropriate strategies to provide a training stimulus within the Balance, Mobility and Cognitive functional domains
2. Review the scientific evidence related to balance training strategies to reduce fall risk
3. Describe evidence-based programs and strategies for improving balance
4. Introduce strategies for improving gait and mobility
5. Review the evidence regarding the role of exercise in cognitive performance
6. Describe effective methods for improving cognition in older adults

Introduction

There are numerous types of exercise movements and strategies that work well for adults of all ages. Some of these options are more appropriate for higher functioning individuals while others are more appropriate for lower functioning individuals. The choice of movements and strategies should not depend on a person's age but rather on their physical abilities, goals and individual concerns (e.g. diseases, injuries). In this module we will identify and describe training strategies for 3 of the 6 functional domains and provide evidence and rationale as to why these are important.

THE BALANCE DOMAIN

Balance is a multi-factorial concept and proper balance is dependent on multiple systems and movement strategies. Balance, at its simplest, can be considered to be control of the body's center of mass over the base of support and within the limits of stability (Rose 2010). These three core concepts are critical to balance training; base of support, center of gravity control, and limits of stability.

Base of support (BOS) refers to the area beneath a person that includes every point of contact that they make with the supporting surface. These points of contact may be body parts e.g. feet or hands, or they may include things like crutches or the chair a person is sitting in. In a standing position a person's foot position determines their base of support. A wide foot position provides a large and stable BOS while a narrow or single foot position creates a small and more unstable BOS. A basic progression from larger to smaller BOS is as follows:

- Wide
- Shoulder width
- Feet together (side by side)
- Semi-Tandem
- Tandem
- Single Leg

Consider a simple standing arm curl exercise. Putting the client in a tandem stance position is going to potentially challenge their balance to a greater degree than a shoulder-width stance. Manipulating base of support is just one simple way to scale (increase or decrease) the balance demand of the exercise movement. It is very common for older individuals to widen their stance during certain exercises in order to get into a more stable position so you may need to cue them to bring their feet closer together if your goal is to challenge their balance. This is often an

uncomfortable position for many because they realize that they are much more susceptible to falling or being knocked over.

Center of gravity control (COG), also called postural control, is the ability to keep one's center of mass (gravity) within their base of support during either static (feet do not move) or dynamic (feet move or change position) activities. Most people have a center of mass that is located just below the navel and just inside the abdominal wall. Some individuals have an altered center of mass due to abdominal obesity or poor posture such as a thoracic kyphosis. If a person's COG moves outside their BOS then they will begin to fall and will need to make quick postural adjustments in order to regain their balance. How far a person can move their COG without losing balance is called their Limits of Stability (LOS).

A person's LOS tends to decrease as they get older but it can be improved through training. Having a person lean or reach for objects in different directions in a narrow standing position will challenge COG control because it causes them to shift their center of gravity around within their base of support. The goal is to have them move as far as possible in all directions (to their LOS) in order to create an overload stimulus on this system. For example, during a forward lean a person should lean far enough so that their heels are about to come off the ground while during a backwards lean they should feel their toes start to come off the ground. This can be a little scary and often the person will lean just a little too far and have to take a step. This is okay as it shows that they are truly at their limits of stability.

Using a weighted implement, such as a medicine ball or dumbbell, can challenge center of gravity control because it artificially shifts the person's center of mass closer to their LOS. Holding even a light weight out to the side (such as in a lateral raise), with the feet close together will shift their center of mass in the direction of the dumbbell requiring them to compensate through postural

adjustments or muscle activation. However, it is important that the base of support is kept small. If the feet are in a wide stance the person's center of gravity control will not be challenged because their BOS is large.

Since most falls occur during dynamic movements, such as walking, it is highly recommended to challenge COG with dynamic exercises. Walking (starting and stopping), stepping (on, off, over), and changing directions/turning are all ways to challenge COG control dynamically. Increasing movement speed and complexity add to the challenge.

Postural control exercises can be either anticipated/planned or unanticipated/unplanned/reactive. There is a growing body of evidence indicating that reactive COG exercises are much more effective because they more closely simulate real-world fall scenarios. Perturbations (external forces designed to throw people off balance) such as a small push or a trip require an individual to "react" quickly to a force that could potentially cause them to lose their balance or fall. Unexpected perturbations more closely simulate what happens in real life situations. However, purposefully tripping someone is too risky without the use of a safety harness. Therefore, other forms of perturbations are more appropriate such as giving a quick shove to a person's shoulder or hip while they are standing with feet together or even while they are walking. It is important that the person has a narrow base of support when giving perturbations because if their base is wide then it becomes more of a core training exercise rather than a balance training exercise.

Balance Overload

Remember that, like every other physiological system, center of gravity control needs to be overloaded in order to stimulate it to improve. Don't allow clients to stay in their "comfort zone" by always using a wide, stable base of support. Continually push them to adopt increasingly unstable (e.g. smaller BOS) positions during both static and dynamic movements.

Balance and Fall Prevention

As discussed in the section on the Physiology of Aging, falls are a major concern for older adults as balance and mobility deteriorate with advancing age. Falls are due to a number of intrinsic and extrinsic factors. Intrinsic factors that increase fall risk include a history of falls, age, living alone, certain medications, impaired mobility and gait, sedentary behavior, visual impairments, poor lower extremity strength and fear of falling (Todd 2004). Extrinsic risk factors include environmental hazards (poor lighting, slippery floors, uneven surfaces, etc.); improper footwear and clothing; and the use of walking aids or assistive devices (Todd 2004). Exercise has been identified as the best single intervention to prevent falls in older adults with up to 42% of falls being preventable by a well-designed exercise program (Todd 2004; Gillespie et al 2009). Other effective interventions include home safety modifications, medication reduction or substitution (especially psychoactive or CNS depressant medications), reducing fear of falling and surgery to correct cataracts.

Balance, being a multi-factorial concept, is controlled by multiple sensory (afferent) and motor (efferent) control systems. The three primary sensory systems: visual, vestibular and somatosensory - send information about the environment to the central nervous system which then determines which muscle responses to make in order to maintain balance (seated or standing). Deficits in either the afferent or efferent pathways or in the processing of information can decrease balance performance and increase fall risk. For example, if a person lacks contractile velocity (movement speed) in their muscles then they may not be able to respond quickly enough to prevent themselves from falling after a trip or slip.

All of the systems responsible for proper balance can improve with proper training which should lead to a reduction in fall risk and, ultimately, a reduction in fall prevalence. Determining which

systems are deficient for an individual is a critical step in developing an effective training program. The balance training approach may differ widely from person to person but there are a number of broad recommendations that have been culled from the research. A recent scientific literature review makes the following recommendations for balance training (Gillespie et al 2009):

Recommendation 1. Exercise must provide a moderate or high challenge to balance. Programs that do not challenge balance are not effective in preventing falls. Balance should be challenged in three ways: 1) Reducing base of support; 2) Movement of the center of gravity; and 3) Reducing the need for upper limb support during standing exercise.

Recommendation 2. Exercise must be of a sufficient dose to have an effect. At least 2 hours per week of exercise for a 6-month period appears to be sufficient.

Recommendation 3. Ongoing exercise is necessary. Balance improvements are lost quickly upon the cessation of exercise.

Recommendation 4. Falls prevention exercise should be targeted at the general community as well as those at high risk for falls.

Recommendation 5. Falls prevention exercise may be undertaken in a group or home-based setting.

Recommendation 6. Walking training may be included in addition to balance training but high-risk individuals should not be prescribed brisk walking programs. Walking training is not a crucial feature of effective falls prevention programs. Therefore, walking should only be included if it does not infringe upon or decrease the effects of the balance training.

Recommendation 7. Strength training may be included in addition to balance training. Strength training is not a crucial aspect of falls prevention programs but may be included due to its many benefits for older populations.

Recommendation 8. Exercise providers should make referrals for other risk factors to be addressed. As part of a comprehensive approach to falls reduction evidence-based

interventions targeting specific risk factors should be provided by appropriate health professionals.

A number of effective falls-reduction (balance enhancement) exercise programs have been developed, studied and implemented such as the Otago Exercise Program, FallProof™ and Tai Chi. Each of these will be discussed in greater detail.

FallProof™ is an individualized balance training program that was developed at the University of California – Fullerton's Center for Successful Aging. This multi-dimensional program utilizes a variety of assessments, many of which have been described in this course, to identify individual areas of deficit and tailor the exercise intervention strategies to address those deficits. It has been implemented successfully in a variety of individual and group settings. Qualified fitness professionals can become certified FallProof™ instructors.

FallProof™ focuses on five different areas:

1. Center of Gravity Control (COG) – Also called postural control, this is typically the first element that is addressed (other than general fitness) in a balance training program. As discussed earlier, it involves teaching someone how to control their center of mass (gravity) within their base of support (BOS).
 - Seated
 - Weight Shifting
 - Leans/Reaches
 - Stability Ball
 - Hip movements
 - Leans/Reaches
 - Standing
 - Weight shifting
 - Leans/Reaches
 - Three Dot Drill
 - Four Dot Drill

- Multi-directional stepping
- 2. Postural Strategies – There are three primary postural strategies that are utilized to maintain balance: Ankle; Hip; and Step. Ankle strategies (movement at the ankle joint) are used during quiet standing and when there are small perturbations and should be the first strategy that is utilized. When the ankle strategy is insufficient to maintain balance, such as during moderate perturbations, then the hip strategy (bending at the hip) is necessary. This is the second strategy that should be used. However, many older adults who are at high fall risk don't use their ankle and hip strategies like they should and instead move straight to the final strategy – the step strategy. The step strategy occurs when a person's COG moves outside their BOS. A step, in any direction, is required in order to prevent a fall from occurring. Each of these strategies can, and should, be trained so that they are utilized more effectively. Research into falls has discovered that many older adults tend to use alternative strategies such as bending their knees and reaching for support with their arms during an actual fall situation. These strategies are ineffective for reducing falls and may actually increase injury risk. For example, if a person reaches for a chair for support when they trip then they may be more likely to hit their head on the chair or another object.
 - Ankle Strategy
 - Ankle Leans – Anterior/Posterior, Lateral
 - Ice Cream Cones
 - Hip
 - Hip hinge
 - Heel/Toe Rocks
 - Forward reach (on floor or on half-foam roller with flat side down)
 - Catch objects (requiring forward reaching)
 - Step
 - Giant Steps
 - Forward Lunge/Mini-Lunge
 - Bug Stomps
 - Sprinter Starts
 - Fake Falls

3. Multisensory – Three sensory systems provide significant contributions to balance: Visual; Vestibular; and Somatosensory. There is a dynamic interplay between these three systems for balance control. In order to promote, and therefore train, one of these systems it is necessary to dampen the input of the other two systems. The basic recommendations for training the three sensory systems are as follows:

- Somatosensory: Remove or dampen visual input by turning down the lights, wearing sunglasses or closing eyes. Sit and/or stand on a hard surface in order to maximize somatosensory input. Performing standing exercises in socks or bare feet to enhance somatosensory input even further.
- Visual: Reduce somatosensory input by sitting and/or standing on a compliant surface such as a foam pad, stability ball or balance pad. Have clients focus on a single point to improve gaze stability. Work on visual focus by having them look from one object to another quickly (start with eye movement only and then combine head and eye movement). Track an object as it moves through the visual field (start with eye movement only and then combine head and eye movement).
- Vestibular: Reduce or remove both visual and somatosensory input using the same methods described above to promote the vestibular system. For example, having a client stand on two stacked foam pads with their eyes closed (such as during condition 4 of the mCTSIB) will require them to rely on their vestibular system for balance. The more somatosensory and visual input are dampened the greater the reliance on the vestibular system. Adding dynamic movement such as reaching or walking under these conditions will require even greater vestibular control. A separate method to promote the vestibular system is to have the person shake their

head from side to side or up and down. The head shaking method is a more advanced method that is typically used by therapists because it can easily cause dizziness and even nausea in some individuals. However, having clients move their heads to simulate looking around is appropriate. For example, have the client walk a straight line while moving their head from left to right in rhythm with each step. When they step forward with their left foot their head (and vision) should turn to the left to about 10:00 on the dial. When they step forward with their right foot their head (and vision) should turn to about 2:00 on the dial. They should be able to walk forward smoothly and quickly without deviating from their straight line. This exercise is called Walking with Head Turns or Tick-Tock Walking.

4. Gait Pattern Enhancement and Variation – Typical gait changes that occur with advancing age can make it much more difficult to navigate obstacles, uneven terrain, stairs and other environmental challenges. Training the gait pattern to be more flexible and adaptable to these challenges can improve balance and reduce a person's risk of falling. Specific gait training and re-training exercises are discussed in greater detail in the section on the Mobility domain.
5. Strength, Power, Endurance and Flexibility – Basic fitness is a foundation to proper balance and fall risk reduction. These components should be addressed if the person is deficient in any of these areas. The types of exercises utilized can vary widely and can range from basic isolation type movements to more complex functional movements. However, when dealing with fallers or those at high fall risk the exercises are typically more basic (such as those utilized in the Otago Exercise Program).

Tai Chi

Contributed by Dianne Bailey, creator of the FAI Open the Door to Tai Chi certification program

Tai Chi is an ancient Chinese martial art with many different forms that incorporates mild strengthening, balance, postural alignment and concentration by utilizing slow, continuous movements of many body parts. It has positive effects on many components of balance and fall rates in older adults (Sherrington et al 2011; Choi et al 2005). Studies report improvements in fear of falling, single-leg stance time, Berg Balance Scale, Timed Up and Go, Functional Reach and lower body strength following Tai Chi. The data indicates that the benefits are greater for independent and transitionally frail older adults compared to older frail individuals. Additionally, Tai Chi training has demonstrated improvements in cardiovascular fitness and psychological well-being (Sherrington et al 2011). Since there are many tai chi forms and training programs used in the research literature it is difficult to create an optimal prescription for older adults although a minimum of two sessions a week for 12 weeks seems to be necessary for improvements (Sherrington et al 2011).

While Tai Chi is exceptional as an exercise protocol to improve balance and reduce the risk of falling there are some basic underlying principles in Tai Chi that really drive the benefits including improved balance. Here is a list of some of these principles and how applying them to your movement can help reduce the risk of falling.

Columns: There are 3 columns in your body. One runs straight down the center of your body and the other 2 run from your shoulder vertically through your hip on both sides. These columns need to keep their integrity by keeping your shoulders above your hips. Think about a person using a walker. They are typically bent forward somewhat and have broken their “columns.” This bent

over position is a risk factor for falling. The idea of keeping the “columns” intact not only helps people keep a good posture, but encourages them to keep their eyes on the horizon and not look down all the time.

Moving from the dan tian: The dan tian is 2 inches in from the belly button and 2 inches down. It is the center of your energy in Tai Chi and it is also the center of your mass. By thinking about moving from the dan tian, you will keep your columns intact and won’t lead with your shoulders or head as you step forward.

Substantial and insubstantial: This principle deals with understanding where your weight is at all times during movement. One leg is substantial and is your base of support. The other leg is insubstantial so you can move forward, backward or to the side. As you move, you should be aware of bringing your dan tian to your substantial side. In other words, you are bringing your center of mass over your base of support which is ideal for balance.

Rooted and grounded: The idea of being rooted and grounded in Tai Chi is one of “fluid stability.” While you can imagine roots growing deep and wide from your feet, you are not glued to the ground. It’s more of an awareness through your feet and allowing them to react to the ground. It’s also the idea of lowering your center of gravity slightly which makes you more stable.

Relaxation: Believe it or not, being able to relax as you move is important for balance. When your body is tense, you are less likely to adapt to change and therefore, you are at a greater risk for falling.

Tai Chi is beneficial for more than just improving balance. As an exercise, Tai Chi can be extremely beneficial especially for our aging population in many ways. It is gentle on the joints and is accessible even for the very deconditioned. It is proven to reduce stress and anxiety,

improve sleep quality and is excellent as a tool to work on brain health as well. It has also been found to be outstanding to reduce the risk of falling not only in the general population, but in groups that are compromised in balance like those with Parkinson's disease or multiple sclerosis. As a gentle form of exercise, it can be the perfect "cross-training" for those that are still able to participate in more vigorous activities.

A high stress workout may be popular and fun, but it may not be the correct exercise prescription for some of our clients who are already over-stressed in other aspects of their lives. As fitness professionals, we need to consider the whole environment for each client and determine if an exercise protocol that is proven to reduce stress and anxiety should be a part of the mix. Tai Chi has been described as "movement meditation." Again, research abounds proving Tai Chi and meditation can reduce blood pressure, relieve anxiety and allow the body to turn off the chronic sympathetic nervous system response. Because Tai Chi is slow moving and gentle on the joints, it is sometimes dismissed as exercise. But it has also been proven to be equivalent to "moderate aerobic exercise" and therefore qualifies for that level of activity in the recommendations for weekly participation in exercise. As a fitness community, we have accepted yoga as an excellent stress-reducing exercise. Tai Chi is an approachable alternative for our clients who don't enjoy or can't do yoga.

The fear of dementia is very real, especially as people approach their "golden years." Mindful movement is an important piece of the puzzle to help keep the brain young and supple. Tai Chi is proven to improve executive functioning. And bonus: improvement in executive functioning also is proven to improve balance and gait! Tai Chi movements involve coordination, sequencing and many of these movements cause the participant to cross the midline which in turn causes the two hemispheres of the brain to communicate. Because it is a martial art, you must memorize a

sequence of movements in order and always keep a sense of an opponent to make the movement meaningful. Even after the memorization is complete, applying all of the underlying principles to each movement is challenging and forces you to concentrate and stay “in the moment.” Much like dancing, Tai Chi improves brain health by combining physical movement with mindful involvement.

No matter how many testimonials you have on your walls, the number of certifications that you have and the honest intention on your part to help each client be the best version of his or herself, there is a huge portion of your community that will never walk through your doors. And if they never contact you, you won’t be able to help them in the way that you know you can. These people may have been hurt in the past by a program that was too aggressive for them. Or they may just be too intimidated because they have never really done any exercise at all. And yet, this is the population that really needs our help. Tai Chi is a great “door opener” because of its gentle movement. Many of these people have been told by their physician to find a Tai Chi class. If you offer Tai Chi, it provides an opportunity for you to gently introduce exercise to them. You will be able to meet them “where they are” and be able to guide them into other forms of exercise later because they will already have a level of trust in you as their fitness guide.

Most health and fitness professionals have very little experience with Tai Chi and haven’t even considered adding it to their skill set so we have created a few short videos to introduce you to this powerful form of exercise. The FAI *Open the Door to Tai Chi* online certification program has been designed to teach fitness professionals how to incorporate Tai Chi movements into the training routines for their older clients without years of intensive study, practice and travel. Tai Chi can actually be quite easy to learn and begin using. For more information on the FAI Open

the Door to Tai Chi certification program go to www.functionalaginginstitute.com or www.taichisystem.com.

Otago Exercise Program

The Otago Exercise Program is an evidence-based fall risk reduction program targeting older adults developed at the University of Otago in New Zealand. It is an individually tailored, home-based, balance and strength fall prevention program that is designed to be delivered by a physical therapist over the course of 52 weeks. It has been modified and adapted in the United States by the Centers for Disease control and Prevention (CDC). After several research and demonstration projects the program is now being disseminated broadly to physical therapists but other professionals may use the program.

There have been four randomized controlled trials assessing the efficacy of the Otago program including over 1,000 men and women aged 65-97 years old. The results of these trials can be summarized as follows:

- The Otago Exercise Program can reduce falls and fall related injuries. The program was most effective for adults 80 years and older.
- Men and women benefited equally.
- Participants' strength and balance improved markedly as assessed by the Chair Stand and the Four-Stage Balance tests.
- While older adults with and without previous falls benefited equally, if resources are limited, first offer the Otago program to adults 80 years and older, as Otago was shown to be particularly effective in reducing falls and injuries among individuals in that age group.

The program begins with three assessments: 30 Second Chair Stand Test; Four-Stage Balance Test; and the Timed Up and Go Test. The exercise program focuses on strength, balance retraining

and walking exercises based on the results of these three assessments. Strengthening and balance retraining exercises are scaled into four levels of difficulty so that the individuals can progress in each exercise as they are able. Adjustable ankle weights are used to load some of the exercise movements.

Since the program focuses on older adults with a history of falls or who are at high fall risk the exercises used are basic. Lower-body strengthening is included at all levels while the balance exercises increase in number and complexity as the client progresses. All of the balance exercises used in the Otago Program are appropriate and effective for older clients as long as they are challenging for the client to perform. They include a mix of static balance, dynamic balance, and gait exercises. The specific exercises and levels are shown in the images below (Source: Tools to Implement the Otago Exercise Program: A Program to Reduce Falls, First Edition. CDC 2020).

Otago Exercise Levels and Repetitions			
WARM-UP (FLEXIBILITY) EXERCISES			
Head Movements	Stand tall, 5 times on each side	Trunk Movements	Stand tall, 5 times each side
Neck Movements	Stand tall, 5 times	Ankle Movements	Stand or sit, 10 times
Back Extension	Stand tall, 5 times		
STRENGTHENING EXERCISES			
Knee Extensor	ALL 4 LEVELS Ankle weights are used to provide resistance; perform 10 repetitions of each exercise, when able to do 2 sets of 10 repetitions add/progress weights.		
Knee Flexor			
Hip Abductor			
Calf Raises	LEVEL C 10 repetitions, hold support, repeat	LEVEL D 10 repetitions, no support, repeat	
Toe Raises	10 repetitions, hold support, repeat	10 repetitions, no support, repeat	

Otago Exercise Levels and Repetitions

BALANCE RETRAINING EXERCISES

	LEVEL A	LEVEL B	LEVEL C	LEVEL D
Knee Bends	10 repetitions Hold support	10 repetitions No support <i>or</i> 10 repetitions Hold support, repeat	10 repetitions No support, repeat	10 repetitions, 3 times No support
Backwards Walking		10 steps, 4 times Hold support		10 steps, 4 times No support
Walking And Turning Around		Walk and turn around (do a figure 8) twice Use walking aid	Walk and turn around (do a figure 8) twice No support	
Sideways Walking		10 steps, 4 times Use walking aid	10 steps, 4 times No support	
Tandem Stance (Heel Toe Stand)	10 seconds Hold support	10 seconds No support		
Tandem Walk (Heel Toe Walk)			Walk 10 steps Hold support, repeat	Walk 10 steps No support, repeat
One Leg Stand		10 seconds, Hold support	10 seconds, No hold	30 seconds, No hold
Heel Walking			10 steps, 4 times Hold support	10 steps, 4 times No support
Toe Walk			10 steps, 4 times Hold support	10 steps, 4 times No support
Heel Toe Walking Backwards				Walk 10 steps No support, repeat
Sit To Stand	5 stands, 2 hands for support	5 stands, 1 hand <i>or</i> 10 stands, 2 hands for support	10 stands, no support <i>or</i> 10 stands, 1 hand for support, repeat	10 stands No support, repeat
Stair Walking	As instructed	As instructed	As instructed	As instructed, repeat

THE MOBILITY DOMAIN

Mobility refers to a person's ability to navigate within their environment. This can include walking, jogging, running, getting into and out of a chair, getting down to and up from the floor, climbing stairs, negotiating obstacles, etc. Mobility is an essential piece of overall function that is dependent on and influenced by every other functional domain. Without adequate strength and power, a person may struggle to get out of a chair or up from the floor. Without adequate cardiorespiratory endurance, a person may not be able to travel long distances. Without adequate balance, a person may not be able to navigate obstacles within their home or the community.

Since mobility is a hallmark of overall function it is important to train mobility. This is best accomplished through mobility tasks that integrate the other functional domains and represent "real world" challenges. Through these challenges the person learns movement strategies and how to best use their new-found physical abilities. Gaining strength and joint mobility in the lower body are important and beneficial but the body needs to learn how to use these in functional patterns. This is akin to a tennis player working on their shoulder internal/external rotation and transverse core stability but not ever swinging a tennis racket. The improvements made in the individual components of the tennis swing need to be used to perform the task of swinging a tennis racket in order to be successful.

Mobility tasks may be used as a sort of litmus test of functional improvement. Most older individuals don't necessarily care about increases in the amount of weight they are lifting on a machine as much as improvements in their functional abilities. A person who cannot get down to and up from the floor without considerable assistance who can now do so with only the "aid" of a chair has obviously made some significant improvements and can more easily realize the benefits of their exercise program. Therefore, a functional aging training program should include mobility

tasks appropriate the person's current level of function. One of the most basic aspects of mobility that should be addressed is the gait cycle.

Although a normal gait pattern seems very simple, it is actually very complex. Gait is a three-dimensional activity that involves a great deal of musculature and proper motor activation patterns. Deficits in joint mobility or stability, muscle strength or endurance, center of gravity, sensory input or motor sequencing can easily disrupt the normal gait cycle. The gait cycle can be broken down into two primary phases: stance phase and swing phase. The stance phase consists of the entire time the lower limb(s) and foot are in contact with the ground. The swing phase consists of the entire time the lower limb and foot are in the air.

During the stance phase there is a brief period when both feet are in contact with the ground which is called double support. Single support occurs when only one foot is on the ground. A normal gait pattern is smooth, linear, has a narrow width foot position, uses long strides, has a tall trunk posture and is of adequate speed. As an individual gets older and begins to accumulate physical deficits in the sensory and motor systems the gait cycle begins to break down.

The "senior shuffle" refers to the stereotypical gait pattern of a low functioning older adult. It is characterized by stooped posture, wider foot position, smaller strides, quicker strides, increased lateral movement, less toe-off for propulsion (i.e. less plantarflexion), slower gait speed and an increase in gait pattern disruptions (it is no longer smooth). As discussed earlier, slow gait speed is a hallmark sign of overall functional impairment that predicts future disability. It is also one of the earliest signs that the gait cycle (without formal gait analysis) is beginning to become impaired.

There are many factors that can impair the gait cycle including pain, cognitive function, orthopedic conditions and neurological conditions. In many cases the gait pattern can improve considerably

with proper exercise training, especially if the changes are primarily due to deconditioning. However, in some cases there are underlying factors that need to be corrected or addressed because these will continue to affect the gait cycle. For example, a person with severe osteoarthritis who has no cartilage left in their knee will not be likely to normalize their gait pattern through exercise training alone. Exercise, in the absence of a total joint replacement, will do very little to minimize the pain and immobility associated with this condition.

The primary goal of gait training is to make the gait flexible and adaptable. This means that the person is able to negotiate environmental challenges such as a sloped floor/ground, uneven surfaces (grass, rocks), unstable surfaces (slippery spots), obstacles (curbs, cones, etc.), moving in different directions (forward, backward, lateral), directional changes, and the need to accelerate or decelerate quickly. In order to accomplish this a wide variety of gait-related tasks must be used that will “force” the individual to emphasize or accentuate normal gait mechanics and counter the “senior shuffle” mechanics. For example, individuals tend to use quicker strides because they do not want to be in single limb support since that requires a greater degree of balance and instability. Challenging clients to take very slow steps with a prolonged single stance phase will improve this one aspect of their gait mechanics. A list of sample exercises and their benefits are listed below.

- High knees and straight leg marching – single leg balance, postural stability, hip flexor strength, hip mobility
- Narrow walking (semi-tandem, tandem) – balance, counters wide foot position
- Wide walking (walk the rails, monster walks) – multi-directional movement, hip mobility
- Large strides – hip mobility, counters short strides, leg strength
- Walking on toes – plantarflexion strength and endurance
- Walking on heels – balance, center of gravity control
- Sideways walking – multi-directional movement
- Backwards walking – multi-directional movement
- Braiding patterns (when one foot crosses the other) – hip mobility, balance, multi-directional movement
- Starts and stops – acceleration and deceleration, postural control, center of gravity control
- Fast walking – counters slow gait speed, balance

- Step over the sleeping dog – single leg balance, postural stability, hip flexor strength, hip mobility

These movements can be combined and scaled according to the person's level of comfort and physical ability. It is appropriate to provide a balance aid such as a rail, chair, walking stick or hand for support for those that need it. Over time the amount of balance support should be steadily decreased. Others may need more of a challenge. Having a person perform a backwards tandem walk slowly while on their toes is an advanced variation appropriate for higher functioning individuals. Advanced variations of gait pattern movements include skipping, galloping, hopping, agility drills (such as with an agility ladder) and obstacle courses. Remember that each individual needs to be challenged if they are to make improvements.

Agility training is a higher level of gait and mobility because it requires rapid and accurate foot movements. These are great exercises to use with your independent and fit older clients. Examples of agility exercises include:

- Quick feet over a line and back (front to back; laterally)
- Four square stepping
- Switch feet forward and backward over a line
- Hopping over a line (forward/backward, sideways)
- Ladder drills
- Carioche (aka grapevine)
- Cone drills

Since postural changes and postural stability can have a negative impact on gait patterning it is recommended to continually monitor their trunk position. Cue them to stand erect as if a string is pulling them up through the top of their head. Having them slightly brace their core is also helpful. These two strategies will help offset the typical kyphotic posture and will improve their balance.

An exaggerated arm swing will also facilitate better movement of the lower limbs since gait is a contralateral movement pattern. Sprinters often work on faster arm swing as a strategy for improving their leg speed. Likewise, driving the right arm forward and left arm backward during a high knee marching pattern with the left leg lifted reinforces this contralateral pattern and facilitates a better engagement through the core.

One of the additional considerations during all gait-related tasks is the person's use of their somatosensory systems. Since many people are visually dependent it is very common for them to perform their gait exercises while looking at the ground or their feet. This is okay when they are first learning a new gait pattern as it helps them to build confidence and learn the pattern. After a few repetitions or a single set or a single session it is time to adjust their visual input. Instruct them to focus on a fixed object straight ahead at about eye level while they are performing the gait exercises. The fixed visual gaze will help them to balance a little better but it will also keep them from looking at the floor or their feet. This has a very practical application since it is important to constantly scan the environment when walking in the community. This helps to keep the person aware of their surroundings including any dangers (such as a person on a bicycle that is about to run into them). You can simply cue them with an "eyes up" command when you see them looking at the ground. An advanced variation that requires a higher level of balance control is to have them perform the movements with their eyes closed.

Gait Exercise Training Tip

When performing any gait movements cue the clients' vision to fix on an object at eye level across the room rather than allowing them to look down at their feet. You want to reduce their visual dependency so always cue their vision. I like to say "eyes up" during all gait movements. If they have a hard time breaking the habit of looking down at their feet then have them hold a light object in front of them, such as a foam pad or empty laundry basket, to block their view of their feet. However, when introducing a new movement pattern it is wise to allow them to look down until they have developed movement competency and confidence before having them look up.

Chair drills are an effective way to combine many elements of mobility and provide an endless variety of movements. Position chairs in a row about 6 feet apart with each chair facing opposite directions (first chair faces left, second chair faces right, etc.). Have the client start in a seated position in the first chair. On your command of "go" instruct them to move to the next chair, sit down and stand up again and continue until they have sat in every chair down the line and back again to end up in the first chair. They should do this as quickly and as safely as possible. The chairs can be arranged in virtually any arrangement, directions and distances depending on the ability of your clients. It will be important to monitor their balance by following them or having multiple spotters positioned along the way.

Getting down to and up from the floor are also mobility skills that need to be worked on. Low-functioning older adults are typically fearful of getting on the floor and typically avoid it. The fear may come from an expectation of falling or an inability (perceived or real) that they will not be able to get back up again. Confidence can be gained over time by teaching proper movement strategies and through repetition. Another reason may be that it is uncomfortable for their knees or back to kneel or lie down on a hard surface.

There are a number of movement strategies that can help older adults be successful with these tasks. Below is a sample sequence for getting down to and up from the floor.

1. Stand in front of a sturdy chair
2. Place both hands on the seat or arms of the chair
3. Place one leg slightly behind you (preferably your weaker leg)
4. Use your arms to help you lower your back knee down to the ground into a half-kneeling position
5. Use your arms to help you into a full kneeling position
6. Place one hand on the floor at a time to get into a quadruped position
7. Lower down onto your forearms and elbows one arm at a time
8. Move one leg back and lower onto your shoulder on the same side using your top hand on the floor to help lower your upper body
9. Extend your other leg and roll onto your back
10. Roll onto your side with your bottom leg extended and top leg bent
11. Roll onto your elbow and forearm by using your top hand on the floor to push you up into position; your top knee should be on the ground
12. Draw your extended leg up so that you are on both knees while you press your upper body up to get onto both hands (quadruped position)
13. Crawl to get close to the chair so you can place one hand at a time on the seat or arms
14. Position your body so you are facing the chair
15. Use your arms to help you get into a half-kneeling position
16. Use your arms and legs to get into a standing position with your hands still on the chair
17. Fully stand up

There are other strategies that may be more helpful for certain individuals. For example, once you are down into a half-kneeling position you could also place your hand (opposite of your front leg) on the floor and roll onto the hip on your hand side to get into a seated position. More functional individuals can perform the movement without the chair but may need to brace their hands against the thigh of their front leg when they lower into a half-kneeling position. If individuals are struggling with getting down to and up from the floor it is beneficial to do some assessments to see where their deficits are. Work on improving these deficits while also practicing this skill.

THE COGNITIVE/EMOTIONAL DOMAIN

Contributed By: Ryan Glatt, MSc Applied Neuroscience, Creator of the Brain Health Trainer Course

As mentioned in the chapter “Physiology of Aging - Cognition”, exercise has been shown to improve cognition and brain health in older adults, while reducing the risk for dementia and cognitive decline. This chapter will focus on implementing cognitive demands within exercise prescriptions and exercise sessions to potentially impact cognition positively across the lifespan, especially when added to an existing multimodal exercise prescription. To review what exercise and neuroscience research has been found to most significantly slow cognitive, we have summarized these highlights below:

- The Physical Activity Guidelines for Americans, 2nd Edition, recommends 150 minutes of moderate-to-vigorous aerobic exercise per week, which includes benefits for cognitive function and brain health (Piercy, et al. 2018)
 - Additional benefits have been found for more minutes (300 minutes per week), as well as the addition of resistance training and neuromotor training
- A multimodal exercise program, consisting of at least aerobic exercise and resistance training, can slow cognitive decline and improve cognition more than single modality exercise programs (Vaughan, et al. 2014).
- A systematic review has demonstrated that 52 hours of exercise, regardless of modality, was associated with significant improvements in executive functioning and processing speed in older adults with and without cognitive impairments (Gomez-Osman, et al, 2018).
- Several systematic reviews have demonstrated that exercise that is combined with simultaneous cognitive demands may improve cognition more than physical or cognitive exercise alone, in older adults with and without cognitive impairment (Joubert, et al. 2018, Law, et al. 2014, Yang, et al. 2019).

In order to better understand the skill-based effects of exercise on the brain, it is helpful to identify them as either open skills or closed skills. Closed skills are fixed, single and predictable tasks which have defined time and space and are performed in static environments. Examples of closed

skills would include using resistance exercise machines (e.g. chest press, leg extension) and linear exercises with repetitive movements (e.g. pushup, bicep curls, walking on a treadmill). Open skills are best understood as tasks in which space and time are not constrained, and interaction with other persons or objects, as well as dual-tasks, are present. In other words, open skills are performed in dynamic and changing environments. Examples of open skills include multi-planar, functional exercises, and activities such as dance, sports, and martial arts. While both open and closed skills are beneficial to the brain, open skill exercises seem to be better at improving certain cognitive functions when compared to closed skills (Gu, et al. 2019).

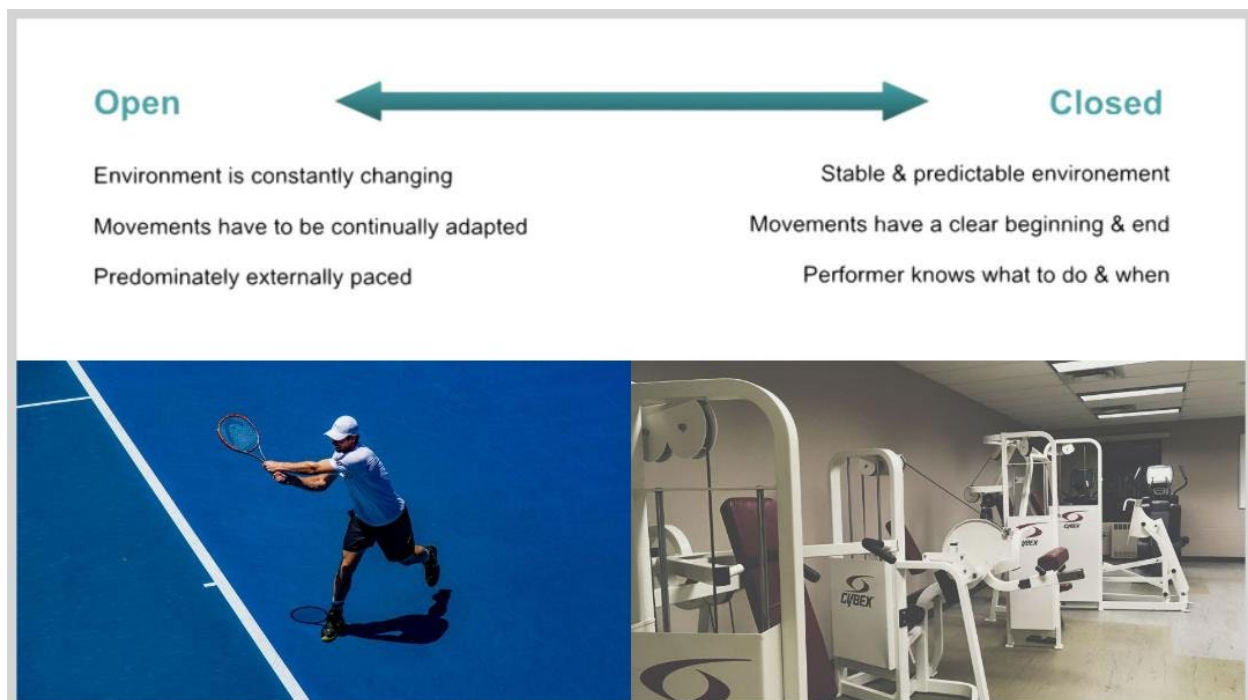


Figure 1: The Open Skill and Closed Skill Continuum. Copyright @ 2018-2021, Brain Health Trainer Course, Ryan Glatt, All Rights Reserved.

Various activities are considered to be “skillful”. In the context of exercise and physical activity, skill relates to the acquisition of knowledge or ability that enables one to complete a movement or task successfully. Closed skill activities are relatively easy to learn and perform and are therefore

considered to be lower skill activities. Open skill activities tend to be more difficult to learn and perform and are therefore considered to be higher skill activities. There are a number of factors that are thought to contribute to cognitive reserve and brain health for these skillful activities. They include:

- Novel experiences
- Stimulating activities
- Cognitive demand
- Social support and interaction
- Facilitating positive mood states

Exercise and skillful activities that possess cognitive demands are thought to improve cognition via the process of skill acquisition, both with and without simultaneous metabolic demands (Tomprowski, et al. 2019).

Measuring Cognitive Load

While fitness professionals have tools to gauge metabolic and physical exertion, the measurement of perceived cognitive effort is less common. Similar to the Rate of Perceived Exertion (RPE), whereby 1 - 10 (or 6-20) is utilized to quantify perceived physical exertion, a similar scale may be used for gauging “mental effort”. A scale of 1 - 10 (1 representing low mental demands, 10 representing significant mental demands) can be utilized to gauge “cognitive load” by asking clients “How mentally demanding was the task or activity?” By utilizing tools such as the NASA Task Load Index, which provides additional information on perceived performance, frustration, effort, as well as physical and mental demands, fitness professionals can better understand the

psychological and cognitive experiences of various types of physical activities (Tomprowski, et al. 2006).

Similar to how 60 - 80% of maximum heart rate (or moderate-to-vigorous intensity, or a 6-8/10 RPE) is recommended for various brain and body health outcomes (Piercy, et al. 2018), it may be recommended that skill-based activities should aim to have a cognitive load of 6-8/10 on the cognitive load scale. Considering that novel activities will often be more cognitively demanding due to the initial phases of motor learning (which have higher working memory demands), it is generally recommended that novel versions of the activity in question, or new activities in general, are recommended regularly in order to provide a progressive overload. For example, it may be recommended that exercises become more coordinatively complex, more difficult dance routines are learned, or more difficult opponents are faced within exercise, physical activity or sport sessions. It may also be recommended that every 3-6 months, an individual adopts a new skill-based activity to add or substitute in their exercise and physical activity program. However, it is more important to encourage lifelong participation in skill-based exercise, more than it is important to promote novelty. To summarize, both novelty and task difficulty may contribute to cognitive load and both should be used to progressively overload the cognitive domain.

It also may be worthwhile to consider the cognitive sub-domains that are likely targeted within certain tasks. There are four primary cognitive sub-domains that are worth defining; Memory; Attention; Processing Speed; and Executive Functioning. These four subdomains make up the core factors for designing exercise programs to enhance specific aspects of cognition.

Memory may be defined as the encoding, storage, and/or retrieval of information (whether it be verbal, visual, and/or procedural information). Tasks that are likely to challenge memory functions

include novel skills, choreographed routines, procedural instructions, and tasks that require spatial memory (where certain actions occur or where objects are).

Attention includes attending (visually or auditory) to a stimulus in sustained (focused), selective (filtering out distractions), switching (alternating attention between stimuli), or divided capacities (attending to multiple stimuli simultaneously). Attentional demands are likely to be present in skill-based routines where attending to an opponent, instructor, or partner is required to successfully accomplish tasks. Attending to visual or auditory cues will also demand attention, as will dual-tasks (when a physical task and cognitive task are performed simultaneously). The filtering of distractions to focus on a task at-hand, or switching from one task to another rapidly, may emphasize different types of attention (selective and switching attention, respectively).

Processing speed may be understood as the length of time required to respond to one or more stimuli, which may also be related to reaction time. Processing speed demands are likely to be present in power training, speed-agility-quickness (SAQ) training, or any activities dependent on reaction time or temporal (speed) demands. The NASA Task Load Index also has a scale for temporal demand by asking the question “How hurried or rushed was the task or activity?”, which may help to quantify perceived speed constraints, as will timing repetitive tasks.

Executive functions are more complex cognitive functions that include impulse control, cognitive flexibility (responding to unexpected circumstances), working memory (temporary information storage), planning, and organizing, among other cognitive functions. Executive functioning demands may be present in a variety of examples, including activities where impulses need to be controlled, extensive motor planning is required, responding to unpredictable stimuli in complex environments, and/or the reversal or scattering of exercise order.

Exercise Video Example 1: Ball Toss with Cognitive Load

This video demonstrates an exercise that utilizes the concept of a simple ball toss during a simultaneous motor activity, which could include a balance (i.e. split stance), strength (i.e. squats or lunges) or a cardiovascular movement (i.e. marching in place). The cognitive demands, temporal (or speed) demands, and/or the cognitive domain specificity of this exercise can be modified as demonstrated in the video. For example, a faster ball toss may increase processing speed demands, whereas creating a choice-reaction time variation (i.e. calling out to whether to catch with the left or right hand) may create greater demands on impulse control, a domain of executive functioning.

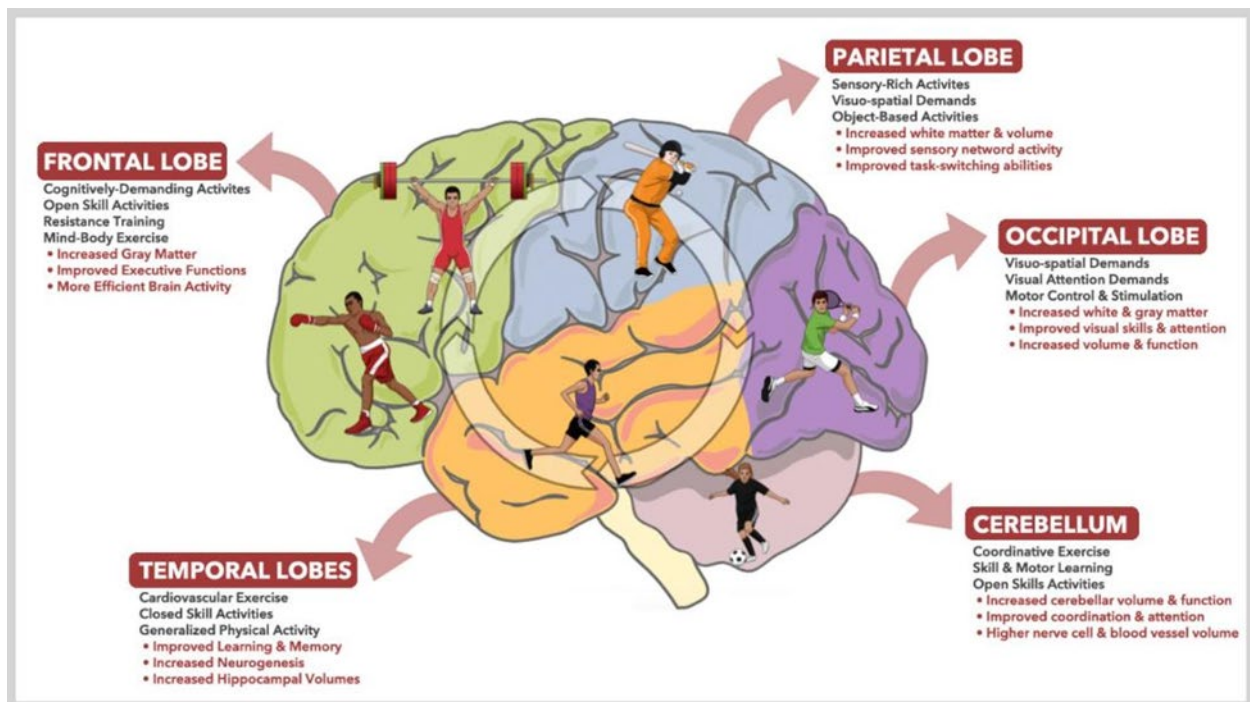
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Exercise Video Example 2: Balance Variations with Cognitive Load

This video demonstrates an exercise that utilizes the concept of a cognitive task utilizing colored and numbered dots during a simultaneous motor activity, which in this case is a balancing task. The balance task can be modified by re-arranging the directions in which the limbs reach towards and/or by modifying the base of support or surface. The cognitive demands, temporal (or speed) demands, and/or the cognitive domain specificity of this exercise can be modified by increasing the speed at which auditory and/or visual cues are given, as demonstrated in the video. Greater complexity may be elicited by giving a visual cue and an auditory cue simultaneously, instructing the client to attend to one over the other, forcing them to filter out the distracting information, therefore utilizing more executive functioning.

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Since cognition is integrated and dynamically emphasized across all sorts of different tasks and exercises, it can be challenging for fitness professionals to isolate and target specific cognitive functions or subdomains without more education and training. As seen in the following image, different types of activities affect different parts of the brain to greater or lesser degrees depending on the specific demands of the activities. However, many activities, such as sports, require similar demands and are therefore beneficial to multiple brain regions. Therefore, it is easier to incorporate more open skill activities that include the characteristics described earlier that will integrate cognitive function in a more general manner across brain regions.



Programming for Different Brain Health Clients

The application of brain health programming is dependent on the overall and cognitive health of the participant. The “Worried Well” are healthy older adults who are concerned about their brain

health and want to know how they can protect themselves against getting dementia. Since they do not suffer from any cognitive impairments they can engage in a higher volume of more intense multidomain exercises of high complexity. Those with “Subjective Cognitive Impairment” feel that their cognitive abilities are starting to deteriorate. They can also participate in a higher volume of more intense exercises but they should be of more moderate complexity. Individuals with documented Mild Cognitive Impairment will need a moderate intensity program that is of lower to moderate complexity so that they can experience success and build confidence. Individuals diagnosed with dementia require a low to moderate intensity program of shorter volume and low complexity with a strong social component to make it as enjoyable as possible for them.

	Frequency	Intensity	Time	Type	Qualitative
Worried Well	4-5x/week (moderate-frequent)	Moderate-High	30-60 min	Multidomain High Complexity	Challenging Stress Reduction
SCI	4-5x/week (moderate-frequent)	Moderate-High	30-60 min	Multidomain Moderate complexity	Skill-Based Enjoyable
MCI	3-7x/week (moderate-frequent)	Moderate	20-60 min	Low-Mod Complexity	Sense of Success Enjoyable
Dementia	Frequent (as willing)	Low-Moderate	10-30 min	Low Complexity	Enjoyable Social

Individuals with mild cognitive impairment (MCI) represent greater risks for developing dementia than those without MCI. Interventions to enhance cognition or prevent further decline are

potentially very valuable among individuals with MCI. Exercise, particularly aerobic exercise, seems to be beneficial for improving global cognition in individuals with MCI. Studies in populations with MCI that compare different types of exercise on cognition, observe the effects on cognitive sub-domains, and measure psychological outcomes are lacking. Therefore, the evidence of exercise on these health outcomes are inconclusive.

Both aerobic and resistance training have demonstrated to improve global cognition in individuals with MCI. Higher intensity, more frequent (3 days a week) resistance training programs were found to lead to significant improvements in global cognition. Recent research reviews have compared the effectiveness of different types of exercise on global cognition in older adults with MCI, and found that resistance training had the greatest effect, followed by exergaming, then aerobic exercise, and finally mind-body exercise (Broadhouse, et al. 2020). Regardless, adherence to ACSMs recommendations of 150 minute of moderate-vigorous intensity exercise, including aerobic exercise, should be prioritized. Client-centered approaches in creating an exercise program for individuals with cognitive issues should be considered, such as; exercise preference, learning ability, equipment, convenience, caregiver involvement, and technology.

Multi-modal exercise programs may not always be compatible for individuals with MCI given their inherent task and organizational complexity. Older adults with cognitive impairments may respond to simpler, single component physical exercises rather than a more complex multi-component program. While some research has shown that in individuals with dementia, exercise may have little-to-no effect, and in some cases speed the progression of dementia, other studies have demonstrated improvements in global cognition with exercise. Although more research is needed, combined cognitive-motor interventions may have positive effects in both individuals with MCI and dementia (Ohman, et al. 2014). Some studies have found that combined cognitive-

physical interventions produce superior cognitive outcomes than single-modality interventions (Karssemeijer, et al. 2017) but this finding has not been consistent (Song, et al. 2018).

Although outcomes are conflicting regarding the cognitive benefits of exercise it is still recommended that individuals with dementia participate in exercise programs in order to enhance physical function and to improve mood states. While combined cognitive and physical exercise interventions may improve global cognition in older adults with MCI or dementia it also seems to improve mood if it is of the right intensity and complexity. Exercise programs that create excessive levels of stress or confusion or are met with refusal should be modified or excluded in favor of more preferred modes.

Brain Health Trainer Certification

Those seeking more in-depth training on how to create effective brain health programs that also enhance physical function or to target specific aspects of cognition in individuals that may have specific deficits should enroll in the Brain Health Trainer (BHT) course offered by FAI. The BHT takes a deeper look at neuroscience, cognitive aging, cognitive conditions and exercise prescription/program design to improve brain health and cognition. It will equip you with the necessary knowledge, skills and tools to address the cognitive needs for a broad range of individuals including the worried well, subjective cognitive impairment, mild cognitive impairment, dementia, and other populations.