Chapter 14

Motor Function Intervention

Michael J. Borst

LEARNING OBJECTIVES

This chapter will allow the reader to:

1. Explain the biomechanical and physiological mechanisms that underlie occupational performance and therapeutic exercise.
2. Apply the conceptual framework for therapeutic occupation to conceptualize frames of reference, intervention approaches, and occupational performance.
3. Use methods to decrease edema and minimize contracture to prevent range of motion loss.
4. Apply principles from the biomechanical and motor learning frames of reference to occupation synthesis in order to improve range of motion, strength, and/or endurance.
5. Design interventions for clients who have impairments in edema, range of motion, strength, and/or endurance as needed to improve occupational performance.

CHAPTER OUTLINE

TERMINOLOGY

Client factors: basic structures and functions of a person that are used for occupational performance; edema, range of motion, strength, and endurance are all client factors[1]

Mechanical advantage (MA): ratio that describes how easily a force can move a resistance using a lever

Moment arm: the perpendicular distance from the axis of rotation to the line of force (force vector)[2] on a lever

Muscle endurance: the ability of a muscle to contract repeatedly or over time without a decrease in force produced[3]

Muscle strength: the maximum amount of force that is produced by a muscle in a single contraction[3]

Range of motion (ROM): the arc of rotational motion through which a bone moves around a joint; usually measured in degrees

Strain: the change in shape of an object that results from the stress placed on it[6]

Stress: the force acting on an object, divided by the cross-sectional area of that object[6]

Torque: the extent to which a force causes an object to rotate around an axis[2]

Occupational performance is influenced by **client factors** such as edema, **range of motion (ROM), muscle strength,** and **muscle endurance.**[1] Occupational therapists sometimes help clients restore or establish these factors by synthesizing occupations, activities, or preparatory tasks designed to create change within the client.[1,4]

Musculoskeletal System

Occupational therapists need to understand the biomechanical and physiological principles behind musculoskeletal system function. This understanding allows occupational therapists to analyze and synthesize occupations to promote successful occupational performance.

Biomechanical Aspects

Biomechanics applies the principles of physics (such as motion and force) to the human body. Kinematics is the study of the motion of an object without regard to the forces that produced the motion.[2] In the human body, we see two types of motion, translation and rotation. Translation occurs when an object or body part moves in a straight line. Rotation occurs when an object or body part moves in a circular motion around an axis. For example, when you walk down a hallway, your head is moving down the hall in a translational manner. In contrast, rotational motion is occurring at your hip joints, knee joints, and ankle joints as each flexes and extends around an axis.[2] Translation and rotation often occur at the same time in the human body.

Kinetics is the study of forces on an object and how those forces change the motion of the object.[2] With regard to the human body, these forces might include muscle contraction, gravity, friction, and any external push or pull on a body part.

Most occupations involve motions and forces. For example, when a person places a glass on a cupboard shelf, muscles in the trunk (internal forces) coactivate to create stability before any arm motion is initiated. Muscles in the shoulder girdle activate synergistically to create force couples (two or more muscles pulling in different linear directions to create rotation in the same direction) that move the sternoclavicular, acromioclavicular, and glenohumeral joints. To raise the glass, the elbow flexor muscles activate concentrically causing elbow joint flexion (rotary motion). To cause this rotation, the elbow flexors must generate enough force to create sufficient internal **torque** to overcome the external torque created by the force of gravity acting on the glass's mass. The movement of the glass upward to the cupboard is an example of translational motion, in which the glass moves in a more or less linear manner, rather than rotating around an axis.

Torque

Any analysis of rotary motion requires an understanding of torque. There are two factors of torque: force and distance. Torque is created when a linear force acts on an object at a certain distance from that object's axis of rotation; this distance is measured perpendicular to the direction of the force. This perpendicular distance between the axis of rotation and a force's line of action (vector) is called the **moment arm.** Torque is calculated by multiplying the linear force by the distance from the line of force to the axis of rotation. Thus, in mathematical terms:

$$\text{torque} = \text{force times the moment arm}$$

In the metric system, force is measured in newtons, and the moment arm is often measured in meters. In the English system, force is measured in pounds, and the moment arm is often measured in feet. Torque is therefore often expressed in newton·meters or foot·pounds.

It is critical to understand the difference between force and torque. A force acts in a linear direction and tends to cause translation motion when directed at the center of an object's mass. In contrast, torque involves rotation around an axis, and the moment arm is just as important as the force in determining how much torque is produced. Returning to our example of lifting a glass up to a shelf, there are two torques involved at the elbow joint: an internal torque and an external torque. The internal torque is the product of the internal (biceps brachii) force acting on the radius bone times the internal moment arm (of the biceps) in relation to the elbow joint (Fig. 14-1A; we are considering only one elbow flexor muscle for the

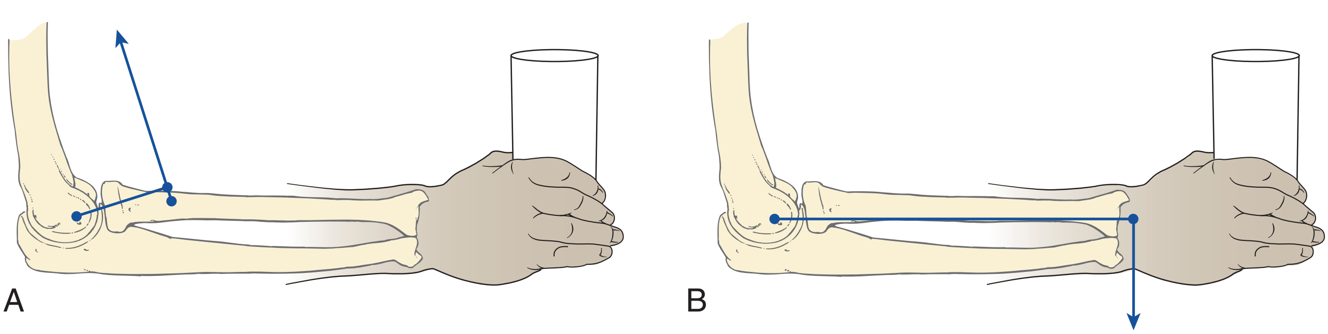

Figure 14-1. Internal and external torque. **A.** Internal (effort) torque. IF, internal force—Line of pull of biceps brachii. IMA, internal moment arm—Perpendicular distance between the IF of the biceps brachii and the axis of rotation. **B.** External (resistance) torque. EF, external force—Line of pull of combined weight of glass, hand, and forearm. EMA, external moment arm—Perpendicular distance between the EF and the axis of rotation.

sake of simplicity). The external torque is the product of the external force (the combined weight of the glass, forearm, and hand) times the external moment arm (of gravity) in relation to the elbow joint (Fig. 14-1B). If the internal torque is greater than the external torque, the muscle will activate concentrically (shorten) and the glass will go up. If the internal torque is less than the external torque, the muscle will activate eccentrically (lengthen while "trying" to shorten) and the glass will go down. If the internal torque is equal to the external torque, the muscle will activate isometrically (stay the same length), and the glass will be held still in midair.

To make an object easier to lift, we can reduce the external torque. This can be done in either of two ways: reduce the weight (force) of the object or reduce the distance (moment arm) between the object and the joint(s) responsible for the lifting. This is why therapists will teach clients to lift heavy objects closer to the body. Reducing the external moment arm will reduce the external torque and therefore also the internal torques required of the client's body. Similarly, when a therapist assists a client during a stand and pivot transfer, the therapist will stand as close to the client as is practicable in order to reduce the external moment arm and thus reduce the external torque, which in turn reduces the internal torques required of the therapist's body.

Levers

Another way to analyze torque production in rotary movement is through the description of levers. A lever consists of a rigid bar (such as a bone), an axis of rotation (such as a joint), and two opposing forces: effort and resistance. Effort is the force that causes movement, and resistance is the force that tends to keep an object from moving.[7] Sometimes, the effort force is simply termed force, and the resistance force is simply termed resistance. When analyzing human occupation, the force generated by muscles is termed internal force, and the force generated by objects outside of the body is termed external force. There are three classes of levers.

A first-class lever has the axis of rotation between the effort and resistance forces.[2] A common example of a first-class lever is the seesaw (Fig. 14-2A). A seesaw remains in balance, with no movement, if two children of the same weight sit the same distance from the axis. This balance, or equilibrium, is maintained because the torque on one side of the seesaw equals the torque on the opposite side of the seesaw. The weight of child 1 times the perpendicular distance from the axis of rotation to child 1 equals the weight of child 2 times the perpendicular distance from the axis of rotation to child 2. Because the torques are equal, the children balance, and there is no movement. If one of the children were heavier, he or she would have to move closer to the axis (shorten his or her moment arm) to decrease his or her torque and maintain equilibrium (Fig. 14-2B).

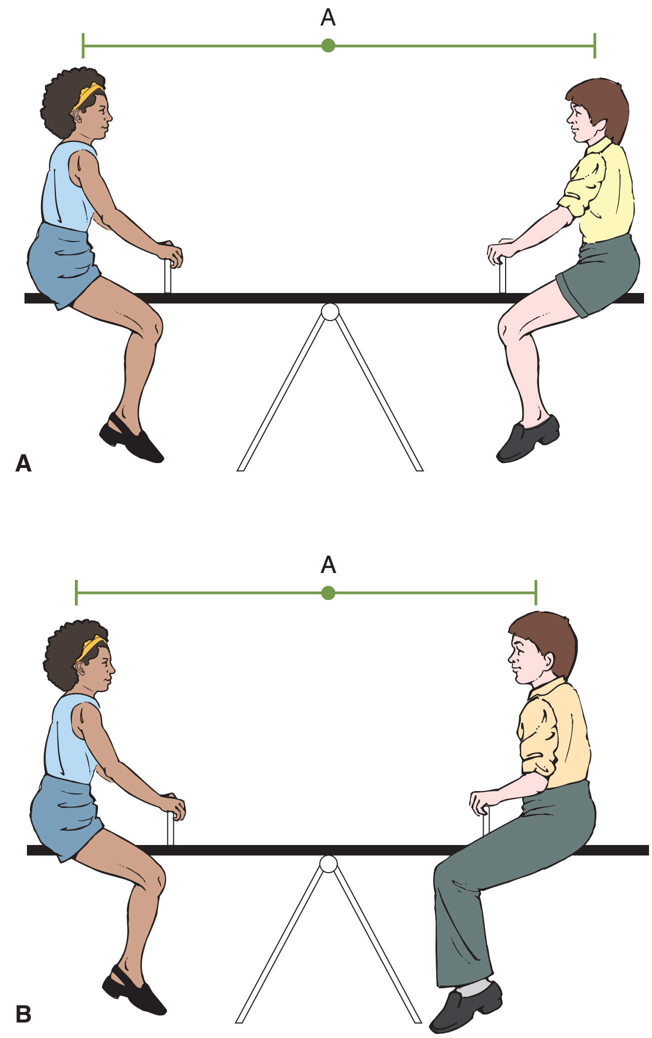

Figure 14-2. First-class lever. **A.** A seesaw as a first-class lever. Balanced equilibrium depicted by children on a seesaw. Both children weigh 60 lb, and they are equidistant from the axis. **B.** A seesaw as a first-class lever. The heavier child must be closer to the axis of the seesaw (shorten his moment arm) to maintain the equilibrium. A, Axis.

A second-class lever has the resistance force between the axis of rotation and the effort force.[2] A classic example of a second-class lever is a wheelbarrow used to move soil when gardening (Fig. 14-3). The resistance force (the pull of gravity on the soil) is between the axis and the effort force. Because the resistance moment arm (the perpendicular distance between the wheel and the resistance force of the soil) is considerably shorter than the effort moment arm (the perpendicular distance between the wheel and the effort force from the person lifting the handles), the person can lift the handles with considerably less force than the actual weight of the soil. Second-class levers are often used in assistive devices such as a key turner, jar opener, or doorknob lever. One disadvantage of second-class levers is that the arc of movement where the effort force is applied is always greater than the arc of movement where the resistance is