# Functional Balance

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Functional balance is the integration of static and dynamic balance training to maintain or improve Activities of Daily Living (ADL) and Quality of Life (QoL). Static balance is the ability to maintain a position. Dynamic balance is the ability to maintain stability with changing conditions of body movement and requires small adjustments to maintain a position over a base of support with any movement. It must adhere to the concept of bio-motor integration which indicates that all movements performed unsupported while on the feet require an integrated combination of the basic bio-motor abilities of balance, coordination, flexibility, strength, endurance, power, and agility. The objective is to develop functional movement patterns by increasing muscular strength and improving the way muscles work together. Functional balance is an integral part of everything we do.

Balance is a key measure of human neuro-mechanical function that describes the capacity to maintain the line of gravity within a base of support. Many people take balance for granted and move about without thinking. However, millions are challenged by instability and the fear of falling. Balance is that indefinable $6^{th}$ sense that helps us navigate through the world - agility. We feel out of control when we lose our balance. Balance is the base to establish before coordination and agility. Balance occurs when the center of gravity (COG) is in alignment with the base of support (BOS). Automatic adjustments are required to return the body to alignment to prevent falls. This requires the ability of the body to employ multiple systems to prevent a loss of balance. The center of gravity and base of support are also effected by movement of the head and simply turning the head away from neutral disrupts the alignment and challenges the limit of stability (LOS).

“Control of balance is reliant on interaction and integration of sensory input from the visual, vestibular, and proprioceptive systems. Contribution of individual sensory systems in maintaining balance during a movement task is variable and dependent on a multitude of factors including the explicit physical demands of the task, external environment, pathological impairment, and age” (Amiridis, Hatzitaki, & Arabatzi, 2003; Balasubramaniam & Wing, 2002; Redfern, Yardley, & Bronstein, 2001). Functional balance training should include protocols that require the body to respond to varied perturbations and exercises to re-enforce the control movement of the head, body and extremities triggering a reaction to stabilize. Exercises should be executed in all planes of motion, keeping in mind the sensory processes that feed the body information.

Balance plays an important role in mitigating fall risk and subsequent injury in the elderly and is positively associated with improved performance and reduced risk for injury in athletic populations. (McGuine, Greene, Best, & Leverson, 2000) Assessments of static and functional (dynamic) balance are common in various populations including athletic post injury, individuals experiencing impaired sensorimotor function, and the elderly. “Balance under static conditions accentuates the capacity to minimize line of gravity sway within a defined, unchanging base of support" (Winter, Patla, & Frank, 1990).

The objective of a thought provoking study, "Effect of Aquatic Immersion on Static Balance," was to quantitatively assess measures of static balance and limits of stability (LOS) in an aquatic environment compared with on land. When participants performed a quiet double-leg stance task, postural sway velocity on land increased and perceived stability decreased when the task was performed in water). In addition, participants achieved greater center of pressure (COP) maximum excursions in the water compared with on land. Questions raised from the study included understanding static land balance versus static water balance and ways to employ static and dynamic (functional) balance exercises in the water to further improve balance on land.

It is known that multiple systems effect balance. L. Denomme stated that "A deficit or impairment in one or more increases the risk of falls. Examples of deficits that impact balance and falls:

- Damaged or impaired sensory processes (visual, vestibular, proprioceptors),
- Musculoskeletal changes (reduced flexibility and ROM, loss of strength),
- Reduced ability to anticipate/adapt to posture and balance needs (cognition),
- Inadequate neuromuscular response (slowed or no motor response).

Therefore, although most falls are associated with older adults in the literature, aging is not the only factor to consider. Trauma or disease processes, may occur at any age and contribute to balance deficits."

Functional balance has a direct reliance on lumbar/pelvic stabilization and articulation. "Stability of the spine is proposed to be dependent upon active (muscles), passive (skeletal/noncontractile), and control (neural) subsystems." (Panjabi 1992) The main function of spinal orientation is to balance external loads applied to the trunk so that residual forces transferred to the lumbar spine can be handled by the local muscles. (Biondi) Vertical loading of the lumbar spine (axial compressions) occurs during upright standing or sitting postures. It is important to be aware of the constant compression forces that are occurring throughout the vertebra, the intervertebral discs, and the facet joints.

Key strategies addressing balance looks at core strength and physical condition as the foundation of all movement and balance. Adequate core strength enables correct body alignment. It also requires coordination of the visual, vestibular, and somatosensory systems to guarantee safe interaction with our environment. Challenged balance for many involves injuries or a decline in vision and hearing loss. If hearing loss is the result of a traumatic accident, dizziness must also be specifically addressed. In this case, dizziness must address the combined impact on the visual and vestibular systems. A traumatic injury heightens these systems and addressing the ability to focus on a spot slightly above eye level and look through the spot assists in bringing focus into frontal vision because peripheral vision has resulted in heightened sensitivity to all that is going on around them, thus no focus or opportunity for the vestibular system to calm. Failure to integrate these systems along with physical pain, increased reaction time, decreased strength in the lower extremities, decreased range of motion, and/or the combination of certain multiple medications place us at increased risk to become out-of-balance.

The association of balance to falling is a permanent linkage. A fall is a sudden unexpected change in position. It must be remembered that a fall is a symptom, not a diagnosis and should not be accepted as a normal part of aging. Falls happen when the limit of stability (LOS) which is the center of mass exceeds base of support (BOS) and recovery to BOS and COG is lost. In water, align the center of buoyancy over the center of gravity. If you align the center of gravity over the base of support, you balance. If your brain senses joint instability, the prime movers that support the joint cannot function properly. You must regain joint stability before the prime movers can be utilized for anything other than correcting your balance. Losing your balance for even a split second means a loss of functional strength while your body/mind focuses on regaining balance.

Musculoskeletal Strength gives us the power to create, hold, and adjust alignment. Strength training is a key piece of the puzzle and a remedy for instability. Increasing strength may offset some contraction speed deficits often found in the physically unfit, LE deficits due to prolonged non-weight-bearing or amputation, the elderly, and congenital abnormalities. The goal is to develop functional movement patterns by increasing muscular strength and improving the way muscles work together.

Muscular strength loss correlates with muscle mass loss. Strength changes occur faster in lower extremities than upper extremities. The more inactive we are, the more strength we lose. Studies have shown a 16.5% decrease after age 30, and 45% decrease by age 65. Most strength is lost after age 50. With strength training of quads, 60-70 year old men increased muscle strength in their quads as much as 227% in 12 weeks. Strength loss correlates with muscle mass loss. Strength changes occur faster in lower extremities than upper extremities. High intensity training needed to increase strength and improve function. If profoundly weak, the lack of balance and a buoyant body will equal difficulty walking in water. They will be unable to maintain verticality against the torque/buoyancy. How can the water be used for strength and maintaining bone health?

Muscular strength and maintaining or slowing the loss of strength is of concern with bone density. The greatest public health concern related to osteoporosis is the increased risk of fracture and accompanying high rates of mortality and morbidity. (Brown and Josse. 2002) Of particular concern is hip fracture, for which women have a 1 in 6 lifetime risk. (Cummings et al, 1989. Melton, 2000. Brown and Josse, 2002) Hip fractures in older adults are related to falls, and each year 1 in 3 community-living adults over the age of 65 falls. (Kanis and McCloskey, 1996) In the U.S. alone, there are 250,000 hip fractures and 500,000 spinal fractures yearly. (Prestwood and Gustavo. Osteoporosis in Older Women. Encyclopedia of endocrine Diseases, Vol. 3, 2004). A study in the medical journal, Nature Genetics, (2012) looked at why some people are more susceptible to bone fractures based upon factors inherited from their parents.

Essentially, each of our bones is continually broken down and replaced. When the rate of bone loss exceeds the rate of replacement, bones weaken, eventually leading to osteopenia followed by osteoporosis and an associated higher risk of fracture. Although findings reinforce the relationship between genetic factors and the risk of osteoporosis, the ability to predict osteoporosis is significantly improved when one combines the genetic predisposition with clinical risk factors such as age, tobacco use, and body weight. Based on these facts, any exercise program designed to retard bone loss must consider the frequency and duration of exercise, the ground reaction forces (GRF) created during the activity, the amount of muscle-bone tension created during the exercise, and the patient's age at the time of activity. (Salzman, Advance for Physical Therapy & Rehab Medicine, 2014) The pull of muscle on bone is most important for laying down new bone and the loss of muscle mass with ageing due to sarcopenia has an effect on the pull of the muscle on the bone to let bone building minerals enter and this decrease muscle mass challenges balance leading to falls and ultimately to frailty.

About 52 million Americans have osteoporosis and low bone mass, placing them at increased risk for osteoporosis. Studies suggest that approximately one in two women and up to one in four men age 50 and older will break a bone due to osteoporosis. Osteoporosis is responsible for two million broken bones and $19 billion in related costs every year. By 2025, experts predict that osteoporosis will be responsible for approximately three million fractures and $25.3 billion in costs each year. (National Osteoporosis Foundation)

Bone Mineral Density is a measure of the amount of minerals (mostly calcium and phosphorous) contained in a certain volume of bone. Bone mineral density measurements are used to diagnose osteoporosis (a condition marked by decreased bone mass), to see how well osteoporosis treatments are working, and to predict how likely the bones are to break. Osteoporosis and Osteopenia are diagnosed on a DXA test measuring Normal Bone Mass. (NIH Osteoporosis & Related Bone Diseases Resource Center) Sarcopenia is the loss of muscle mass, strength and function related to aging. It is most commonly seen in inactive people, but sarcopenia also affects those who remain physically active throughout their lives (Brink, "Preventing Sarcopenia," LifeExtension Magazine. 2007). When sarcopenia is coupled with other diseases associated with aging, its affects can be even more pronounced. Loss of muscle mass and strength is a significant risk factor for disability in the aging population. People who suffer from sarcopenia and osteoporosis have a higher incidence of falling and risk of fracture. (Sarcopenia: European Consensus on Definition and Diagnosis. Age and Ageing, April 13, 2010.)

In support aquatic exercise, Colado found that Water-based exercise may be a useful alternative to land-based exercise for people with osteoporosis who have difficulty exercising on land due to fear of falls, poor balance and pain. (Colado, Juan. IAFC 2013, Osteoporosis & Sarcopenia: Falls and Aquatic Physical condition.) In addition, Colado, et al. (2009) demonstrated that aquatic resistance training could offer significant physiological benefits in health and performance that are comparable to those obtained from land-based program performed by postmenopausal women.

Harush, et al. (2008) study investigated the effect of a 7-month water exercise program on BMD in postmenopausal women. The sessions were composed of 20 minutes of aerobic training at an intensity of 12-16 on the Borg scale and 20 minutes of resistance training with different exercises and devices. The findings of the study support the hypothesis that it is possible to plan and execute a water exercise intervention that has a positive effect on bone density. In older adults with osteoporosis, exercise contributes to decreasing fracture risk by maintaining or improving BMD and improving balance, lead to decreased risk of falling. (Brown & Josse, 2002) However, the optimal type, duration and frequency of such exercise have not yet been established. (Goliespie, et al. 2003; Carter, et al., 2004).

A direct comparison of actual movements and additional variables such as water depth, knowledge of participant's BMD, initial physical condition, etc. would provide additional insight into forming a "general" exercise protocol that would optimize bone health in shallow water. People with osteoporosis and many inactive or older adults are at higher risk of fracture due to falling. Improving balance and functional ability should be a high priority for exercise programs for people with low BMD. When prescribing physical activity programs for osteoporosis prevention, not only aerobic but also resistance exercises should be adopted since the improvement in strength reduces fall risk, which is the main cause of fracture and morbidity in people with low BMD. The added resistance by water's viscosity will stimulate bone growth by requiring the muscle to pull against the bone. (Salzman, 2014). Colado (2009) demonstrated that aquatic resistance training could offer significant physio9logical benefits in health and performance that are comparable to those obtained from land-based programs performed by postmenopausal women. Salzman (2014) reminds us that the consequences of osteoporotic fractures are not limited to the hips, but also the spine and the wrist. Poor endurance, restricted movement, and pain can be managed in a pool program.

Developing the aquatic program for functional balance should take into consideration physical conditioning, diagnoses that effect balance, and goals that transfer to land. The recommended starting point to work on balance is to look at basic yoga (land and pool), and progress to Ai Chi. Functional balance challenges include perturbations, water jets/turbulence, shifts out of Center of Balance with return to stability, strength training for the core, lower extremities, upper extremities, resistive and isometric exercises, and dynamic balance moves with head movements.

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