Biomechanical Principles

Levers

The levers of the body allow you to apply force to create movements of many different kinds. A lever is a very basic machine. It is a bar or a stiff, straight object that can be used to lift weight, increase force, or create speed. The bones of your body are levers that allow you to perform many skills. For example, the bones of your foot act as a lever when you push with your foot while you walk and run. The calf muscles shorten, causing your foot to push down against the ground. To do its work, a lever must have a pivot point at its middle or at its end.

When you use the foot as a lever in walking and running, the ankle is the pivot point and the bones of the foot are the levers. When you use the bones as levers in this way, they are called first-class levers. First-class levers can allow you to lift a heavy weight with a small amount of force. For example, first-class levers allow you to lift your whole body weight with the relatively small leg muscles (figure 2.2). A first-class lever also causes a change in the direction of the force so that the muscles in the back of your lower leg, which pull upward on the back of your foot (your heel), make the front of your foot (your toes) push downward against the ground.

In a first-class lever, the fulcrum (or pivot point) is between the resistance (or weight) and the effort (or force). First-class levers can be used to either increase the force applied or increase the speed and distance of movement.

Second-class levers are not common in the body. However, a good example of a second-class lever is seen in a person doing a push-up (figure 2.3). The body is straight from the shoulders to the feet. It acts as a lever with

![Figure 2.2](first-class-lever.png)

**Figure 2.2** First-class lever: toe raise.

![Figure 2.3](second-class-lever.png)

**Figure 2.3** Second-class lever: push-up.
the pivot at the feet. The weight of the body is near the center, near the waist, and the arms work at the shoulders to lift the body. The force required for the arms to lift the body is about half the total body weight. In a second-class lever, the weight (or resistance) is between the fulcrum (or pivot point) and the effort (or force). Second-class levers increase the force applied.

The most common levers in the body are third-class levers. In a third-class lever, the effort (or force applied) is between the weight (or resistance) and the fulcrum (or pivot point). Third-class levers increase speed in movements such as throwing and kicking.

In the human body, third-class levers have the pivot point at one end. The muscles apply force to the lever near the pivot. This causes the levers (your bones) to move. For example, in performing a biceps curl (see figure 2.4), the force of the contraction of the muscles of the upper arm pulls the lever (the lower arm) upward. The fulcrum or pivot point is the elbow, and the weight or resistance is the weight of the lower arm and the weight that’s held in the hand. Third-class levers allow you to do fast movements such as throwing, kicking, or swinging a tennis racket.

When you kick a ball, you use the bones of the upper leg, the lower leg, and the foot as third-class levers. In a third-class lever, the effort (or force applied) is between the weight (or resistance) and the fulcrum (or pivot point). Third-class levers increase speed.

For example, in kicking, the muscles of the hip move the upper leg forward, the muscles of the front of the upper leg move the lower leg forward, and the muscles of the lower leg move the foot forward and upward with great speed. That allows you to kick the ball a good distance if you make good contact with the ball when you kick it. Adding the levers one at a time in the proper sequence results in even faster movement of the leg.

The levers of the arm work in a similar way. With practice, you can learn to move the levers with improved accuracy as well as improved speed.

You have to learn to use the levers of the body efficiently if you are going to learn a wide variety of skills. The more you practice, the better you become at using the body levers. With practice your timing improves so that you can kick, throw, jump, and do other skills faster and better. Practice helps your body memorize movements so that you can control them better and so that you can perform skills more accurately.

**Applying the Principle**

When you move one of the body’s third-class levers such as a leg, the muscles move only a
short distance, but the end of the lever (the leg) moves a much greater distance. This creates a fast movement at the end of the lever (leg). This fast movement is helpful in skills such as kicking. As shown in the following pictures, adding the levers one after another results in even faster movement of the leg. The form for correctly kicking a ball (one that is lying on the ground) is described and pictured here.

The levers of the arm work in a similar way. When you throw a ball there are steps that you should take to use the levers of the body to produce efficient throwing. With practice, you can learn to move the levers with improved accuracy as well as improved speed. The form for correct overhand throwing is shown and described next.

**Principle in Practice**

Practice kicking a ball using the levers of the lower body. Practice throwing a ball with an overhand motion using the levers of the upper body. Follow the steps described with the preceding photos. Work with a partner. When you perform the skill, your partner can watch to see if you are doing the steps correctly and give you feedback. Then you can switch to observe as your partner performs the skills.

As you improve, the speed of your arm or foot will increase and the distance you can kick or throw will increase. Practice will also help you improve accuracy of kicking or throwing. However, it is best not to focus too much on accuracy when you are first learning. Once you have learned a skill properly, additional

- Take a long step forward with the opposite foot so that it lands just beside and slightly in front of the ball.
- The body leans forward.
- The kicking leg and hip lag behind.
- Swing the hip and upper kicking leg (lever) forward.
- The lower leg lags behind. The knee stays bent.
- The toe points away from the ball.
- Arms at side for balance, body leans back.

- As the hip and upper leg continue forward, swing the lower leg forward as the knee straightens.
- The foot lags behind.
- The foot makes contact with the ball after the leg is almost straight.
- Follow through with the leg well after the kick.
practice will help you improve accuracy. As your kicking improves, you can try kicking a moving ball or kicking a ball that is in the air (punting) as a goalie does in soccer. As you improve you can try other kinds of throwing such as passing a football, pitching a softball (underhand throw), or passing a basketball (two-hand pass) or throwing to a moving target (like a receiver in football). You may want to use an activity sheet to record information about using the levers of the body in kicking and throwing.

- With the elbow at or above shoulder height, reach back with the arm and throwing hand.
- The opposite hip and shoulder face the target.
- Take a long step forward with the opposite foot.
- This step turns the lower body toward the target.
- The upper body and arm lag behind.

- Quickly turn the throwing shoulder toward the target.
- The upper arm (lever) moves forward, elbow stays high.
- The lower arm (lever) then moves forward.
- The wrist and hand (lever) move forward last, before the ball is released.
- Follow through with the arm and upper body.