BIOMECHANICS LABORATORY

Biomechanics of Standing Balance

Object:

To understand how the nervous system affects the postural stability via measurement of the center of pressure with eyes open and eyes closed.

Introduction

Balance is the ability of human body to maintain center of gravity within the base of support to prevent falling.

When a person is standing completely still (Fig.1), the ground produces a reaction force equal and opposite to their body weight (a consequence of Newton's Third Law). This ground reaction force (GRF) is really an average of all the forces or pressure under the feet. Pressure is not borne evenly by all parts of the sole, but is concentrated in two main regions: the heel and the ball (metatarsophalangeal joints). The location of the center of pressure (CoP) marks the line of action of the GRF, and in normal quiet standing is about 5 cm anterior to the ankle joint (under the navicular bone). The CoP is a purely mathematical concept. It is, however, an extremely useful one.
Thus, the human body internal forces should exceed the gravitational force, the weight of the body itself or of the moving or equilibrating segments, the air pressure, environmental resistance, inertia, accelerating forces, reaction forces of the supporting surface, frictional forces and other forms of external resistance.

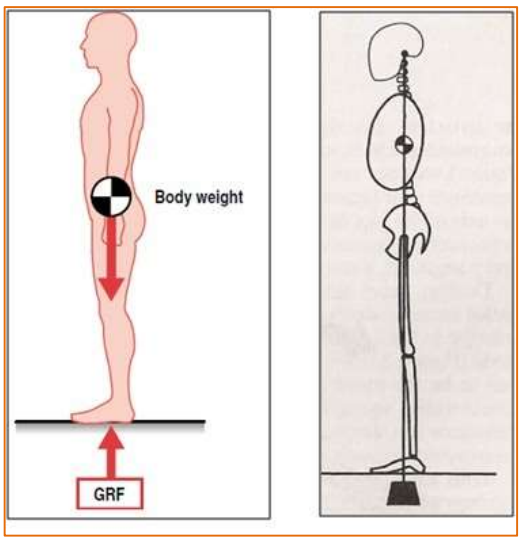

Figure.1 The GRF vector during quiet standing. During quiet standing, balanced alignment aligns the body weight vector between the ear canal in the head and anterior to the ankle (near the middle of the supporting foot). It passes slightly anterior to the thoracic spine L4, just anterior to the knee and barely posterior to the hip joint.

Whenever a force is applied some distance away from a joint or fulcrum, it will tend to rotate the joint in the direction of the force. This effect is called the *moment of force*, or simply the *joint moment*. In normal standing, with the CoP 5 cm anterior to the ankle joint, the foot will tend to dorsiflex.

Since there is no movement in quiet standing, there must be an equal and opposite opposing moment (Newton's Third Law again). This moment is produced by tension (force) in the Achilles tendon, which inserts onto the calcaneus bone on the opposite (posterior) aspect of the ankle joint. In effect, the two forces (ground reaction and Achilles tendon tension) act as an inverted see-saw (Fig. 2), Thus,

Internal (Stabilizing) Torques = External (Destabilizing) Torques

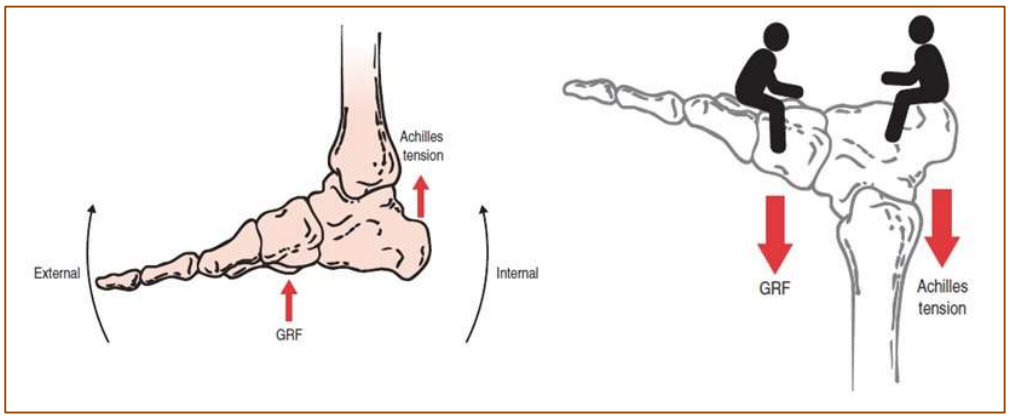

Figure.2 Balanced equilibrium between external (GRF) and internal moments (Achilles tendon) at the ankle.

Factors Influencing Stability

- Sensory Factors (vision, the vestibular system, somatosensory system)
- Motor Factors (change segments alignment)
- Biomechanical Factors (Size of the base of support).

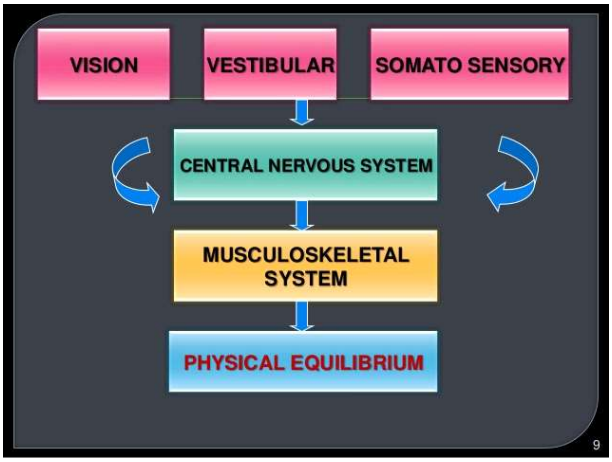

Figure.3 The major sensory systems are involved in balance and posture.

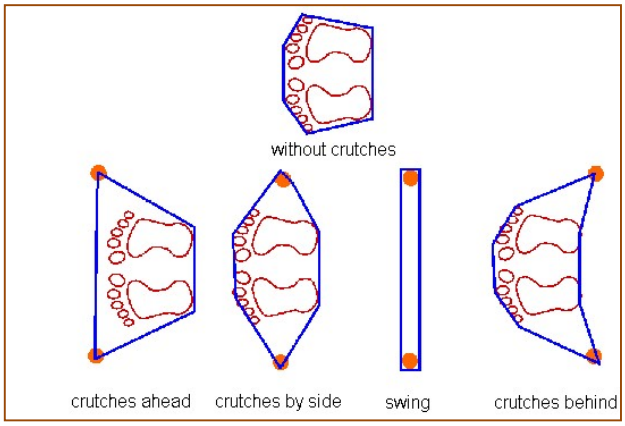

Figure.4 Effect of crutches use on base of support

Generally, commercially available, laboratory grade force plates are recognized as a outstanding tool for assessing balance due to their ability to accurately measure COP.
When standing upright, your whole body center of mass is continuously moving. In response, you adjust the COP underneath your feet in a way that keeps the center of mass within the feet, i.e. the base of support (Fig. 5). Hence, a plot of the COP motion, termed a stabilogram, can be used to assess one's standing balance. In this lab, we will compare the stabilogram observed during standing with eyes open and eyes closed to assess the effect of vision on standing balance.

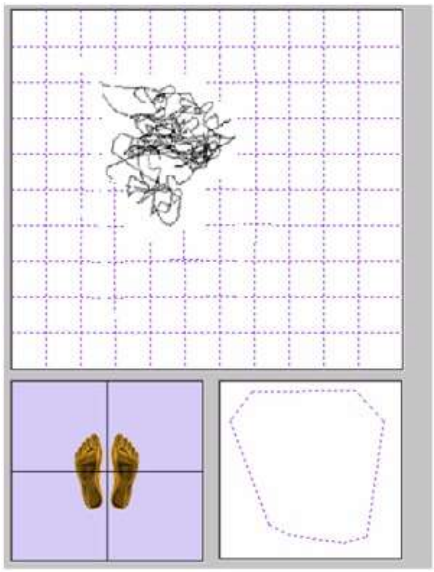

Figure.5 A stabilogram shows the x- and y-coordinates of the COP over a period of time.

Procedure:

Stand still on the platform with eyes open (EO) and heels together, near the center of the platform. Collect force plate data for 30 seconds. Repeat this experiment with your feet in the same place but your eyes closed (EC).

Discussion

1. How does the center of pressure motion differ between the eyes open and eyes closed conditions? Does the COP location vary more in the anterior – posterior (x-axis) or left – right (y-axis) direction? Suggest some possible reasons for your observations.

2. If you wanted to measure balance using COP data, what are some ways you could think of to quantify the stabilogram plots?