Integrated Balance Training
Introduction

Neuromuscular efficiency enables the body’s neuromuscular system to synergistically produce force, reduce force, and dynamically stabilize the entire kinetic chain in all three planes of motion. In other words, neuromuscular efficiency enables a person to maintain his or her balance during functional movement patterns, whether competing on the field of play or participating in day-to-day activities.

Balance is a component of all movement, whether strength, speed, skill, or flexibility dominates the movement in question. Accordingly, this chapter focuses on the relationship between balance and neuromuscular stabilization training so that the health and fitness professional can design an integrated training program that remedies kinetic chain dysfunctions and improves a client’s balance during functional movement patterns.

Balance appears to be a relatively simple concept, but it has many complex applications. Balance is often thought of as a static process, such as when a person stands rigid and stationary. In reality, balance is a highly integrated and dynamic process that involves multiple neurological pathways and requires constant sensory afferent feedback from all of the mechanoreceptors.²,³,⁴ For example, a relatively simple activity such as sprinting is a highly complex movement pattern. Sprinting requires losing and regaining your balance on one leg in less than 1/10th of a second. While balance is a dynamic and fundamental process, it can be easily and dramatically affected by a number of kinetic chain dysfunctions. These dysfunctions challenge a person’s ability to maintain his or her center of gravity over a changing base of support during functional movement patterns. These dysfunctions include muscle imbalances, proprioceptive deficits, joint dysfunction, and decreased neuromuscular efficiency. As part of a balance training program, the health and fitness professional must be able to identify and correct these dysfunctions, then customize a stabilization training program that applies neuromuscular stabilization guidelines and progressions.
Section I: 
Neuromuscular Stabilization Concepts

Postural-Control System

Health and fitness professionals must understand the postural-control system and its components. The postural-control system utilizes complex processes that involve visual, vestibular and proprioceptive inputs from the kinetic chain. Maintaining postural equilibrium requires sensory detection of motion, sensorimotor integration, and the execution of the appropriate musculoskeletal responses. Daily activities such as walking, stair climbing, reaching, and throwing require static foot placement with controlled balance shifts. Considered in this light, balance is both a static and dynamic process. The accomplishment of static and dynamic balance is based on the interaction between the kinetic chain (muscular, articular, neural systems) and the environment.

To sense its position relative to gravity and its surroundings, the body combines visual, vestibular, and proprioceptive inputs, and thereby establishes balance and neuromuscular control with sensorimotor integration in the central nervous system. The appropriate motor program is then executed based on the sensory information sent to the central nervous system. These complex processes help produce optimum neuromuscular efficiency during functional movement patterns.

Neuromuscular Efficiency

Neuromuscular efficiency is the ability of the neuromuscular system to allow the agonists, antagonists, synergists and stabilizers to efficiently work together in all three planes of motion. Appropriate movement sequencing and efficient motor programs are essential for optimum performance and maintenance of structural integrity throughout the kinetic chain. Optimum neuromuscular efficiency requires optimum postural alignment, muscle balance, dynamic flexibility, core stabilization, multiplanar functional strength, and neuromuscular stabilization.

Inefficient neuromuscular stabilization leads to abnormal stress in the kinetic chain. If the neuromuscular system is inappropriately trained, it will not respond to the demands imposed during functional activities. A lack of joint stabilization predisposes an individual to functional instability. A lack of neuromuscular stabilization alters length-tension relationships, force-couple relationships, and joint kinematics, which decreases performance and leads to tissue overload.
As the efficiency of the neuromuscular system decreases, the ability to maintain appropriate forces also decreases. This leads to compensations and substitution patterns, which then lead to excessive mechanical loading in the contractile and noncontractile tissues of the kinetic chain. This initiates the cumulative injury cycle.

The kinetic chain is only as strong as its weakest link. The central nervous system will allow recruitment of the prime movers only to the degree that the body maintains dynamic joint stabilization and postural equilibrium. The kinetic chain will break down at the weak link or transfer forces elsewhere throughout the kinetic chain. This leads to tissue overload, compensation, adaptation, and substitution patterns. Each tissue located in the kinetic chain has a different breakdown rate. This is referred to as the tissue stress continuum. Microfailure occurs in collagen tissue located in the kinetic chain when the tissue is deformed by 6 to 8%. Therefore, with a lack of neuromuscular control, the kinetic chain compensates to maintain force production. When forces are transferred to another link in the kinetic chain, alterations in stability and neuromuscular control occur. This further alters the normal force-couple relationships in the kinetic chain, and leads to altered reciprocal inhibition, synergistic dominance, and arthrokinematic inhibition.

The central nervous system is organized so that it selects optimum movement strategies to maintain adequate force production. If a prime mover is weak or slow to activate, synergistic muscles are recruited to maintain force production. Synergists fatigue more quickly and lack the precise neuromuscular control that the prime movers provide. This leads to faulty movement patterns and tissue overload.
Section II: Peripheral Neural Mechanisms in Proprioception

A proprioceptively enriched environment is fundamental to optimum performance. Health and fitness professionals must therefore have a thorough understanding of the peripheral neural mechanisms involved in proprioception in order to design effective integrated training programs.

Figure 1: Peripheral Neural Mechanism

- Proprioception
- Kinesthesia
- Balance
- Postural Control System

Proprioception is the cumulative neural input to the central nervous system from all mechanoreceptors that sense position and limb movement.\(^3,12,13,34\) Position sense is largely mediated through the muscular mechanoreceptors. Joint position sense is mediated through the ligamentous mechanoreceptors, and structural integrity and joint position sense are mediated through the articular mechanoreceptors. Kinesthesia is the conscious awareness of joint movement and joint position sense that results from proprioceptive input to the central nervous system.\(^3,12,13,34\) Balance is the highly integrated and dynamic process that involves the interaction of multiple neurological pathways. Balance makes it possible for the body to maintain its center of gravity over its base of support.\(^1,2,3,4\) This information comes from the muscular, articular, and neural systems (kinetic chain). The postural-control system works as an integrated feedback-control circuit between the central nervous system and the musculoskeletal system (kinetic chain).\(^3,5,6,7\) Control of our center of gravity comes from appropriate muscle activation patterns. This is controlled by a complex interaction between cerebral, cerebellar, spinal, and peripheral afferent and efferent signals.\(^35,36,37\) The maintenance of postural equilibrium requires the sensory detection of body motion, the integration of sensory motor information within the central nervous system, and the execution of appropriate musculoskeletal responses.\(^3,8–1\)
Integrated Balance Training

Figure 2: Postural Equilibrium

- Sensory Organization
- Sensorimotor Integration
- Muscle Coordination

Maintenance of Postural Equilibrium

The combination of sensory organization, sensorimotor integration, and muscle coordination results in optimum neuromuscular control. Sensory organization is the process that determines the timing, direction, and amplitude of corrective postural actions based on the information received by the visual, vestibular, and proprioceptive inputs. This is a reason why it is very important to train in a multi-sensory environment to elicit maximal sensory stimulation. This results in a vast amount of sensory afferent information bombarding the central nervous system. Muscle coordination is the process that determines the sequencing and distribution of the contractile activity among the muscles of the kinetic chain, which generate supportive reactions necessary to maintain balance. When movement occurs in a joint that is rotating, loads and deformations are produced in the soft tissues around the joints, soft tissues of the joint, and articular tissues. All these tissues are highly innervated by mechanoreceptors. This causes a reflex-mediated response and sensation of joint movement or changing position.

Mechanoreceptors are specialized neural cell aggregates embedded in connective tissue that transduce mechanical distortions of the tissue into neural codes that are then conveyed to the central nervous system. Tissue distortion — resulting from elongation, compression, traction, or tension — triggers an electrical charge across the membrane of receptor endings that generate neural impulses that are sent to the central nervous system. Impulses from peripheral mechanoreceptors are conducted to the central nervous system through different types of fibers that are specific to each sensory mortality.

Mechanoreceptor Function

Mechanoreceptors provide position sense and initiate protective joint stabilization reflexes. Research has validated that mechanoreceptors exist in the muscle, ligament, capsule, and articular structures.
Skin Receptors

Joint rotation causes the skin to stretch on one side and relax on the other side. The sensory afferent neurons that detect skin stretching potentially signal joint rotation. Studies have demonstrated that cutaneous afferents provide signals of joint motion and provide proprioceptive input to the central nervous system.⁴,¹²,⁴¹

Figure 3: Mechanoreceptors

- Skin
- Muscle
- Joint
- Ligamentous

Muscle Mechanoreceptors

Joint movement will stretch one muscle and relax another. Muscle sensory afferents provide unidirectional signals of joint movement. Excitation of muscle mechanoreceptors causes sensations of joint movement and position sense. When a muscle tenses around a joint, it increases the stretch sensitivity of the muscle spindle, which dramatically enhances proprioception at the joint level.¹²,⁴² The stimulation of muscle mechanoreceptors initiates protective reflexes about the joint position.³⁴,⁴⁴ Appropriate activation of muscle receptors during functional movement training creates maximal joint stabilization and maximal sensory input to the central nervous system. This enhances neuromuscular efficiency and prevents injury.

There are two primary muscle mechanoreceptors — the muscle spindle and the golgi tendon organ (GTO). The muscle spindle (intrafusal muscle fiber) is a small complex proprioceptive organ located within the muscle fibers (extrafusal muscle fiber).¹²,⁴²,⁴³ The muscle spindle has both sensory and motor innervation. Sensory information regarding the length of the muscle and the rate of change of length is transmitted to the central nervous system by the muscle spindle. The muscle spindle also contains contractile fibers that are controlled by gamma motor neurons from the spinal cord. When stretching activates the muscle spindle, a sensory response is evoked and transmitted to the spinal cord, which in turn sends impulses back to the muscle. This reflexively produces a quick contraction of the agonist and synergistic muscle fibers and causes reciprocal inhibition of the antagonist muscle fibers. The strength of the muscle spindle response is determined by the rate of stretch. The faster the load is applied, the greater the firing frequency of the
Integrated Balance Training

muscle spindle, and the greater the resultant reflexive muscle contraction.\textsuperscript{1,4,43} This coactivation of the muscle spindle and the extrafusal muscle fibers allows for continuous monitoring of the length and the rate of change in length of the originating muscle. This allows the muscle spindle to remain under tension and provide sensory information about the length and rate of change in the muscle even after the muscle has been shortened. This improves the excitability and sensitivity of the central nervous system.\textsuperscript{4} The GTO, a muscle mechanoreceptor located at the musculotendinous junction in series with the extrafusal muscle fibers,\textsuperscript{1,4,43} is primarily sensitive to tension development and rate of tension development in the skeletal muscle.\textsuperscript{12} The GTO has an inhibitory effect on the skeletal muscle. Upon activation, impulses are sent to the spinal cord, causing reciprocal inhibition of the alpha motor neurons of the agonist and synergists, thereby limiting force production. Research postulates that the GTO functions as a protective mechanism to prevent overcontraction and overstretching of the muscle.\textsuperscript{1,4,43}

Joint Mechanoreceptors

Joint rotation or deformation stretches the joint capsule on one side of the joint and may also compress it against the underlying bone. The structures on the other side of the joint will be unloaded. Ligamentous structures may also be loaded with joint rotation.\textsuperscript{1,13,34} There are several types of joint receptors including ruffini afferents, paciniform afferents, GTO-like afferents, and nocioceptors. Ruffini afferents are large, encapsulated, multicellular end organ structures located within the collagenous network that makes up the fibrous capsule of the joint.\textsuperscript{1,36} These receptors are slowly adapting sensory neurons that continue to discharge information as long as a mechanical stimulus is present. These receptors are mechanically sensitive to tissue stress, and activated during extreme extension and rotation movements. They are generally considered to be the limit detectors of motion.\textsuperscript{11,1,33,34,45} Paciniform afferents are large, cylindrical, thinly encapsulated, multicellular end organ structures. These receptors are widely distributed around the joint capsule and periarticular tissue and are mechanically sensitive to local compression and tensile loading. They are primarily sensitive at extreme ranges of motion. They exhibit a rapid burst of impulses following stimulation, after which there is a rapid decline in the impulse rate. These receptors are associated with the detection of acceleration, deceleration, or sudden changes in the deformation of the mechanoreceptors.\textsuperscript{12,13,34,46} Golgi afferents are high-threshold, slowly adapting sensory receptors located in ligaments and menisci. These receptors are mechanically sensitive to tensile loads and are more sensitive at the end ranges of motion.\textsuperscript{12,13,34,46} Nocioceptors are small-diameter afferents primarily located in articular tissue and are sensitive to mechanical deformation and pain. The sensory receptors lack directional specificity. Optimum stimulation for these sensory receptors includes abnormal rotation, deformation, or chemical changes.\textsuperscript{12,47,48} The motto “No pain, no gain” has no place in an integrated training program. Inflammation and abnormal sensory input to the central nervous system creates pain,
and results in decreased neuromuscular efficiency and tissue overload. Forceful joint rotation into the limit of movement causes a discharge in the sensory afferents. The sensory neurons become more sensitive with joint inflammation. Inflammation produces spontaneous discharge of the nociceptors. Inflammatory mediators (histamine, bradykinin, and prostaglandin) lower the threshold activation for the nociceptor.

Figure 4: Joint Mechanoreceptors
- Ruffini Afferents
- Paciniform Afferents
- Golgi Afferents
- Nocioceptors

**Ligamentous Mechanoreceptors**

Ligamentous mechanoreceptors are deformed during rotation and are mechanically sensitive to stretching. Movement of the joint in any limiting position results in sensory stimulation. Ligamentous receptors cause an increased level of response in the gamma efferent muscle spindle receptors. This is primarily responsible for the appropriate muscle-firing patterns necessary to help protect the joint during stabilization. Joint receptors and muscle receptors work interdependently to provide optimum proprioceptive input to the central nervous system. Joint receptors increase the response when muscle mechanoreceptors are losing their ability to signal changes and angular displacement. This results in maximal sensory input at the central nervous system level and optimum neuromuscular efficiency.
Section III: Motor-Control Concepts

Balance training restores dynamic stabilization mechanisms, improves neuromuscular efficiency, and maximally stimulates joint and muscle receptors to encourage maximal sensory input to the central nervous system.\textsuperscript{16,53,54,55,56} Developing a training, reconditioning, and performance-enhancement program that incorporates proprioceptively mediated muscular control of joint stabilization necessitates an appreciation of the central nervous system’s influence on motor control. Mechanoreceptors contribute to the central nervous system function at three distinct levels of motor control.\textsuperscript{11,49,57} Each of these three levels of motor control must be addressed during balance training. The three levels of motor control are reflex-mediated control, brainstem-mediated control, and cognitive-mediated control\textsuperscript{49,57}

Figure 5: Levels of Motor Control

<table>
<thead>
<tr>
<th>THREE LEVELS OF MOTOR CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflex-Mediated Control</td>
</tr>
<tr>
<td>Brainstem-Mediated Control</td>
</tr>
<tr>
<td>Cognitive-Mediated Control</td>
</tr>
</tbody>
</table>

Reflex-Mediated Joint Stabilization

Reflex-mediated joint stabilization regulates the antagonistic and synergistic patterns of muscle contraction.\textsuperscript{57} This mechanism provides reflex muscle splinting during conditions of abnormal joint stress, providing optimum joint stabilization.\textsuperscript{49} The muscle spindle plays a significant role in dynamic joint stabilization. Muscle spindles continuously adapt to changes in length and provide continuous sensory information to the central nervous system in regard to the length, rate of change in length, and joint movement. Activities that encourage joint reflex stabilization should dominate this phase of training.\textsuperscript{49,57,58} These activities include training on an unstable surface utilizing functional movement patterns.
Brainstem-Mediated Motor Control

The brainstem-mediated motor control mechanism interacts with the vestibular system for control of postural equilibrium. This mechanism works interdependently with the muscles in the kinetic chain complex by inhibiting antagonistic muscle activity under conditions of rapid lengthening and periarticular distortion. Sensory information from visual, vestibular, and proprioceptive receptors are relayed to the brainstem to assist with posture and balance. Balance activities with and without visual input will enhance motor function at the brainstem level. Clients should initially concentrate on position sense (kinesthesia) and neuromuscular control to facilitate maximal sensory stimulation. As the task becomes easier, the health and fitness professional should incorporate activities to distract his or her client’s concentration. This will help with the conversion to unconscious motor patterns. Activities include training in an unstable environment utilizing functional movement patterns with the eyes open and the eyes closed while throwing and catching an object. This creates maximal stimulation at the brainstem level.

Cognitive-Mediated Control

Sensory afferent receptors interact and influence cognitive awareness of body position and joint movement. This mechanism is mediated by cognitive awareness of body position and movement. Higher centers (motor cortex, basal ganglia, and cerebellum) initiate and program commands for voluntary movement. Repeated movements can be stored as central commands and can be performed without continuous reference to consciousness. The health and fitness professional needs to include an appreciation of joint position sense at the highest level of motor control in a balance training program.
Integrated Balance Training

Section IV: Scientific Rationale for Balance Training

Several authors have demonstrated specific kinetic chain imbalances in individuals with altered neuromuscular control. Complex kinetic chain dysfunctions, including muscle imbalances, joint dysfunctions, and decreased neuromuscular control, lead to decreased balance and neuromuscular efficiency throughout the kinetic chain. Therefore, all individuals require a comprehensive neuromuscular stabilization program.

Faulty Movement Patterns

Alterations in the kinetic chain affect the quality of movement and perpetuate faulty movement patterns. The faulty movement patterns alter the activation sequence or firing order of the muscles involved. These patterns disturb specific functional movement patterns and decrease neuromuscular efficiency. Prime movers may be slow to activate, while synergists and stabilizers substitute and become overactive. This creates decreased neuromuscular efficiency and leads to abnormal joint stress, which affects the structural integrity of the kinetic chain. This may also lead to the insidious onset of pain elsewhere in the kinetic chain, joint dysfunction, and further decreased neuromuscular efficiency. Research demonstrates that joint dysfunction creates muscle inhibition. Joint injury results in joint effusion, which results in the interruption of sensory afferent neural input from articular, ligamentous, and muscular mechanoreceptors to the central nervous system. This results in a clinically evident disturbance in proprioception. Research also demonstrates altered sensory afferent feedback to the central nervous system following ankle sprains, ligamentous injuries to the knee, and low back pain. Subjects with chronic low back pain were unable to preferentially recruit the inner unit musculature of the lumbo-pelvic-hip complex during functional movements. Instead, the subjects recruited motor units from the outer unit, leading to synergistic dominance and abnormal neuromuscular control. These compensatory changes alter the normal force-couple relationships, length-tension relationships, and joint kinematics. The majority of the clients with whom the health and fitness professional works will present with decreased neuromuscular efficiency.
It is therefore imperative that the health and fitness professional understand balance, neuromuscular efficiency, and the peripheral neural mechanisms involved in neuromuscular control.

**Postural Control and Injury Prevention**

Balance training has been linked to decreased anterior cruciate ligament (ACL) injuries, increased ankle stability, and increased postural control. In fact, various research has shown that implementing a balance training program, in as little as six weeks, can improve proprioception, muscle coordination, and reaction times. Research has investigated proprioceptively enriched training programs to determine their effect on the injuries plaguing athletes and individuals with higher physical demands. In several studies, researchers have shown that implementation of a neuromuscular stabilization (balance) training program has decreased the general incidence of injury and increased postural control.

In a study done by Kovacs et al., athletes requiring a high demand of postural control in a demanding sport such as figure skating were hypothesized to benefit from a proprioceptively enriched off-ice training program to increase performance and avoid injury. Figure skating is a demanding physical sport that requires exceptional postural control and balance to be successful on the ice. Researchers found that the skaters who used the neuromuscular training program had significant improvements in postural control versus the skaters in the traditional training group. In fact, the largest improvement seen in the skaters who participated in the neuromuscular training group was seen in the landing jump with eyes closed test; a 21% improvement in postural control was shown. Researchers determined that a progressive-demand neuromuscular training program can help increase postural control and balance in ice skaters.

Many studies have been reported in the incidence of injury in soccer players. Based on the global popularity of the sport, many researchers focus on injuries reported by soccer players to understand the incidents of injury and potential intervention strategies to evade injury to areas such as the ankle and knee. In fact, injury reports indicate 12 to 35 injuries per 1,000 match hours and 1.5 to 7.6 injuries per 1,000 training hours. Given this, researchers sought to understand the role of specific intervention strategies in reducing injury in soccer players. In research performed by Junge et al., soccer players, typically plagued by high injury rates, saw a 20% decrease in general injuries and 36% decrease in injury rates per player after implementing a proprioceptive training program.

Ankle instability is a problem plaguing approximately 10,000 individuals per day. Athletes in sports that require high amounts of cutting and jumping are particularly affected by ankle-inversion sprains and often find a high rate of recurrent injuries due to instability. Ankle sprains can be attributed to slow reaction times of surrounding musculature, poor proprioception, muscle imbalances, and mechanical instability (ligaments lengthened, creating poor structural stability). Overall, ankle instability poses a problem for athletes
and general consumers, creating a need for a thorough rehabilitation process that can be utilized with both large and small groups that is time and cost efficient. In a study by Eils and Rosenbaum, researchers derived a program method using various proprioceptive tools, in a multistation setup, requiring participants to move from one exercise to the next, performing six exercises, one set each for six weeks. The study participants in the exercise group showed increased proprioception, muscle coordination and reaction times, allowing researchers to determine that one set per week of multiple proprioceptive exercises will work well to rehabilitate those with ankle injury and instability.

The statistics among young female athletes shows that females are four to six times more likely to injure their ACL than their male counterparts. Approximately two million female athletes compete in high school sports and upwards of 20,000 knee injuries are expected to occur in high school female athletes alone. As a result, a barrage of research and training programs has surfaced to help reduce the incidence of ACL injuries in female athletes. Various researchers hypothesize the reasons behind the gender differences in ACL injuries (hormones, Q-angles, etc.), and while more research must be completed, many researchers have looked to biomechanics as a potential mechanism of increased injuries. As found by Ford et al. and Malinzak et al. in two different research studies, there was a marked difference in coronal plane motion, leading them to hypothesizing a gender difference in lower extremity mechanics. Given this, researchers have deduced that coronal plane motion may be a “risk factor for ACL injury.”

Previous research has found that neuromuscular training programs that included balance training has shown decreases in ACL injuries and improve lower extremity mechanics. A study by Paterno et al. focused on determining if a six-week neuromuscular training program could improve balance, and, in addition, if improvement in anterior-posterior or medial-lateral stability would be seen. The results indicate an overall improvement in postural stability and an increased stability in anterior-posterior movements. The correlation of increased stability and decreased ACL injuries continues to grow as many researchers determine the best methods to decreasing the large numbers of female injuries specific to the knee. A study by Hewett et al. showed that implementing a pre-season training program that incorporates neuromuscular training techniques coupled with education about proper mechanics during weight training and plyometrics can positively affect the injury rates. Untrained females had 3.6 times higher incidence of injury than trained females and a higher incidence of noncontact ACL injuries.

As a result, researchers have shown that neuromuscular training helps to increase neuromuscular control (efficiency) enhancing movement, decreasing unwanted movement and allowing for proper biomechanics when performing activities such as cutting and jumping (or landing). All of these have been theorized to help reduce the biomechanical factors speculated to induce ACL injuries, create increased ankle stability, and reduce recurrence rates of ankle-inversion sprains, while increasing postural control in subjects in a high-demand physical sport.
Section V: Assessment of Balance and Neuromuscular Efficiency

Neuromuscular efficiency is an extremely important component of all integrated training programs. Therefore, before a health and fitness professional implements a comprehensive balance training program, he or she should perform an assessment on the client. For example, the multiplanar balance excursion test is an assessment of neuromuscular efficiency of the lower extremity.

Figure 6: Multiplanar Balance Excursion Test

This test is designed to assess dynamic balance and neuromuscular efficiency of the testing leg. Also, this test establishes objective range of motion measurements during closed-chain functional movements. The individual is instructed to stand on the testing leg. He or she then squats down as far as he or she can control (knee aligned in a neutral position—i.e., balance threshold). He or she is then to reach with the opposite leg in the sagittal, frontal, and then the transverse plane. The clinician measures from the first toe of the test leg to the heel of the reaching leg. A goniometer can be used to measure closed-chain range of motion at the ankle, knee, hip, and lumbar spine. This can be compared to the other planes of motion to assess any differences.
Section VI: Guidelines for Balance Training

Traditionally, personal training, reconditioning, sports medicine, and performance enhancement have focused solely on isolated joint kinematics, uniplanar flexibility, and isolated muscle strength, not on functional neuromuscular efficiency and functional strength improvements. Whether a person is on a basketball court, stability ball, or climbing stairs, balance is a key to all functional movements.

In functional activities, balance does not work in isolation; therefore, it should not be thought of as an isolated component of function. Balance is a component of all movements, whether dominated by strength, speed, flexibility, or endurance. We tend to think of balance as a static process, but functional balance is a dynamic process that involves multiple neurological pathways. The maintenance of postural equilibrium is an integrated dynamic process that requires optimal muscular balance, joint dynamics, and neuromuscular efficiency. The integrated performance paradigm requires adequate force reduction and stabilization to produce optimum force. The ability to reduce force at the right joint, at the right time, in the right plane of motion, and the right direction requires optimum levels of functional dynamic balance and neuromuscular efficiency. Integrated training should constantly stress an individual’s limits of stability (balance threshold). An individual’s limits of stability are the distance outside of his or her base of support he or she can go without losing control of the center of gravity. An individual’s limits of stability must be constantly stressed in a multiplanar, proprioceptively enriched environment that utilizes functional movement patterns to improve dynamic balance and neuromuscular efficiency.

Integrated training requires a paradigm shift. The new paradigm requires the health and fitness professional to achieve neural adaptations as opposed to solely trying to improve morphological adaptations. Integrated functional training concurrently develops stabilization, strength, speed, power, and neuromuscular efficiency. An integrated training program that follows a progressive functional continuum that constantly forces neural adaptations yields measurable functional improvements.

The health and fitness professional must follow a progressive, systematic training program in order to develop consistent, long-term changes in each client. This is the concept of planned performance training. An integrated training program requires training balance, core strength, reactive neuromuscular control, integrated functional strength, dynamic flexibility, and speed strength. Limiting training, performance enhancement, and reconditioning vis-a-vis a traditional program design often results in incomplete formation or restoration of functional ability. Balance training fills the gap created by traditional training. Balance training focuses on functional movement patterns in a multisensory environment. The design
and implementation of a balance training program is critical for developing, improving, and restoring the synergy and synchrony of muscle-firing patterns required for dynamic joint stabilization and optimal neuromuscular control.\textsuperscript{3,4,57,58}

**Figure 7: Balance Training Guidelines**

<table>
<thead>
<tr>
<th>BALANCE TRAINING PROGRAM GUIDELINES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on Science</td>
</tr>
<tr>
<td>Systematic, Progressive and Functional</td>
</tr>
<tr>
<td>Begins in the most challenging, but controllable environment</td>
</tr>
<tr>
<td>Performed in proprioceptively enriched environments</td>
</tr>
</tbody>
</table>

All integrated training programs should include a balance training program. Proprioceptive training has been shown to be particularly beneficial to improve dynamic joint stabilization.\textsuperscript{2,59,66,69,74,91,92} Balance and neuromuscular efficiency are improved through repetitive exposure to a variety of multisensory conditions.\textsuperscript{3,49} The main goal of balance training is to continually increase your client’s awareness of his or her balance threshold or limits of stability by creating controlled instability. Designing a functional balance training progression requires creating a proprioceptively enriched environment and selecting the appropriate exercises. A balance training program should adhere to the following guidelines: it should be based on science; be systematic, progressive and functional; begin in the most challenging but controllable environment for the individual; and be performed in a proprioceptively enriched environment.

**Exercise Selection Guidelines**

Designing an integrated training program requires selecting the appropriate exercises. The exercises must be safe and challenging, stress multiple planes of motion, incorporate a multisensory approach, and be derived from fundamental movement skills that apply directly to an activity.\textsuperscript{3,49}

**Progressive Integrated Continuum**

When designing an integrated balance training program, health and fitness professionals should follow a continuum of function. The exercises progress from slow to fast, simple to complex, known to unknown, low force to high force, static to dynamic, two arms to one arm, two legs to one leg, stable to unstable, eyes open to eyes closed, and, most importantly, quality before quantity.\textsuperscript{4,13,39,60,72,75}
Adding External Resistance

A balance training program can be progressed by adding external resistance. External resistance comes from many forms, including tubing, dumbbells, medicine balls, power balls, and bodyblades. Proprioception should be the key to progression, and external resistance is added as each movement is mastered appropriately.

Is the Program Functional?

To determine if your program is functional, ask yourself the following questions: Is it dynamic? Is it multiplanar? Is a multidimensional? Is it proprioceptively enriched? Is it systematic? Is it progressive? Is it specific? And finally, is it based on current science?
Section VII: Balance Training Progression

NASM has designed a systematic, progressive, and integrated balance training program utilizing the Optimum Performance Training (OPT) model. The program includes three distinct phases: Level 1, Stabilization; Level 2, Strength; and Level 3, Power.

Figure 8: Optimum Performance Training model
Balance Stabilization

In balance stabilization training, exercises involve little joint motion. They are designed to improve reflexive joint stabilization contractions to increase joint stability. This means that when the body is placed in unstable environments, it must react by contracting the right muscle at the right time to maintain balance.

- Single-leg balance
- Single-leg balance on ½ foam roll
- Single-leg balance on Airex pad
- Single-leg balance w/multiplanar reach 1
- Single-leg balance w/multiplanar reach 2
- Single-leg balance w/multiplanar reach 3
Balance Strength

In balance strength training, exercises involve more dynamic eccentric and concentric movement of the balancing leg, through a full range of motion. Movements require dynamic control in the mid-range of motion, with isometric stabilization at the end range of motion. The specificity, speed, and neural demand are progressed in this level. These exercises are designed to improve the neuromuscular efficiency of the entire kinetic chain.
Integrated Balance Training

Single-leg Romanian deadlift 1
Single-leg Romanian deadlift 2
Step up to balance – front 1
Step up to balance – front 2
Step up to balance – side 1
Step up to balance – side 2
Step up to balance – turning 1
Step up to balance – turning 2
Balance Power

In balance power training, exercises are designed to develop high levels of eccentric strength, dynamic neuromuscular efficiency, and reactive joint stabilization.
Integrated Balance Training

Single-leg hop w/stabilization – side 1
Single-leg hop w/stabilization – side 2
Single-leg hop w/stabilization – side 3

Single-leg hop w/stabilization – turning 1
Single-leg hop w/stabilization – turning 2
Single-leg hop w/stabilization – turning 3

Single-leg box hop up 1
Single-leg box hop up 2
Single-leg box hop down 1
Single-leg box hop down 2
## Integrated Balance Training Program Design

<table>
<thead>
<tr>
<th>OPT™ Level</th>
<th>Phase</th>
<th>Example Balance Exercises</th>
<th>Sets/Reps</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stabilization</strong></td>
<td>1</td>
<td>1–4 Balance Stabilization</td>
<td>1–3 x 12–20 (or single-leg: 6–10 reps ea)</td>
<td>0 – 90 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single-leg Balance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single-leg Balance w/Multiplanar Reach</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single-leg Lift and Chop</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Strength</strong></td>
<td>2, 3, 4</td>
<td>*0–4 Balance Strength</td>
<td>2–3 x 8–12</td>
<td>0 – 60 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single-leg Squat</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single-leg Squat Touchdown</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Step up to Balance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lunge to Balance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>5</td>
<td><strong>0–2 Balance Power</strong></td>
<td>2–3 x 8–12</td>
<td>0 – 60 s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single-leg Hop w/Stabilization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single-leg Box Hop Up w/Stabilization</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table I – Integrated Balance Training Program Design

*For the goal of muscle hypertrophy and maximal strength, balance training may be optional (although recommended) for individuals.

**Because balance exercises are performed in the dynamic warm-up portion of this program, and the goal of this program is power, balance training may be optional (although recommended).
Section VIII: Summary

Neuromuscular efficiency represents one of the most important components of an integrated training program. Research amply demonstrates that poor posture, muscle imbalances, joint dysfunction, and injury all decrease proprioception, kinesthesia, limits of stability, postural control, and balance. Therefore, the health and fitness professional must understand the concepts of balance training before designing an integrated training program.
Appendix: Integrated Balance Training Parameters

1. Exercise Selection Guidelines
   a. Safe
   b. Challenging
   c. Stress multiple planes of motion
   d. Incorporate a multisensory approach
   e. Derived from fundamental movement skills that apply directly to an activity

2. Progressive Integrated Continuum
   a. Slow to fast
   b. Simple to complex
   c. Known to unknown
   d. Low force to high force
   e. Static to dynamic
   f. Two arms to one arm
   g. Two legs to one leg
   h. Stable to unstable
   i. Eyes open to eyes closed
   j. Quality before quantity

3. Forms of External Resistance
   a. Tubing
   b. Dumbbells
   c. Medicine balls
   d. Power balls
Integrated Balance Training

- e. Weight vest
- f. Bodyblade

4. Proprioceptive Progression
   - a. Floor
   - b. Balance beam
     - i. Two feet
     - ii. One foot
   - c. Core board
     - i. Two feet
     - ii. One foot
   - d. ½ foam roll
     - i. One under each foot
     - ii. One foot
   - e. Airex pad
     - i. Two feet
     - ii. One foot
   - f. Bosu ball
     - i. Rounded portion up
     - ii. Rounded portion
   - g. Dyna disc
     - i. One under each foot
     - ii. One foot
References


Integrated Balance Training


