Core, Balance, and Gait

By the end of this chapter you will understand:

- Movement and stability
- Postural control
    - Static balance
    - Dynamic balance
- The importance of core strength for balance and movement
- Core anatomy
    - Musculature
    - Fascial subsystems
- Gait mechanics
- Exercise strategies

Movement and Stability

As mentioned in Chapter 4, the first goal of any training program is to ensure activities of daily living (ADLs) can be performed. Each foundational functional movement (squatting, single leg movements such as lunges or walking, pushing, pulling, and rotating [Cook, Burton, & Hoogenboom, 2006; Galati, 2015]) requires a certain level of stability and mobility through the kinetic chain. Stability is the body's ability to resist a change of direction and is achieved via muscle activation that creates stiffness around a joint; mobility indicates the extent of articulation around a joint (Comana & McGrath, 2015; Galati, 2015). For static and dynamic balance to be achieved, and proprioception to be effective, each joint or segment needs to be able to perform its primary function as listed below and detailed in Figure 4.2.

- Feet – stability
- Ankles – mobility
- Knees – stability
- Hips – mobility
- Lumbar spine – stability
- Thoracic spine – mobility
- Scapula – stability
- Glenohumeral – mobility

Postural Control

For ADLs to be performed, proper movement and postural control are required; however, in addition to joint mobility and stability, proper movement and postural control also require static and dynamic balance. Balance involves the integration of nervous signals from the proprioceptive, vestibular, and visual systems. Static balance is characterized by an ability to maintain the body's center of gravity (COG) over its base of support (BOS) (Dalcourt & Comana, 2015; Wang, Ji, Jiang, Liu, & Jiao, 2016). The COG is the point at which all weight is evenly distributed around and may change as the body is repositioned. The base of support is the area around and between the points of a body in contact with a surface. The proprioceptive system provides information regarding spatial relationships and movement, the vestibular system (inner ear balance mechanism) provides information regarding inertia and acceleration, and the visual system provides information regarding layout and location, and accounts for up to 75% of human sensory input (Dalcourt & Comana, 2015).

Dynamic balance is the ability to maintain postural control while moving and involves internal and external input to maintain postural control when stability is disrupted. Based on neuromuscular control, the body-brain connection uses three movement strategies to maintain postural control and stabilize the COG during deliberate and unplanned disturbances to stability (Dalcourt & Comana, 2015; Horak, 2006). When there is a small disturbance, postural sway will occur primarily at the ankle, allowing the COG to remain over the BOS. For

disturbances of a larger or faster magnitude, the postural sway initiates at the hips allowing the upper and lower body to move in opposite directions. The third strategy involves the knee or taking a step. This is usually initiated when ankle and hip strategies are insufficient to retain the COG over the BOS, or when purposeful dynamic balance occurs such as walking (Horak, 2006). Each strategy is exemplifies Newton's third law of motion; for every action there is an equal and opposite reaction. When balance is disturbed, an equal reaction takes place in the form of postural sway or stepping.

The Core

The purpose of the core in the kinetic chain is to provide stability for efficient movement. Based on the three movement strategies for balance, and because all movement passes through the core to the extremities, it is easy to see how important the core and its subsystems are for balance. The core, also known as the lumbo-pelvic-hip complex, has 29 pairs of muscles to stabilize the spine and pelvis for static balance, and stabilize the kinetic chain for dynamic balance and efficient movement (Faries & Greenwood, 2007). The core is a box with the diaphragm at the top and the pelvic floor at the bottom. Abdominal, paraspinal, and gluteal muscles are in the front and back, and oblique muscles make up the sides (Huxel-Bliven & Anderson, 2013). The synergistic relationship between the mobilizers and stabilizers of the core allows movement to be transferred from one extremity to another.

In addition to the core, there are four fascial subsystems, or slings, that transfer kinetic energy from one part of the body to another and assist in load transfer between the upper and lower body (Dalcourt & Comana, 2015; Donatelli, 2007). A fifth sub-system, known as the serape effect, provides stability and torque production during rotational movements by

crisscrossing certain segments of the body (Santana, McGill, & Brown, 2015). Table 16.1 details the muscles and fascia associated with each sling.

Table 16.1

Muscles and fascia associated with myofascial slings

Myofascial Slings	Muscles and Fascia
Posterior oblique sling	Latissimus dorsi Gluteus maximus Thoracodorsal fascia
Anterior oblique sling	External oblique Anterior abdominal fascia Contralateral internal oblique Hip adductors
Deep longitudinal sling	Peroneals Biceps femoris Sacrotuberous ligament Deep lamina of thoracodorsal fascia Erector spinae
Lateral sling	Gluteus med/min Tensor fascia latea Lateral stabilizers of thoracopelvis region
Anterior Serape	Hip flexors Adductors Internal and external obliques Right and left serratus anterior Rhomboids
Posterior Serape	Gastrocnemius and soleus Hamstrings Glutes Latissimus dorsi Pectoralis

Donatelli, 2007; Santana, McGill, & Brown, 2015

The Gait Cycle

Walking is a single-leg movement and functional ADL, and is considered a series of controlled falls and regaining balance (Dalcourt & Comana, 2015); as such, walking requires, stability, mobility, and dynamic balance. The gait cycle consists of two steps, or one stride, and starts when the heel of one foot contacts the ground and finishes on the next ground strike

with the same heel. During that time, one foot is in the stance phase and stabilizing, while the other is in the swing phase and mobilizing (Kharb, Saini, Jain, & Dhiman, 2011). Phases of the gait cycle are in Table 16.2. For proper locomotion, mobility is required in the feet and ankles, hips, pelvis, and thoracic spine, while stability is required in the feet and hips. The stability and mobility phases of the gait cycle are listed in Table 16.3.

Table 16.2

Phases of the gait cycle

Initial contact:	
Heel strike	Floor contact is made with the heel of one foot while the other foot is in terminal stance.
Loading response	Weight is transferred to forward limb. Opposite limb begins pre-swing.
Mid-stance	One limb advances while the other limb supports the body weight.
Terminal Stance	The body is still in single-limb support. It begins with heel rise and continues until the other foot strikes the ground.
Heel-off & Pre-swing	The body moves forward as the weight is transitioned from the stance leg to the opposite leg as it prepares for the heel-off.
Swing phase:	
Initial & mid	The leg transitions from heel-off and prepares for the next heel strike.
Terminal Swing phase	One leg is in terminal stance while the other is in heel strike.

Dalcourt & Comana, 2015; Kharb et al., 2011

Table 16.3

Mobility and stability phases of the gait cycle

Body part	Stabilization	Mobility
Hips	Mid-stance, swing phase of opposite leg	Swing phase
Feet/ankles	Heel strike	Heel off
Thoracic spine		Opposite shoulder extends during swing phase
Pelvis		Counter-rotates with thoracic spine

Dalcourt & Comana, 2015; Kharb et al., 2011

Exercise Strategies

It is important to understand the relationship between stability, mobility, balance, core, myofascial slings, and gait. Without the efficient transfer of loads from one body segment to

another, movement and locomotion would not be possible. Therefore, to develop an exercise program a fundamental understanding of efficient core movement and dynamic balance strategies is essential. Further, any program designed to prevent an injury or correct movement dysfunction needs to incorporate neuromuscular, endurance, and strength components to challenge balance, posture, and the core (Huxel-Bliven & Anderson, 2013).

Because spinal stability and a lower risk for injury are associated with endurance, exercise strategies for the core should focus on muscular endurance and the reeducation of faulty motor patterns prior to building strength (Faries & Greenwood, 2007). To stiffen the torso, the core relies mostly on co-contraction; therefore, any training program should encourage exercises that use all of the musculature of the core, such as abdominal bracing instead of drawing in, crunches, or torso twists (Maeo, Takahashi, Takai, & Kanehisa, 2013: McGill, 2010). Additionally, because contracting the rectus abdominis brings the rib cage and the pelvis together, a movement not generally used for dynamic function, sit-ups are discouraged. McGill (2010) suggests the following training progression below (see Chapter 22 for more details on training of the core and low back). This progression can be incorporated with the core and myofascial sling exercises listed in Table 16.4.

1. Corrective and therapeutic exercise.
2. Groove appropriate and perfect motion and motor patterns.
3. Build whole-body and joint stability (mobility at some joints such as the hips and stability through the lumbar/core region).
4. Increase endurance.
5. Build strength - for occupational/athletic clients.
6. Develop speed, power, and agility - for occupational/athletic clients.

Table 16.4

Core and myofascial sling exercises

Core stabilization and motor pattern recruitment	Diaphragmic breathing
	Abdominal Bracing
	Hollowing
	Modified curl-up – one leg straight, one leg bent
	Side bridge
	Quadruped birddog
Anterior oblique sling	Plank
	Standing cable press
	High to low cable chop
Posterior oblique sling	Quadruped birddog
	Single arm cable pull
	Single-leg Romanian deadlift
Lateral sling	Side plank
	Lateral step-up
	Lateral lunge
Deep longitudinal sling	Bridging
	Step-up
	Romanian deadlift
	Windmill
	Turkish get-up

Dalcourt & Comana, 2015; Faries & Davies, 2007, Huxel Bliven & Anderson, 2013; McGill, 2010

Static balance can be progressed by increasing the need for postural sway via manipulation of a stance used for any given exercise (Muehlbauer, Roth, Bopp, & Granacher, 2012). To further challenge balance, sensory perception can be manipulated by having a client stand on a foam pad and/or block a client's vision. The stance progression should be:

- Bi-pedal – feet next to each.
- Semi-tandem – one foot slightly in front and offline of the other.
- Tandem – one foot directly in front and inline of the other.
- Mono-pedal – single leg.
- Repeat standing on a foam pad.
- Repeat with hindered vision.

To reduce the likelihood of falling, a client should start with static balance and progress to dynamic (Dalcourt & Comana, 2015; Donath, van Dieen, & Faude, 2016). After moving through the progression suggested for static balance, a directional agility program using the movement patterns below can be implemented to improve dynamic balance.

- Forward movement
- Lateral movement
- Backwards movement
- Rotational and cross-over movements
- Curving and cutting movements

To progress, these movement patterns can be manipulated by changing direction, changing acceleration and deceleration, performing them as reactive or explosive movements, or combining the movement patterns.

Discussion and application

1. What is the role of the core in balance and gait?
    a. Discuss the ankle, hip, and step strategies for recovery of balance and gait.
    b. How would you explain this to a client who displays poor balance?
2. Design balance progression for a client and explain your exercise selection.

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