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Dizziness & Vertigo

Overview

Dizziness and vertigo are symptoms stemming from a multitude of pathologies that can often involve several anatomical systems, and can be attributed to both local and systemic factors. As a purely subjective complaint, dizziness is nonspecific and may be difficult to trace because its source may involve several structures, whereas true vertigo almost always involves the vestibular system directly. Vertigo can best be described as an illusion or hallucination of movement that results in a sense of falling, spinning, swaying, or rotating. Because of the obscured sense of equilibrium, this symptom is often accompanied by nausea, sweating, vomiting, oscillopsia, and/or dizziness itself (Burmeister et al. 2010). In addition, the presence of vestibular dysfunction significantly increases the likelihood of falls, which makes it a potentially costly risk factor in older individuals (Agrawal et al. 2009).

Benign Paroxysmal Positional Vertigo (BPPV) is the most common cause of vertigo, which accounts for about 20-30% of diagnoses (Von Brevern et al. 2006). BPPV is often first detected by a positive history of vertigo-like symptoms elicited by rolling over in bed, lying down/getting up too quickly, bending over, or looking up (Solomon 2000). However, symptoms alone are not enough to confirm a diagnosis and a thorough differential diagnosis must consider each aspect of the complaints to rule in/rule out various systems. It is imperative that a clinician fully understands the neuroanatomy of the vestibular apparatus as well as its pathways in order to accurately diagnose and treat vertigo (Umpred 2013).

Pathology – Anatomy

The peripheral vestibular apparatus is located in the inner ear and is comprised of two symmetrical labyrinths, each containing three semi-circular canals and two otolith organs called the utricle and saccule. The semi-circular canals are oriented at right angles to each other and are called the horizontal canal, superior canal, and posterior canal. Their primary function is to detect angular acceleration and rotatory changes during rapid changes in head position, and they are most sensitive to motions that correspond to their respective direction (Umphred 2013). When there is an acceleration of the head, fluid in the membranous canals called endolymph passively moves in the opposite direction of the acceleration, which is interpreted by both canals to relay information about direction and velocity to the brain. Simultaneously, the cupula, a flexible structure at the end of the canal called the ampulla, bends to stimulate hair cells that send additional information to the brain (Kandel 2000).

The otolith organs, named for the presence of calcium carbonate crystals called otoconia, serve to detect gravity and linear acceleration in the sagittal plane (saccule) and the horizontal plane (utricle). These organs contain tiny hair cells that are immersed in a gel-like substance called the macula and project to an otolithic membrane that communicates with the millions of otoconia to sense gravity and movements as they occur (Umphred 2013). Perturbations of the otoconia will initiate a shift of the otolithic membrane to deflect hair bundles, and provide an afferent response to the brain about the magnitude and orientation of any acceleration. The otolith organs along with the semicircular canals respond to various movements through a precise sequence of excitation and inhibition from right to left and are compared bilaterally by the central nervous system to make sense of the movements (Kandel 2000).

The hair cells of the vestibular organ transmit afferent information, both tonically and phasically, via the vestibulocochlear nerve to the vestibular nuclei of the brain stem before traveling to other parts of the central nervous system such as the cerebellum, vestibulospinal tracts, and the medial longitudinal fasciculus (Guyton & Hall 2006). With time, accommodation of the nerve fibers can occur due to a decrease in vestibular afferent firing (Kandel 2000), however many individuals experience episodic symptoms that require treatment by a healthcare professional. Interventions will often include symptom-provoking maneuvers to encourage adaptation to the stimulus (Umphred 2013). Efferent stimulation of the vestibular organ hair cells is poorly understood but has notable effects, with some hair cells showing decreased excitability and other exhibiting increased excitability (Kandel 2000).

Since the neural projections from the vestibular apparatus to the central nervous system are far-reaching, there is an important association between it and many other structures. For example, the intimate relationship between the vestibular and oculomotor systems allow for the stable perception of images during movements and contribute heavily to a sense of balance and equilibrium. The Vestibulo-Ocular Reflex (VOR) refers to the reflexive stabilization of the eyes during head movements and serves to counteract information from the semicircular canals regarding speed and direction. Similarly, the Vestibulospinal reflex involves projections down the spinal cord that detect changes in vertical posture and transmit corrections to avoid falls (Kandal 2000).

Clinical Manifestations - Vertigo

Dysfunction of the vestibular organ, nerve, or central projections can result in vertigo. Vertigo can have many causes, the most common being Benign Positional Paroxysmal Vertigo (BPPV), which is an excessive response of the vestibular organ from otoconia traveling into the

semi-circular canals – most commonly the posterior canal. The cause of BPPV can be the result of head trauma, where the otoconia become dislodged, or is idiopathic (Von Brevern et al. 2006). Other causes of vertigo include Meniere's disease, which is characterized by a progressive loss or hearing, a sense of aural "fullness", and tinnitus. These symptoms are the result of increased endolymphatic pressure (Teggi et al. 2010). In addition, labyrinthitis, or vestibular neuritis, is the result of a viral and bacterial infection affecting the inner ear or vestibular nerve. This type of vertigo is usually accompanied by some level of hearing loss and typically resolves within days to weeks (Campellone, "NLM" 2015).

Vertigo is often accompanied by nystagmus, which is an involuntary oscillation, or rhythmic beating, of the eyes. This symptom can be triggered by certain movements, during gait when changing gazes, or can occur spontaneously. The nature and direction of the nystagmus can reveal to a clinician where the dysfunction may be (Umphred 2013). For example, to determine whether the vestibular lesion is central or peripheral, the patient will be asked if visual fixation relieves the nystagmus and/or if the oscillation lasts for a short or long duration (Umpred 2013).

Differential Diagnosis

Testing the various aspects of vestibular function is a crucial component in diagnosing vertigo, and the findings of vestibular testing can indicate whether the pathology is peripheral or central. Equally important is ruling out other systems to ensure that the cause is what it seems. Specific testing for vestibular function may include the VOR1 test, which has the patient focus on the examiner's fingertip while they shake their head side-to-side, as if communicating "No", or up and down, as if communicating "Yes." They would slowly increase the distance of rotation as well as the speed to try and elicit symptoms. VOR2 testing involves the same setup except the examiner moves the point of visual fixation in the opposite direction of the patient's head shake.

The examiner will note at which point the patient experiences any blurred vision, nystagmus, or vertigo (Umphred 2013).

Perhaps most specific to the diagnosis of BPPV (posterior or anterior canals) is the Hallpike-Dix maneuver, which has the patient in a long sit on a plinth while looking up and over their shoulder so the suspected side of the dysfunction is in the dependent position. The examiner then quickly brings them down to supine with their head rotated 30-45 degrees and extended off the edge by about 20 degrees. The examiner carefully supports the patient's head as they observe for either a reproduction of their initial symptoms and/or checks for nystagmus, and is typically elicited within 30 seconds of the descent to table (Umpred 2013). Testing for horizontal canal BPPV is performed with the patient in supine with their neck flexed 30 degrees and the examiner will rotate the head side-to-side, carefully observing for the onset of nystagmus (Umphred 2013).

In addition to the above vestibular-specific tests, it is crucial to further assess any of the patient's subjective findings such as tinnitus and/or hearing loss, which can indicate an infection of the inner ear such as labyrinthitis (Campellone "NLM" 2015). Exploring the nature of any dizziness complaints would also warrant vitals assessment since abnormally low plunges in blood pressure, known as orthostatic hypotension, will cause lightheadedness and is often confused for dizziness.

Other possible culprits that present similarly to a vestibulopathy, such as a cerebellar pathologies, needs to be ruled out. For example, testing the patient for disdiadocokinesia, an inability to efficiently elicit voluntary rapid agonist-antagonist movement pairs of an extremity, involves having the patient perform rapid alternating motion of the extremities (Umphred 2013). This motion must be assessed for the both speed and quality by the examiner. Further, dysmetria should be evaluated, which is performed by having the patient alternate an extended finger from

their nose to a specific point in front of them. The examiner will be carefully observing their ability to judge and scale movement distance. Finally, cerebellar lesions can often present with an essential tremor as well as impaired speech (ataxic dysarthria), so careful observation will be vital (Umpred 2013).

Gait assessment is also a very powerful diagnostic tool in neurological examination. For example, cerebellar ataxia is a uniquely representative finding, marked by a wide-stance, short strides, a high flexing leg, and overall poor balance. Gait with vestibular dysfunction can present similarly to cerebellar gait, but adding a visual challenge such as head turning can help distinguish the two, as this disadvantages with visual system (Umphred 2013).

Medical Management

Although vestibular rehabilitation and home remedies are strongly indicated for the treatment of vertigo, especially BPPV, there are pharmacologic interventions that can address some of the secondary symptoms of vertigo. In the case of labyrinthitis, the infection causing the vertigo may be treated with antibiotics or steroids (Labyrinthitis and Vestibular Neuritis-Topic Overview). Menieres's disease may be treated with diuretics since the underlying cause is excessive perilymphatic pressure (Meniere's Disease-Topic Overview). For general vertigo symptoms, Promethazine, which used for to prevent motion sickness, can be used, though it needs to be emphasized that this drug only addresses the symptoms and should be used short-term only (Solomon 2000).

In rare cases, surgery may be explored if none of the conservative or pharmacological treatments are working. One surgical option is a singular neurectomy, which involves cutting the branch of the vestibulocochlear nerve innervating the posterior semicircular canal. The procedure is difficult to perform and quite rare (Solomon 2000). In addition, posterior semicircular canal

plugging can be performed, but is also rare. Hearing loss is an inherent risk of these procedures and with any surgical procedure the risk for should be carefully considered prior to operating (Solomon 2000). Hand-held massagers that provide an oscillation to the mastoid bone have also been used to treat posterior canal BPPV with mixed results. More research is needed regarding the efficacy of oscillating device treatments (Solomon 2000).

Implications for Physical Therapy

Since vertigo is a sign of dysfunction in the body's primary facilitator of balance and posture, it must be viewed as a true movement disorder. Physical therapy is certainly recommended in most cases, and BPPV in particular requires aggressive vestibular rehabilitation involving physical maneuvers and skilled positioning. General balance dysfunction, though stemming from a myriad of causes, falls into a similar category of movement impediments best corrected through processes of adaptation and habituation (Umphred 2013).

The approaches for habituation and adaptation have the patient challenged in various ways, often by disadvantaging their strongest sense, and compelling them to rely more on the sense of impairment (Umphred 2013). For example, single leg balancing and controlling one's center of gravity is a profound milestone in optimal movement requiring primarily three systems: vision, proprioception, and vestibular function (Umphred 2013). Patients working on vestibular rehabilitation might be instructed to eliminate their use of vision during balancing tasks in order to facilitate recruitment of the remaining systems.

Indeed, there is a strong correlation between vestibular dysfunction and falls, which is one of the most costly health conditions affecting older individuals (Agrawal et al. 2009). Falls prevention is paramount in physical therapy intervention, particularly those with advancing age and neurological conditions. One study demonstrated that individuals with vestibular dysfunction

had a twelve-fold increase in the chances of falling (Agrawal et al. 2009), which underscores the significance of screening for and treating vestibular defects. Physical therapists are uniquely qualified to help in this regard.

Case Scenario

A 67 year-old male presents to our clinic after visiting his primary care physician, who recommended vestibular rehabilitation to treat his complaints of vertigo and to address his history of falls. The patient reports that moving too rapidly has recently caused him to feel as if he is falling/spinning, which is usually followed by a bout of nausea, dizziness, and occasional vomiting. He reports having fallen two years ago, which resulted in a distal radius fracture. Otherwise, he has no significant medical history. Initial physical therapy examination revealed the following:

Subjective

- Pt c/o increased dizziness with movement/physical activity; increases in nausea about half the time, and occasionally vomiting; 2/10 dizziness at rest, up to 8/10 during spells
- Pt reports that his walking gait has been impacted and he must sit until the dizzy spell subsides; feels a spinning sensation during episodes; denies taking any medication
- PMHx includes falls, one resulting in distal radius fx; maintains that balance continues to be a major obstacle
- Denies permanent changes in vision or hearing impairments, but claims to have minor visual blurring and shakiness when the dizziness occurs
- Pt reports significant motion sickness while riding buses and anytime he is on a boat; prefers riding the subway
- Pt reports having bumped his head while passenger in off-road van trip 3 weeks ago

Objective

- Vital Signs: BP 129/77 mmHg; HR 79 bpm; O2 saturation 99%; RR 15 breaths/min
- Patient is 5 feet 10 inches; 175 pounds

- Alert & Oriented x3 (person, place, time)
- Emotional/Behavioral responses unimpaired
- Integumentary inspection: OK
- Speech intact: (-) slurring, (-) ataxic dysarthria, good cadence, >10 syllables/breath
- Gait impaired: decreased cadence, Right drift with eyes closed; decreased timing, guarded quality, OK stride length, (+) heel strike, (-) cerebellar ataxia
- Balance impaired in both standing and walking:
    - Dynamic Gait Index (DGI) score: 17/24
    - Berg Balance Scale (BBS) score: 44/56
- Manual Muscle Test (Bilateral Lower Extremities):
    - Hip: Flexion 4/5; Extension 4/5; Abduction 3+/5; Adduction 4+/5; ER/IR 4/5
    - Knee: Flexion 4+/5; Extension 5/5
    - Ankle: DorsiFlexion 3+/5; PlantarFlexion 4-/5; Inv/Eversion 4/5
- Active Range of Motion (Bilateral Lower Extremities):
    - Hip: Flexion 0-110; Extension 0-10 degrees; Abduction 0-35; Adduction 0-20; ER 0-30; IR 0-25
    - Knee: Flexion/Extension 0-125
    - Ankle: DorsiFlexion 0-15; PlantarFlexion 0-35; Inversion 0-25; Eversion 0-10
- Neurological Testing:
    - Light touch sensation intact in all extremities; Vibration (128 Hz) intact in UEs, diminished in LEs; Proprioception intact in UEs, diminished in LEs
    - (-) Babinksi; (-) Clonus, (-) spasticity (b/l elbows and knees checked), (-) Hoffman's Sign, reflexes WNL
    - (-) VOR1/VOR2 test horizontally, (+) VOR1/VOR2 test vertically with onset of blurred vision and eventually vertigo
    - (-) Disdiadocokinesia using hands, (-) Dysmetria using finger to nose. (-) intentional or resting tremor
    - (+) Hallpike-Dix maneuver with Right sided involvement: Onset of vertigo within 5 seconds, unidirectional nystagmus toward Right that suppressed in 20 seconds

Assessment

Evaluation: Differential Diagnosis

Rule In:

+ Impaired balance testing (DGI, BBS)
+ Impaired gait mechanics
+ Muscle weakness in LE's
+ Mild neurological sensory deficits in LE's
+ BPPV, Positive Hallpike Dix with nystagmus
+ Vestibular sign, positive VOR1/2 vertical test

Rule Out:

- Orthostatic hypotension/cardiovascular pathology
- Hemiplegic signs (-unilateral deficit, -speech impairment)
- Cognitive impairment
- Upper Motor Neuron signs (-Babinski, -clonus, -Hoffman's sign)
- Spasticity
- Cerebellar signs (-disdiadocokinesia, -dysmetria, -tremor)
- Meniere's Disease/Labrynthitis (-hearing impairment, -tinnitus)
- Central vestibular signs (-direction changing, +suppression with fixation)

Patient presents with classic signs of Benign Paroxysmal Positional Vertigo (BPPV) such as subjective complaints of sudden dizziness coupled with unidirectional nystagmus that matches the onset of vertigo with a Hallpike-Dix maneuver. The symptoms suppressed with fixation within 20 seconds. Cerebellar, central vestibular, cognitive, and other vertigo-related impairments have been ruled out through objective testing. Patient's case is further obscured by a history of falls, potentially as a result of prolonged sedentary lifestyle and marked weakness and loss of range of motion in several lower extremity muscles. His slightly diminished sensory findings in the distal lower extremities are important findings. Patient is most likely experiencing

balance loss due to impairments from both peripheral vestibular symptoms as well as lower extremity deficits. In addition, recent history of bumping head correlates with BPPV onset.

Diagnosis:

Pattern 5A: Primary Prevention/Risk Reduction for Loss of Balance and Falling

Prognosis:

Given the nature of the pathology leading to BPPV, and the presence of lower extremity muscle weakness, this patient has very good rehabilitation potential. The physical therapy interventions will focus on vestibular rehabilitation, therapeutic exercise, and balance/ coordination training.

Plan:

Short-Term Goals:

1. Decrease incidence and severity of vertigo to 3/10 within one week
2. Improve baseline dizziness to 0/10 within three weeks
3. Increase gross lower extremity strength to at least 4/5 in three weeks
4. Educate patient on home exercises/maneuvers to be implemented immediately

Long-Term Goals:

1. Eliminate all incidences of vertigo
2. Improve DGI score to 20/24 within four weeks
3. Increase BBS score to 52/56 within five weeks
4. Increase gross lower extremity strength to at least 4+/5 within six weeks

Physical Therapy Program

The physical therapy sessions will primarily revolve around vestibular rehabilitation, therapeutic exercise, and balance/coordination training. Vestibular rehabilitation in the case of BPPV involves selective timed positioning in order to reposition the otoconia in the semicircular canals. These maneuvers are highly provoking-positions, so it is essential to educate the patient

on what to expect and that it might be uncomfortable. Since our patient appears to have posterior canal dysfunction, our job will be to maneuver his head until the otoconia "pours" out back into the utricle. Perhaps the best known sequence is the Epley maneuver, which involves the patient assuming a supine position with their head off the edge of the table at about 45 degrees of rotation to the involved side and about 20 degrees head extension for one minute. The patient then turns their head 45 degrees in the opposite direction for about one minute. They then roll to the side of their head, making sure to turn their body and head as one unit, again holding for one minute. They then are brought up to sitting with the help of the therapist until the symptoms resolve (Umphred 2013). It is crucial at this point to educate the patient about avoiding head tilts and rotations for at least 24 hours. Though the Epley maneuver is often enough to correct the trapped otoconia, the test may need repeating (Umphred 2013).

The next phase of our treatment will involve exercises to address the lower extremity weaknesses. Strengthening the hip abductors will be key in improving balance since this muscle will stabilize the pelvis during gait stance. Side-lying hip abduction is a good starting point to learn how to engage the muscle, and we can add a light cuff weight to increase the resistance. In addition, the weak plantar/dorsi flexors can be strengthened by theraband exercises, with a loop tied in the band wrapped around the forefoot to resist the appropriate motions. Finally, a multi-joint functional movement to increase strength in the posterior chain should be implemented. A squat against the wall with physioball is a good place to start since the ball adds both an easy surface to glide over as well as a bit of instability for balance (Kisner & Colby 2007).

The third part of our treatment will incorporate balance exercises, and eventually these will be progressed to disadvantage one or two of the three major systems of balance, in this case vision and/or somatosensation (Umpred 2013). For example, we can start with a simple single

leg stance exercise, holding each side for about 30 seconds at a time. We can soon add an unstable layer of foam under his stance foot to challenge his proprioception, or stay on the ground and ask him to close his eyes. These two variations will allow his internal vestibular system to be challenged to a greater degree. Eventually, we can hopefully combine both a moderately unstable surface with eyes closed to increase the difficulty further. In addition, a balance activity that involves head movements should be done to discourage the lack of head movement common in vertigo patients (Umphred 2013). One interactive exercise might be walking in a straight line while tossing a ball back and forth with the therapist in various directions. This activity both improves gait balance and visual tracking during movements (Kisner & Colby 2007).

Ideally by week three, the direct symptoms of BPPV should be resolved, so the focus of the physical therapy can move onto increasing the strength and balance training intensity. We can now progress the hip abductor and ankle exercises to more functional and dynamic movements. We will have our patient perform lateral band walks, with a continuous theraband around his knees as he walks laterally with slow, deliberate steps. Further, ankle plantarflexion can be challenged with bilateral calf-raises off a step with unilateral eccentric control of the descent. Further, we can target the dorsiflexors and hip flexors simultaneously while supine on the ground and performing hip flexion against a cable pulley with an attachment on the forefoot. Finally, the ball squat can be progressed to a free-standing squat, weighted as appropriate, to provide an addition balance challenge during a functional movement (Kisner & Colby 2007).

Throughout the physical therapy sessions, it will be important to frequently measure how much progress is made and to gauge the extent of their improvement. Since our patient's initial complaints were dizziness and a sense of spinning, we can revisit the DGI and BBS at 3 and 6

weeks. This repeated measure is especially important given his history of falling. In addition, it will be crucial to retest the weak muscles found in our assessment, and we should see significant improvements within 4-6 weeks in this regard. The patient should be following a home exercise program with progressions to address the strength deficits in his lower extremities and to challenge his ability to balance in various environments. Overall, this patient has excellent rehabilitation potential, and proper physical therapy interventions should both alleviate his vertigo and improve his safety during an array of functional activities.

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Home Exercise Program

Patient X – BPPV, Balance Rehab
18 April 2016

THESE EXERCISES ARE DESIGNED TO IMPROVE YOUR BALANCE/SAFETY DURING FUNCTIONAL TASKS AND TO DECREASE THE INCIDENCE OF DIZZINESS. THESE EXERCISES SHOULD NOT CAUSE ANY PAIN. IF YOU EXPERIENCE PAIN OR SUDDEN DISCOMFORT DURING THE EXERCISES, STOP. PLEASE DO NOT HESITATE TO CONTACT ME OR YOUR PHYSICIAN IF PAIN PERSISTS.

Objective: To improve balance and to strengthen the muscles that stabilize your legs

A. Balance exercises

These exercises will challenge the various systems contributing to balance. They will also strengthen the stabilizing muscles of your hip, knee, and ankle to increase safety during functional activities.

Single Leg Stance

http://www.hep2go.com/exercise_editor.php?exId=20&userRef=gciaake

With a stable object nearby, such as a chair, balance on one leg for 30 seconds. Try to keep good posture and to keep your head up. Perform 5 sets in total on each leg.

Progression: Once cleared by your therapist, you may progress this exercise to the one below.

Single Leg Stance on Foam

http://www.hep2go.com/exercise_editor.php?exId=15495&userRef=gciaake

Perform the same single leg stance exercise above, but instead your balancing leg will be placed on a foam surface to challenge you further. Perform 5 sets of 30 seconds on each leg.

Progression #2: Once this becomes easy, you may perform the balancing exercises with your eyes closed. Make sure to keep your hands near a stable surface such as a doorframe or kitchen rack to alert you of any balance loss. Perform 5 sets of 30 second balancing on each leg.

B. Strengthening the hip muscles

Strengthening the hip muscles will provide better stability for your pelvis and lower extremities, as well as improve posture and stability during activities.

Procedure:

1. For each exercise, perform 2-3 sets per day with 10-12 repetitions per set.
2. Proceed with the exercises and review them every week to revise or correct the movements, and note any progressions if it becomes too easy.
3. You should not feel any discomfort after these exercises.

Exercise 1: Hip Abduction

This exercise will strengthen your hip abductor muscles, which are essential in preventing excess movements of your pelvis during gait.

http://www.hep2go.com/exercise_editor.php?exId=124&userRef=gciaake

While laying on your side, bend your bottom knee so that you do not rock back and forth and place your arms in a comfortable neutral position. Begin by lifting your top leg up in the air, making sure to keep the leg completely straight and your toes straight. Make sure not to rock front to back or twist your torso. Perform 3 sets of 10 repetitions on each side.

Progression: Once cleared by your therapist, you may progress this exercise to the one below.

<u>Lateral Band Walks</u>

http://www.hep2go.com/exercise_editor.php?exId=448&userRef=gciaake

With a looped thereband around your lower leg, begin this exercise by slowly stepping to the right or left, and then slowly controlling the trailing leg to the starting position. Repeat to make 12 side steps, and then reverse the direction. Make sure to always keep a space between your feet and to have your knees bent.

Exercise 2: Squats

This exercise will strengthen the muscles of your buttocks and thighs, and will be important in safely negotiating stairs, push-off during gait, and general lower extremity power.

http://www.hep2go.com/exercise_editor.php?exId=522&userRef=gciaake

Begin this exercise by standing with your back against a physioball just above your waist and your feet pointed away from you. Squat by bringing your hips down and back as if sitting in a chair under the ball, making sure to bring your feet out enough so that your knees do not bend past your toes. Allow the ball to roll up your back as you descend. Once your thighs are parellel to the floor, push back up to the starting position. Perform 3 sets of 10 repetitions.

Progression: Once cleared by your therapist, you may progress this exercise to the one below.

Free Squats

http://www.hep2go.com/exercise_editor.php?exId=4342&userRef=gciaake

Place your feet shoulder width apart and lock your hands together in front of your body. Starting with the hips, squat down and back as if sitting into a chair behind you, making sure to keep your knees behind your toes. When your thigh is parallel to the ground, push back up to the starting position. Perform 3 sets of 10 repetitions.