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The ability for us to maintain postural control and balance is fundamental for general performance, injury resistance, and rehab that will follow any injury. Balance is somewhat loosely defined as the ability to keep their center of gravity in the base of support they have. The center of gravity is the body's midpoint, which varies based on the person and their body. We put balance into the categories of static, semi-dynamic, and dynamic. Static balance is when someone seeks to maintain their posture and control in a non-moving position. Semi-dynamic balance is when someone wants to keep balance while the base only moves. Dynamic stability is keeping balance while the center of gravity is ever-changing, usually on many uneven surfaces. Keeping balance in different situations requires using multiple systems together, like the visual, vestibular, and somatosensory systems. The ability to feel the center of mass moving toward a person's limits is a product of those three systems we just mentioned: visual, vestibular, and somatosensory. Most Popular Cert Best Online NCCA Cert Best Study Materials Gold Standard Cert A Good Option Best CPT for you? Research has shown balance training to be great for optimizing someone's performance, improving resistance to injuries, and enhancing rehab. Balance Training for Performance has been shown to: Improve static and dynamic balance Improve neuromuscular control in the lower extremities Improve balance after injury Improve lower extremity muscular strength (especially when done with resistance training) Improve the ability to participate in daily living activities and decrease self-reported disability in older adults. Improves agility-based outcomes in athletes Balance Training has been seen to do these things in terms of resistance to injury: Improves landing mechanics, which may reduce lower extremity injuries, such as ACL injuries and ankle sprains Improves performance in athletes, such as vertical jump height Reduces risk of falling in older adults Improves physical performance and overall confidence during activities of daily living in older adults Balance training done for Rehab has been shown to: Improves performance during single-limb activities Improves proprioception and self-reported function in athletes with ankle instability Enhances rehabilitation outcomes for both limbs in athletes who suffer an ACL injury and surgery on one limb Enhances rehabilitation outcomes that focus on decreasing the risk of falls in older adults Effective balance training programs should make sure to challenge the threshold of someone's limit of stability. The individual's threshold should be stressed in multiplanar ways, enriched proprioceptively in the environment, and the programs should use functional patterns of movement to improve static, semi-dynamic, and dynamic stability. Exercise for balance is needed as part of an integrated program due to help ensure good muscle recruitment and coordinated movement. The main goal is to increase the awareness of the limits of stability for the client with progression in proprioceptive demands during exercise. Proper programs will always be systematic and progressive. The exercises can be regressed and progressed through changes in the requirements for surface, visual condition, and position of the body and its movements. Initially, exercises should start with very little to no movement in the joints of the balance leg. Next, we progress to eccentric and concentric movements of the leg that balances in a full range of motion. Lastly, the progression should be designed to develop correct deceleration for moving the body from dynamic to controlled stationary positions. Quality is always more important than quantity, and the five checkpoints should always be watched: Feet pointing straight ahead Knees in line with the second and third toes (avoid allowing knees to cave inward) Hips level and in a neutral position Shoulders in a neutral position (not protracted or elevated) Head with cervical spine in a neutral position (chin tuck) It is important to know the steps and the differences for all of the exercises throughout this chapter of the book, and the videos are very well done in teaching the movements. Falling can be a serious and life changing event, especially for older adults. There are some simple interventions that can help reduce the risk of falling, and exercise is one of them. The statistics on falling are somewhat staggering. (1-3) More than 1 out of 4 older adults over the age of 65 fall each year, this number has been referenced as high as 1 out of 3 older adults. 1 out of 5 falls results in serious injury (i.e., broken bones, head injury). Every 20 minutes an older adult dies from a fall. Falls are the leading cause of fatal injury among older adults. More than 95% of hip fractures are caused by falling. Falling is the biggest predictor of another fall. Falls threaten an older persons independence. Many don't, or won't, tell their doctor that they've fallen. A fear of falling may lead some older adults to limit their activities, which can create a downward spiraling situation where they become less socially engaged, experience more physical decline and weakness, and become depressed. Key Risk Factors There are many risk factors that can contribute to falls. Some of these include (1-2): Muscle weakness: Decreased strength in the lower body (and also balance and walking difficulties) Foot problems: This can include foot pain, loss of sensation, or even improper footwear (slippers without traction, high heeled shoes, etc.). Medical conditions and medications: These include dizziness, vertigo, sleepiness, hypotension, prescription and over-the-counter medications, etc. Have client consult with their doctor and/or pharmacist to address these issues. Vision: Our vision needs change as we age. Sometime there is a need for more light or a change in vision/eye wear prescriptions. Environmental hazards: These include trip and fall hazards in the home such as unsecured throw rugs, slippery or uneven surfaces, even pets getting under foot. Secure or remove loose rugs, remove clutter, quickly dry spills, install handrails in bathrooms and stairs. How can exercise help? Though environmental hazards are the leading cause of falls, gait and balance disorders closely follow. Lower body weakness increases the odds of falling fourfold.(4) Strength programs and balance activities greatly help to reduce the risk of falling.(5,6,7) After assessing your client for overall functional ability and fall risk (with tests such as the Timed Up and Go (TUG)) follow the Optimum Performance Training® (OPT ®) model for fall prevention programming. For a scientific approach to designing programs for older adults, click here. Exercise Programming Tips Here are some tips on incorporating balance and strength activities into a client's fall prevention program.(3,7) Balance Starting with the balance stabilization level, consider activities such as the single leg balance or single leg balance with reach. These activities require little joint motion and can be progressed with various unstable surfaces or regressed by adding a support, such as a chair. Single leg balance Single leg balance with reach Single leg balance with support At the balance strength level, moves become dynamic and movement is through a full range of motion with an isometric stabilization hold at the end-range. Examples include step-up to balance or a single leg squat. Step up Single leg squat Power for fall prevention? Yes, the power level can be used with older adult clients. It develops high levels of eccentric strength, improves neuromuscular efficiency and reactive joint stabilization. Examples include multiplanar hops with stabilization in various planes of motion. Since many older adults have vestibular issues that can lead to dizziness or a loss of balance when moving in a rotational fashion, always begin balance exercises in the sagittal plane, followed by the frontal plane, then the transverse plane.(1,3) Be sure to have balance assistance nearby or be ready to offer your client a steading spot. This will also help reassure a client and reduce their anxiety. Tai chi is an activity shown to significantly reduced falls by improving balance, physical performance and reducing the fear of falling.(6,8) During a six-month trial study on the effects of tai chi there was a 55% reduction of falls compared to the those in a stretching control group. Check out this NASM Roundtable on the importance of Balance Training for more info on its importance! Strength Strength moves for fall prevention. Use your training creativity to modify the following lower body exercises to meet your client's needs across the OPT levels. Squats / knee bends (supported/unsupported) Leg extensions (supported/ unsupported) Hamstring curls (supported/ unsupported) Calf and toes raises (supported/ unsupported) Squats Single leg squat with assistance Core Core exercises are also important for fall prevention to improve the strength and control of the deep stabilization muscles for lumbo-pelvic-hip complex stabilization. (3) Stabilization level exercise examples include planks, bird dogs, and supine marching or floor bridges. Strength level could include crunches and back extensions, and ball slams and chest passes for power level moves. Plank (prone-iso-abs) Bird dog (Quadruped arm raise) Bird dog (quadruped arm opposite leg raise) Supine marching Floor bridges Medicine ball slams Medicine ball chest pass For more information on working with older adults and fall prevention programming, check out the NASM Senior Fitness Specialization. References Centers for Disease Control and Prevention. Important facts about falls. 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Social media can connect us to the communities and world around us, but it can also have serious impacts on mental health and wellness, like increasing rates of depression ... Fitness wellness spotlight The human body is not made up of isolated segments of muscles, bones, connective tissue, and ligaments. Rather, the body is a series of interconnected parts that all impact each other. This impact can either be positive or negative. Ideally, when the ... Fitness Weight Loss wellness Nutrition Embarking on a journey to address obesity through medication is a significant decision that requires careful consideration. In this exploration, we delve into the key aspects of using medication, specifically focusing on Semaglutide, as a potential tool ... Fitness wellness Nutrition In 2009, my family captured a five-generation photo: five children (ages 5, 2, 2, 2, and 2), myself (age 26), my mother (age 55), my grandfather (age 79), and my great-grandmother (age 107). Although my great-grandmother passed away at almost 108 years ... New clients, or even those that you've been working with for some time, can all benefit from focusing some of their training on stabilization work. Without a strong structural base to move from, how can we continue to build upon our foundation or safely excel in our fitness endeavors? Not very well! Stabilization training helps us to establish this base, while also laying the groundwork to achieving multiple fitness goals and higher training levels. NASM's Optimum Performance Training™ (OPT™) model is a three level system of five phases that starts with stabilization endurance training. No matter a client's ability, this initial phase can be manipulated to challenge even the most seasoned athlete or regressed to accommodate a novice exerciser. What is Stabilization Endurance? Stabilization endurance training uses high repetitions and proprioceptively enriched activities—activities that challenge an exerciser's balance. These proprioceptive type activities are progressively introduced from stable to unstable. For example, as a client masters a push-up on the ground he or she will then move to performing the push-up on a stability ball, a BOSU®, a Core-Tex™, a suspension trainer, or a whole-body vibration (WBV) platform. This increases the neuromuscular recruitment required to stabilize the joints through the upper body and maintain optimal posture. Phase 1 can also be applied to core and balance activities in addition to resistance training. Core exercises in this phase of training involve little motion through the spine and pelvis (i.e., floor bridge, plank) while balance movements involve minimal joint motion and focus on reflexive joint stabilization (i.e., single-leg balance, single-leg lift and chop). Even plyometric activities can be adapted to Phase 1 by adding a static hold to landings (i.e., squat jump with a 3-second hold on the landing). Weight loss is one of the top reasons people join a fitness club. And using the 1st phase, you can design great programs for weight loss. Fitness professionals can help members achieve this goal with Phase 1 stabilization endurance training as well. The additional muscles recruited to stabilize the body, the higher repetitions, the minimal rest between sets, or the use of a circuit format can enhance the calorie burning of a session. During Phase 1, rest time between sets ranges from no rest at all to 90 seconds. Repetitions range between 12 to 20 per set, with 1 to 3 sets of each exercise. The amount of weight being moved during Phase 1 is less intense—approximately 50 to 70% of a client's one repetition maximum (1RM) or even just body weight alone. If you aren't sure about your clients' maxes, you can calculate their one rep maxes here. Tempo of movement during Phase 1 is set at a slower 4/2/1 pace. This means that it is 4 seconds for the eccentric contraction, 2 seconds for the isometric hold, and 1 second for the concentric contraction. By utilizing slower eccentric and isometric actions, more demand is focused on the connective tissue and stabilizing muscles, preparing the nervous system for future functional movements. OPT™ Model Phase 1 Workout Sample Here is an NASM OPT™ Phase 1 sample workout. It includes a short warm-up that utilizes foam rolling moves. Each of the listed exercises also offer progressions and regressions to help meet the needs of your clients. The majority of the exercises are flexion/extension-type moves performed in the sagittal plane, moves most people will probably be more comfortable with when initially starting an exercise program. But don't worry, this program can be a challenge even for your more advanced clients. Give it a try; it may look easy on paper, but it will definitely bring a challenge, especially if you make it a three round circuit with minimal rest between sets and only a one- to two-minute rest between rounds! Remember, fitness professionals need to complete a health history and fitness assessment on their clients prior to designing an exercise program. This is to identify what specific movement restrictions they may have and therefore, select the appropriate flexibility and strengthening exercises based on the results, their goals, and if medical clearance to exercise is needed. Modify where appropriate for your clients and their specific needs. OPTIMUM PERFORMANCE TRAINING™ (OPT™) MODEL OPT Level 1: Stabilization Endurance Reps: 12 to 20 (Single-leg workouts or arm variations: 10 reps each side) Sets: 1 to 3 Tempo: 4/2/1 Intensity: 50 to 70% of 1RM Rest: 0 to 90 seconds Circuit option: After warm-up, complete 1 set of all exercises with minimal rest between moves. Perform first pass, rest 1 to 3 minutes and repeat circuit 1 to 2 more times, then cool down. WARM-UP Foam Roll Hold on tender spot for 30 seconds: Calves, adductors, hip flexors and upper back Static Stretch Hold a static stretch of each area for 30 seconds: Calves, hip flexors, adductors and latissimus dorsi *Include foam rolling and stretches for areas identified as tight/overactive during the client assessment. EXERCISES Single-Leg Balance Stand with feet shoulder-width apart, toes pointed straight ahead and hips in neutral position. Lift one leg directly beside balance leg and dorsiflex toe. Flex hip and knee to bring thigh parallel to ground. Hold for 5 to 10 seconds. Repeat. Switch legs. Regress: Perform while holding on to a stable surface. Progress: Perform on foam pad. You can see an exercise demonstration of the single-leg balance here. Plank Lie face down on the floor with feet together and forearms on the ground. Keeping abs in and glutes tight, lift entire body off the ground until it forms a straight line from head to heels. Hold for 1 to 2 seconds, return to start, repeat. Regress: Perform on knees or with hands on a bench. Progress: Alternate lifting one leg off the ground each rep. See how to do a plank here. Squat Jump With Stabilization Stand with feet shoulder-width apart, toes pointed straight ahead, hips in neutral position and knees aligned over second and third toes. Squat slightly as if sitting in a chair. Jump up, extending arms overhead. Land softly and hold for 3 to 5 seconds. Repeat. Regress: Decrease the depth and do only a shallow squat. Progress: Pull knees up higher into a tuck jump. Watch a squat jump breakdown here Step-up to Balance, Curl and Overhead Press Stand in front of a step or plyo box (6 to 18 inches high) with dumbbells in hand. Step up with one leg, keeping foot pointed straight ahead and knee lined up over mid-foot. Push through the heel and stand up straight, balancing on one leg. Flex the other leg at the hip and knee. Once balanced, curl, then press dumbbells overhead. Lower dumbbells, return lifted leg to the ground, step off box to starting position. Switch legs. Repeat. Regress: Omit the balance hold. Progress: Perform in the frontal or transverse plane. Cable Squat Stand with feet shoulder-width apart, toes pointed straight ahead, hips in neutral position, knees aligned over second and third toes. Hold cables to the side of the body and slowly begin to squat, not allowing any internal rotation at the hips or knees. Sit back while maintaining a neutral spine and chest up. Stand back up by contracting the glutes and pressing through the heels as knees extend. Repeat. Regress: Ball squat against a wall or decrease depth of motion. Progress: Squat without cables. Dumbbell Chest Press Lie on your back with a stability ball between shoulder blades, feet shoulder-width apart and pointed straight ahead, knees bent, glutes contracted and hips lifted. Start with a dumbbell in each hand at chest level, press both dumbbells straight up and then together by extending elbows and contracting chest. Slowly return to start position and repeat. Regress: Perform on a flat bench. Progress: Alternate arms. Dumbbell Row on Ball Start in a prone position with abdomen over a stability ball, feet pointed down, legs straight and abs drawn in. Hold dumbbells in each hand and extend arms in front of body. Lift chest off the ball and row the dumbbells bringing thumbs toward the armpits. Repeat. Regress: Kneel over the ball. Progress: Alternate arms. Overhead Military Press on Ball Sit on a stability ball with feet planted hip-width apart and pointing forward. Starting with dumbbells at shoulder level, press them overhead until both arms are fully extended, palms facing forward. Slowly return dumbbells to starting position. Repeat. Regress: Seated on a bench. Progress: Alternate arms. Single-Leg Biceps Curl Stand on one foot, toes pointed straight ahead, knee slightly bent over second and third toes. Start with arms by the sides, dumbbell in each hand. Perform a biceps curl by flexing the elbow. Slowly return to start position, repeat for 10 reps and then switch legs. Regress: Stand on both legs. Progress: Alternate arms or stand on an unstable base. See more arm exercises here. Single-Leg Triceps Extension Grasping cable machine handles with palms facing the ground and elbows bent at a 90° angle, stand on one foot, toes pointed straight ahead and knee slightly bent over second and third toes. Keeping shoulders back and down, extend the elbows by pushing down on the handles until arms are fully extended. Return to start and repeat. Regress: Stand on both legs. Progress: Alternate arms. Cool-Down Repeat warm-up activities Should You Be Sore? Clients, especially those new to exercising, may ask you about muscle soreness in the days following their training and when it will subside. Other clients may judge the value of their workout on their soreness level. As the body responds to and adapts to new physical stressors (i.e., exercise, increased overload), delayed-onset muscle soreness (DOMS) may occur. DOMS is often felt 24 to 72 hours after the exercise session. Minimize DOMS by starting clients at appropriate, yet low levels of intensity, gradually progressing their training overload as their body becomes more efficient and adapts to the stressors. For clients needing more overload in their training program, adjust acute variables such as reps, sets, tempo, rest, intensity, and the exercises selected to increase the challenge. For additional workout ideas, be sure to check out these resources And watch this NASM Roundtable Video on Balance Training for some food for thought. Figure 10.2 Effects of joint dysfunction Table 10.1 Balance training parameters OPT Level (adaptation): Stabilization, Strength, or Power Be familiar with all exercises listed, as well as how to regress and progress the exercises listed Type of Exercise: Balance Table 10.2 Balance training program design Key to all functional movements. Balance – When body is in equilibrium and stationary, meaning no linear or angular movement. Maintaining handstand without falling over. Dynamic Balance – ability to move and change directions under various conditions without falling. Running on uneven surfaces. Balance is dependent on internal and external factors to maintain body's center of gravity over its base of support. Dynamic process involving multiple neurologic pathways. Research shows that specific kinetic chain imbalances(such as altered length-tension relationships, force-couple relationships, and arthrokinematics) can lead to altered balance and neuromuscular inefficiency. Flawed movement patterns alter firing order of muscles activated. Joint dysfunction creates muscle inhibition. Leads to joint injury, swelling, interruption of sensory input from articular, ligamentous, and muscular mechanoreceptors to the central nervous system, results in clinically evident disturbance in proprioception. Sensory feedback to CNS is altered after ankle sprains, ligamentous injuries to the knee, and low-back pain. Importance of Properly Training the Balance Mechanism Balance training should stress individual's limit of stability(or balance threshold). Limit of stability is distance outside of the base of support that he or she can move into without losing control of his or her center of gravity. Threshold must be stressed in multiplanar, proprioceptively enriched(unstable yet controlled) environment, using functional movement patterns to improve dynamic balance and neuromuscular efficiency. Benefits of Balance Training Balance training effects on injury Research shows performing exercises that demand balance can reduce rate of ankle sprains and other lower extremity injuries. Part of ACL injury prevention programs. Integrated injury prevention programs that include balance exercises in addition to plyometric or strength greatly influenced ability to improve lower extremity biomechanics. Should be performed at least 10 mins a day, 3 times a week, for 4 weeks. Designing a Balance Training Program Must be systematic and progressive. Main goal of balance training is to continually increase client's awareness of his or her limit of stability(or kinesthetic awareness) by creating controlled instability. Levels of Training Three levels of training – stabilization, strength, and power. Proper balance training program follows same systematic progression. Surfaces change in difficulty as individual moves from stable surface(floor) to unstable surfaces(half foam roll, foam pad, balance disc). Eyes open is easier than eyes closed. Change one variable at a time. Balance Stabilization Exercises Involve little joint motion; instead are designed to improve reflexive(automatic) joint stabilization contractions to increase joint stability. Sample exercises: single-leg balance, single-leg balance reach, single-leg hip internal and external rotation, single-leg lift and chop, single-leg throw and catch Balance Strength Exercises Involve dynamic eccentric and concentric movement of balance leg, through full range of motion. Sample exercises: single-leg squat, single-leg squat touchdown, single-leg romanian deadlift, multiplanar step-up to balance, multiplanar lunge to balance Balance Power Exercises Designed to develop proper deceleration ability to move body from dynamic state to a controlled stationary position, as well as high levels of eccentric strength, dynamic neuromuscular efficiency,and reactive joint stabilization. Exercises include: multiplanar hop with stabilization, multiplanar sing-leg box hop-up with stabilization, multiplanar single-leg box hop-down with stabilization. Implementing a Balance Training Program According to the NASM online study guide for Chapter 2 you should know: Chapter 2 Basic Exercise Science Know all definitions Figure 2.34 Figure 2.38 Table 2.5 Muscle Fiber Types Table 2.6 Muscle as Movers Introduction to Human Movement Human movement is accomplished through the integration of the nervous, skeletal, and muscular systems. The nerves, muscles, and joints must work together in a chain to produce motion(kinetic). These three systems are also referred to as the kinetic chain. Human Movement System – The combination and interrelation of the nervous, muscular, and skeletal systems. The Nervous System Anatomy of the Nervous System Neuron – Functional unit of the nervous system. Billions of neurons make up nervous system, provides it with ability to communicate internally with itself as well as externally with environment. Transmits impulses through both electrical and chemical signals. Forms the core of the nervous system which includes the brain, spinal cord, and peripheral ganglia. Neurons are composed of cell body, axon, and dendrites. The cell body of Neuron contains a nucleus, lysosomes, mitochondria, and a Golgi complex. Axon – cylendrical projection from the cell body that transmits nervous impulses to other neurons or effector sites(muscles, organs). Provides communication from brain and spinal cord to other parts of the body. Dendrites – gather information from other structures and transmit it back into the neuron. Sensory (afferent) neurons – Respond to touch, sound, light, and other stimuli and transmit nerve impulses from effector sites(muscles, organs) to the brain and spinal cord. Interneurons – Transmit nerve impulses from one neuron to another. Hence INTER neuron. Between neurons. Motor (efferent) neurons – transmit nerve impulses from the brain and spinal cord to the effector sites such as muscles or glands. So sensory neurons transmit from muscles and organs to the CNS. Motor neurons transmit nerve impulses from CNS to muscles and organs. Interneurons transmit impulses between neurons. The Central and Peripheral Nervous System The nervous system is composed of two interdependent divisions, the CNS and the PNS. Central Nervous System – Consists of the brain and the spinal cord, and its primary function is to coordinate the activity of all parts of the body. Peripheral Nervous System – Nerves that connect the CNS to the rest of the body and the external environment. Nerves of PNS are how CNS receives sensory input(from sensory afferent neurons) and initiates responses(through motor efferent neurons). The PNS serve two main functions. They provide a connection for the nervous system to activate different effector(organ, muscle) sites. Second they relay information from effector(organ, muscle) sites back to the brain via sensory receptors, providing constant update to the relation of the body and the environment. The PNS consists of the somatic and autonomic nervous system. The somatic nervous system consists of the nerves that serve the outer areas of the body and skeletal muscle and are responsible for the voluntary control of movement. So somatic is what controls your biceps and legs and whatnot. The autonomic nervous system supplies neural input to the involuntary systems of the body, like your heart. Autonomic, auto, think autopilot, you don't have conscious control over the autonomic process. The autonomic is divided into sympathetic and parasympathetic nervous systems. The sympathetic system increases the activation level of neurons in preparation for activity(ramps you up). The parasympathetic ramps your system down, decreases levels of activation. Sensory receptors are specialized structures that convert environmental stimuli(heat, sound, taste, etc) into sensory information for the brain. These receptors are divided into four categories, mechanoreceptors, nociceptors, chemoreceptors, and photoreceptors. Mechanoreceptors – specialized structures that respond to mechanical pressure within tissues and then transmit signals through sensory nerves. Respond to outside forces such as touch, pressure, stretching, sound waves, and motion. Senses distortions in body tissues. Muscle Spindles – Sensory receptors, run parallel to muscle fibers. Are sensitive to changes in muscle length and rate of length change. Help regulate the contraction of muscles via the stretch reflex mechanism. This mechanism is a normal response to the body to a stretch stimulus in the muscle, it is designed to protect and prevent overstretching and muscle damage. Gogli Tendon Organs(GTOs) – Specialized sensory receptors located where the skeletal muscle fibers attach to the tendons. Sensitive to changes in muscular tension and rate of tension change. Activiating the Gogli tendon organ causes the muscle to relax which prevents the muscle from excessive stress or injury. Joint receptors – located around joint capsule, respond to pressure, acceleration, and deceleration of the joint. Signals extreme joint positions and thus helps prevent injury. Performance increases in early stages of training result from changes in the way the CNS controls and coordinates movement. Unsuccesful performances can be cross referenced with other sensory input and new movement strategys found. Regular training causes adapations int he CNS, allowing greater control of movements, thus causing movements to be more smooth and more accurate – improving performance. Skeletal System Skeletal System – Body's framework, composed of bones and joints. Provides shape and focus for bodies. Produces blood for the body and stores minerals. Growth, maturation, and functionality of skeletal system are greatly affected by posture, physical activity, and nutrition. Bones – Provide a resting ground for muscles and protection of vital organs. Joints – Junctions of bones, muscles, and connective tissues at which movement occurs. Also known as articulation. The skeletal system is divided into two divisions. Axial Skeleton – Portion of skeletal system that consists of skull, rib cage, and vertebral column. Think torso and head. 80 bones. Appendicular Skeleton – Portion of skeletal system that includes the upper and lower extremeties. Arms, legs. Think appendage, appendicular, arms, legs. 126 bones. 206 bones in the skeletal system, 177 used in voluntary movement, more than 300 joints in the body. Bones serve two vital functions – leverage and support. Remodeling – Process of resorption and formation of bone. Old bone is broken down and removed by osteoclasts, new bone is laid down by cells called osteoblasts. Osteoclasts – Bone cell that removes bone tissue. Clast. Clap. You want to get rid of the clap. Osteoclasts get rid of bone. Osteoblasts – Bone cell that forms bone. Blast. You like having a blast. You like building bone. Osteoblasts build bone. Remodeling follows lines of stress placed on bone. Exercise and habitual posture fundamentally influences the health of the skeletal system. Incorrect exercise and posture will lead to remodeling process that reinforces predominating bad posture. Types of Bones Five major types of bones. Shape, size, and proportion determine their classification. Long bones – long cylindrical body, irregular or widened ends. Shaped like a beam and have slight curvature. Predominantly composed of compact bone tissue for strength and stiffness. Has considerable amount of spongy tissue for shock absorption. Epiphysis – End of long bones, mainly composed of cancellous bone and house much of the red marrow involve din red blood cell production. One of primary sites for bone growth. End of long bones, red marrow which produces red blood cells. Knobby end looking parts of the bone. Diaphysis – Shaft portion of long bone. The shaft. Long part. Compact bone(strong). Epiphyseal Plate – Region of long bone connecting the diaphysis to the epiphysis. A layer of subdividing cartilaginous cells in which growth in length of the diaphysis occurs. Periosteum – Dense membrane composed of fibrous connective tissue that closely wraps (invests) all bone, except that of the articulating surfaces in joints, which are covered by a synovial membrane. Inner surface provides materials for nutrition repair and facilitates growth in the diameter of the bone. Medullary cavity – Central cavity of bone shafts where marrow is stored. Contains fatty yellow marrow, predominantly fat and serves as energy reserve, center of diaphysis. Articular (hyaline) cartilage – Covers the articular surfaces of bones. "articular surface" means the parts of the bone that moves in joints. Hard, white, shiny tissue that along with synovial fluid helps reduce friction in freely moving synovial joints. Fundamental to smooth joint action. Short bones – Similar in length and width. Somewhat cubical in shape. Consist predominantly of spongy bone tissue to maximize shock absorption. Carpals of hands and tarsals of feet. Flat bones – Thin bones, two layers of compact bone tissue surrounding a layer of spongy bone tissue. Involved in protection of internal structures and also provide broad attachment sites for muscles. Sternum, scapulae, ribs. Irregular bones – Unique shape and function. Veterbrae, pelvic bones, facial bones. Sesamoid Bones – Small bones embedded in a joint capsule or found in locations where tendon passes over a joint. Develop within particular tendons at a site of considerable friction or tension. Serve to improve leverage and protect the joint from damage. Bone Markings Bones have specific distinguishing structures called surface markings. They increase stability in joints as well as provide attachment sites for muscles. Divided into depressions and processes. Depressions – Flattened or indented portions of bone, which can be muscle attachment sites. Indents. Grooves. Processes – Projections protruding from the bone where muscles, tendons, and ligaments can attach. Part that sticks out on bones. Where there is a depression on both sides will generally be processes. Vertebral Column Vertebral Column – Backbone, spinal column, series of irregularly shaped bones called vertebrae that houses spinal cord. First seven vertebrae starting from top are cervical vertebrae, flexible framework and provide support and motion for the head(your neck, basically). Next 12 are upper and middle back, called thoracic vertebrae, move with the ribs to form rear anchor of rib cage. Larger than cervical vertebrae and increase in size from top to bottom. Next five are lumbar vertebrae. Largest in spinal column, support most of the body's weight and attached to back muscles, often location of pain because they are subject to largest forces and stresses. The sacrum is a triangular bone located below lumbar vertebrae, four or five sacral vertebrae in a child which become fused into a single bone during adulthood. Bottom of spinal column is coccyx or tailbone, 3 to 5 bones fused together. Intervertebral discs are fibrous cartilage that act as shock absorbers and allow the back to move. Optimal arrangement of curves is referred to as a neutral spine. Vertebrae and associated structures under the least amount of load. Joints Formed by one bone that articulates with another bone. Categorized by structure and function. Arthrokinematics – Joint motion. Rolled, slide, and spin. Motions rarely occur in isolation. Rolling movement – bicycle roll on street. Sliding – tire skidding on street. Spinning movement – twisting lid off a jar. Synovial joints – Held together by a joint capsule and ligaments and are most associated with movement in the body. 80% of all joints in the body, have greatest capacity for motion. Produce synovial fluid, resembles egg whites and works like engine oil. Nonsynovial joints – do not have a joint cavity, connective tissue, or cartilage. Exhibit little to no movement, seen in skull, distal joint of tibia and fibula. Ligaments – Primary connective tissue that connects bones together and provides stability, input to the nervous system, guidance, and the limitation of improper joint movement. Fibrous connective tissues, bone to bone, provide static and dynamic stability as well as input to nervous system (proprioception). Made up of collagen. Ligaments have poor vascularity, blood flow, thus do not heal or repair well. The Muscular System Muscular system – series of muscles that move the skeleton. Muscles generate internal tension, under control of nervous system, manipulates bones to produce movements. Movers and stabilizers. The Structure of Skeletal Muscle Skeletal muscle one of three major muscle types, others are cardiac and smooth. Made up of individual muscle fibers. Bundles of muscle fiber can be broken down into layers. First layer is fascia, connective tissue. Epimysium – layer of connective tissue that is underneath the fascia and surrounds the muscle. Inner layer immediately surrounding the muscle. Fascia and epimysium are connected to bone to help form muscle's tendon. The next bundle of muscle fiber is called fascicle. Each fascicle is wrapped by connective tissue called perimysium. Perimysium – connective tissue that surrounds fascicle. Each fasicle is made up of many individual muscle fibers which are wrapped in a connective tissue called endomysium. Endomysium – deepest layer of connective tissue that surrounds individual muscle fibers. Connective tissues within muscle play vital role in movement, they allow forces generated by muscle to be transmitted from contractile components of muscle to bones, each layer of connective tissue extends the length of the muscle helping form the tendon. Tendons – Connective tissues that attach muscle to bone and provide an anchor for muscles to produce force. KNOW THIS FIGURE! Muscle Fibers and their Contractile Elements Fibers are encased in a plasma membrane known as sarcolemma. Sarcomere – functional unit of muscle that produces muscular contraction and consists of repeating sections of actin and myosin. Neural Activation – Contraction of a muscle generated by neural stimulation. Motor Unit – Motor neuron and all of the muscle fibers it innervates. Neurotransmitters – Chemical messengers that cross the neuromuscular junction (synpase) to transmit electrical impulses from nerve to the muscle. Acetylcholine (ACh) is what is used by neuromuscular system. Once attached ACh stimulates fibers to go through a series of steps that initiates muscle contractions. Muscles are divided into motor units. Single motor unit consists of one motor neuron(nerve) and the muscle fibers it innervates. If stimulus is strong enough it will spread through whole length of muscle fiber, all of the muscle fibers supplied by a single nerve. If the stimulus is not strong enough then there will be no action potential and no muscle contraction. Motor units cannot vary the amount of force they generate. They either contract maximally or not at all. Because of all or nothing law the overall strength of skeletal muscle contraction depends on size of the motor unit recruited(how many muscle fibers are contained within the unit) and number of motor units activated. Muscles that control fine movements are made up of many small motor units. Large muscles are made up of larger motor units. 10-20 fibers in each eye motor unit. 2,000 to 3,000 fibers in intestinal motor units. Understand this figure. Muscle Fiber Types Fiber types vary in chemical and mechanical properties. Two main types, type I and type II. Type I(slow twitch) contain large number of capillaries, mitochondria(transforms energy from food into ATP), myoglobin(increased delivery of oxygen). Red fibers Type II(fast-twitch) subdivided into Type IIa and Type IIx. Contain fewer capillaries, mitochondria, and myoglobin. White fibers. Type IIx have low oxidative capacity and fatigue quickly. Type IIa higher oxidative capacity and fatigue more slowly than IIx. IIa are known as intermediate fast-twitch fibers. Type I are smaller in diameter, slow to produce maximal tension, more resistant to fatigue. Produce long term contractions. Think marathons. Maintaining posture against gravity. Type II larger in size, quick to produce maximal tension, fatigue more quickly. Sprint muscles. All muscles have combination of slow and fast twitch. Ex. shin has 735 slow twitch type I whereas calf muscle has 49% slow twitch. Know this. Muscles as Movers Agnost muscles act as prime movers. They are most responsible for a particular movement. Synergist muscles assist prime movers. Synergist, think synergy. Assists with. Stabilizer support and stabilize the body. Antagonist muscles perform opposite action of prime mover. Know this figure for the test. The Endocrine System System of glands that secrete hormones into bloodstream to regulate variety of bodily functions. Mood, growth, development, tissue function, and metabolism. Endocrine Glands Primary endocrine glands are hypothalamus, pituitary, thyroid, and adrenal glands. Pituitary, "master" gland. Controls functions of other endocrine glands. Thyroid produces hormones that regulate metabolism and affect growth. Adrenal glands secret hormones – corticosteroids, catecholamines, cortisol, adrenaline in response to stress. Hormonal activity control rests with hypothalamus and pituitary gland. Insulin, Glucagon, and Control of Blood Glucose Glucose is primary energy source during vigorous exercise. Glucose principal fuel for the brain. Too much glucose can damage vascular system. Control of glucose regulated by pancreas – producing insulin and glucagon. Insulin – Regulate energy and glucose metabolism. Glucose rich blood is circulated through pancreas, elevated levels of glucose trigger release of insulin. Circulating insulin binds with receptors in skeletal muscle and liver cells and cell membranes become more permeable to glucose. Glucose then diffuses from bloodstream into cell resulting in drop in blood glucose. Thus insulin causes fat, liver, muscle cells to take up glucose from the blood and store it as glycogen in liver and muscle. Glucagon – Opposite effect of insulin, functions to raise blood glucose by triggering release of glycogen stores from liver. Drop in circulating blood glucose triggers release of glucagon from pancreas. As activity levels increase the glucose uptake by cells increases. Increases insulin sensitivity in cells. Glucagon also increases helping m aintain steady supply of glucose. Adrenal, Pituitary, Reproductive, and Thyroid Hormones Catecholamines – two, epinephrine(adrenaline) and norepinephrine. Produced by adrenal glands(on top of each kidney). Help prepare body for activity. Fight or flight. Hypothalamus triggers adrenals to secrete epinephrine for fight. Epinephrine – increases heart rate and stroke volume, elevates blood glucose levels, redistributes blood to working tissues, opens up airways. Testosterone – produced in testes in males, ovaries and adrenal glands in females. Males produce up to 10x more. Fundamental role in growth and repair of tissue. Estrogen produced in ovaries in female and small amounts in adrenals in males. Cortisol – Catabolic hormone. Secreted by adrenals, serves to maintain high energy supply. Chronic cortisol can lead to significant breakdown of muscle tissue. Growth Hormone – Released from pituitary, regulated by hypothalamus. Stimulated by several factors: estrogen, testosterone, deep sleep, vigorous exercise. Primary anabolic hormone responsible for most of growth and development during childhood until puberty when primary sex hormones take over. Increases development of bone, muscle tissue, and protein synthesis. Increases fat burning and strengthens immune systme. Thyroid gland located at base of the neck below thyroid cartilage(adams apple). Releases hormones responsible for metabolism regulation. Testosterone and growth hormone levels increase after strength training and moderate to vigorous aerobic exercise. Prolonged bouts of endurance training or extremely intense training lowers testosterone levels while raising cortisol levels. Figure 10.2 Effects of joint dysfunction Table 10.1 Balance training parameters OPT Level (adaptation): Stabilization, Strength, or Power Be familiar with all exercises listed, as well as how to regress and progress the exercises listed Type of Exercise: Balance Table 10.2 Balance training program design Key to all functional movements. Balance – When body is in equilibrium and stationary, meaning no linear or angular movement. Maintaining handstand without falling over. Dynamic Balance – ability to move and change directions under various conditions without falling. Running on uneven surfaces. Balance is dependent on internal and external factors to maintain body's center of gravity over its base of support. Dynamic process involving multiple neurologic pathways. Research shows that specific kinetic chain imbalances(such as altered length-tension relationships, force-couple relationships, and arthrokinematics) can lead to altered balance and neuromuscular inefficiency. Flawed movement patterns alter firing order of muscles activated. Joint dysfunction creates muscle inhibition. Leads to joint injury, swelling, interruption of sensory input from articular, ligamentous, and muscular mechanoreceptors to the central nervous system, results in clinically evident disturbance in proprioception. Sensory feedback to CNS is altered after ankle sprains, ligamentous injuries to the knee, and low-back pain. Importance of Properly Training the Balance Mechanism Balance training should stress individual's limit of stability(or balance threshold). Limit of stability is distance outside of the base of support that he or she can move into without losing control of his or her center of gravity. Threshold must be stressed in multiplanar, proprioceptively enriched(unstable yet controlled) environment, using functional movement patterns to improve dynamic balance and neuromuscular efficiency. Benefits of Balance Training Balance training effects on injury Research shows performing exercises that demand balance can reduce rate of ankle sprains and other lower extremity injuries. Part of ACL injury prevention programs. Integrated injury prevention programs that include balance exercises in addition to plyometric or strength greatly influenced ability to improve lower extremity biomechanics. Should be performed at least 10 mins a day, 3 times a week, for 4 weeks. Designing a Balance Training Program Must be systematic and progressive. Main goal of balance training is to continually increase client's awareness of his or her limit of stability(or kinesthetic awareness) by creating controlled instability. Levels of Training Three levels of training – stabilization, strength, and power. Proper balance training program follows same systematic progression. Surfaces change in difficulty as individual moves from stable surface(floor) to unstable surfaces(half foam roll, foam pad, balance disc). Eyes open is easier than eyes closed. Change one variable at a time. Balance Stabilization Exercises Involve little joint motion; instead are designed to improve reflexive(automatic) joint stabilization contractions to increase joint stability. Sample exercises: single-leg balance, single-leg balance reach, single-leg hip internal and external rotation, single-leg lift and chop, single-leg throw and catch Balance Strength Exercises Involve dynamic eccentric and concentric movement of balance leg, through full range of motion. Sample exercises: single-leg squat, single-leg squat touchdown, single-leg romanian deadlift, multiplanar step-up to balance, multiplanar lunge to balance Balance Power Exercises Designed to develop proper deceleration ability to move body from dynamic state to a controlled stationary position, as well as high levels of eccentric strength, dynamic neuromuscular efficiency,and reactive joint stabilization. Exercises include: multiplanar hop with stabilization, multiplanar sing-leg box hop-up with stabilization, multiplanar single-leg box hop-down with stabilization. Implementing a Balance Training Program If you have not yet signed up for the NASM PES certification, receive a big discount here. Get your copy of the NASM PES exam cheat sheet. It helps immensely for studying for the exam. My PTP students report cutting their NASM PES study time and effort in half with Trainer Academy. Benefit from the Exam Pass Guarantee and Retake Fee Guarantee. Plus, take advantage of my current discount code PTPMAY for 50% off the MVP Program (Ends May 29th, 2025). Try it out for free here to see if it's right for you, or read my detailed review for further insights. Be able to explain the functioning of the components of the postural control system in keeping our balance and preventing injuries to the body. Describe the role that balance training has in improving sports performance and preventing injuries. Find the attributes of progressive balance training programs for athletes at any level of training. Balance is the ability for us to keep the center of gravity within the base of support. We achieve it through interactions of active and passive restraints imposed on the muscular system, reflexive action by the peripheral nervous system, and anticipatory feed-forward control from the central nervous system. It is important to have knowledge of the postural control system and the kinetic chain, especially the lower extremities, as they probed the base of support for the most part. Sports performance professionals need to understand the control of posture and out components of posture to be able to be efficient with their training of athletes for optimal performance. Maintaining of posture while doing exercise is the continuous process of tiny adjustments that will keep the center of gravity over the base of support. That is the essence of postural control. Maintaining the equilibrium will require sensory detection of motion and position in space, resulting in sensorimotor integration and the execution of the right responses of the musculoskeletal system. Most Popular Cert Best Online NCCA Cert Best Study Materials Gold Standard Cert A Good Option Best CPT for you? For sensing the position relative to gravity and the individual's surroundings, the human movement system must use visual, vestibular, and proprioceptive inputs, which establish balance. Neuromuscular efficiency will be the ability of the neuromuscular system to allow the agonists, antagonists, synergists, neutralizers, and stabilizers to all work together to provide efficient movement through our three planes. Balance is a complex and highly integrated dynamic process that involves multiple pathways from constant sensory afferent feedback from a full array of mechanoreceptors. Mechanoreceptors are our specialized neural receptors embedded in the connective tissues and are responsible for converting mechanical distortions into the neural codes conveyed to the central nervous system. Joint rotation causes the skin to stretch on one side and relax on the other. The sensory afferent neurons will detect the skin stretching to give information regarding the rotation. Joints will move when muscle tension overcomes resistance. When movement happens in the joint, some muscles will shorten, and some will lengthen. The muscle sensory afferents will give us information regarding the length and tension of the muscle to help with all of this. The two most important receptors here will be the Golgi tendon organ and the muscle spindle fibers. The Golgi tendon organ is a receptor that is located in the musculotendinous junction that is sensitive to tension and the rate of change in tension. Muscle spindles are a major organ for the sensory system and are made up of microscopic intrafusal fibers lying parallel to the extrafusal muscle fibers. These will be sensitive to changes in length and the rate of length change. Joint rotation and deformation stretch the joint capsule on one side. They may also compress it against the underlying bone, with structures on the contralateral side of the joint correspondingly unloaded. Most Popular Cert Best Online NCCA Cert Best Study Materials Gold Standard Cert A Good Option Best CPT for you? The ligaments may also be loaded in some form through this joint rotation process. We have several types of joint receptors, like the Ruffini afferents. These joint receptors are sensitive mechanically to tissue stressing that is activated when extending or rotating. Paciniform afferents are going to be large, cylinder shaped, thinly encapsulated organ structures that are sensitive to the local compression and loading of tensile tissues. Golgi afferents are higher thresholds and slow to adapt to sensory receptors in our ligaments and menisci. Nociocepors are smaller afferents in our articular tissues and are sensitive to pain and deformation. These will be deformed when rotated and they are simply sensitive to stretches. Anticipating posture will play an important role in keeping balance when doing a task. Adjusting the posture of the legs and the trunk may be done before the actual movement that is voluntary in the trunk or the upper limbs. Research has also shown increased activation in the core related muscles before acting out a movement. When athletes move, they are not usually aware of these complex motor processes of the sensorimotor system. Inefficient stabilization of the neuromuscular system will lead to abnormal stresses being put onto the human movement system. The human movement system will not respond to the demands of functional activities. When the efficiency of the neuromuscular system goes down, the ability to maintain the right forces also goes down. This leads to compensation and alterations in the movement patterns, which then advances further to excessive mechanical loading in both the contractile and the non-contractile tissues. The human movement system will

only be as strong as its weakest link. Dynamic joint stabilization is defined as the ability of our kinetic chain to stabilize the joints during movements. Multi-sensory condition means that the training environment gives heightened amounts of stimulation to the proprioceptors and the mechanoreceptors. Controlled instability is an unstable training environment to the level that the individual can control it. Balance is the component in all movements, whether dominated by strength, flexibility, or endurance. The balance should not be trained in an isolated fashion, as in sports, it will not work in isolation either. Designing the progressions for integrated balance training requires the creation of a proprioceptively enriched environment and selecting the right exercises. These programs should be based on science with an approach to functional work, a systematic approach, and one focused on progressing. The NASM has made a safe and integrated balance training program that follows the OPT model well. Make sure to review the diagrams, steps, and exercises for the program and its phases individually. These are the phases of stabilization, strength, and power.