

UNLOCKING SCIENCE HANDSON!

MUSCLE FATIGUE

God created our bodies with three types of muscles—smooth, cardiac, and skeletal. Smooth muscles line your digestive tract and can keep working nonstop. Cardiac muscle keeps your heart pumping, and it goes nonstop for your entire life. Neither of these muscle types fatigue—they never get tired or sore. But that is not the case with skeletal muscles, the muscles that move your arms and legs and head. I bet you have experience with muscle fatigue. Maybe it was on a long hike up a mountain, trying to make it across the monkey bars, or holding a smile forever trying to get the perfect family portrait.

Skeletal muscles can create a lot of power, but only for a relatively short time. As the long fibers contract, getting shorter and pulling on a bone, they require lots of energy. They need a chance to reset, and they can't stay contracted or keep contracting forever. After lots of aerobic exercise, lactic acid can build up in the muscles and make them sore. You know your muscles are reaching the point of fatigue when they start to tremble or twitch. That's when they need a rest. Continually working your muscles will cause them to grow, giving you more power and more endurance next time you need to make it to the top of that mountain for an amazing view of God's beautiful creation.

Extra Family Fun: Set up a family endurance contest to see who can do the longest wall sit or hold a weight for the longest. Encourage one another to persevere.



Tests of Endurance

Supplies

- Foam ball
- Tennis or racquet ball (or any hollow ball)
- Weights of various sizes (approx. 1 to 5 pounds). A fillable container like a milk jug and a scale would also work well.
- Stopwatch



Figure 1: Supplies

Get a Grip

- 1 You will need two balls of different density. A foam ball and something hollow like a racquet ball or tennis ball will work well.
- 2 Holding the ball in your hand, squeeze it as firmly as you can and hold the squeeze for as long as you can. Try to get to three minutes.
- 3 Use a stopwatch to measure the time until you start to feel your muscles in your forearm trembling.
- 4 Record the time in the data table.
- 5 Repeat with the opposite hand and then repeat with the other ball, giving yourself a short rest between the trials. The other ball should be firmer and harder to squeeze than the foam ball to allow for comparison.

Hold It!

- 1 Take a weight in your hand and raise your arm out to the side so it is parallel to the ground (arm at 90° to your body). Start with a lighter weight and end with a heavier one.
- 2 Use a stopwatch to measure the time until you start to feel the muscles in your arms start to tremble.
- 3 Record the time and weight in the data table.
- 4 Repeat with the opposite arm and then repeat with increasing weight, giving yourself a rest between the trials.

Activity: Tests of Endurance

Complete the Get a Grip and Hold It! activities described above, recording the data in the table below.

Get a Grip

Person	Foam Right (sec.)	Foam Left (sec.)	Firm Right (sec.)	Firm Left (sec.)

Hold It!

Person	Weight	Time of Tremble (sec.)	
		Right Hand	Left Hand

Analysis Questions and Discussion

- 1 Using the foam ball, were you able to endure three minutes with your right or left hand? What about with the firmer ball? *Most people will be able to grip longer with their dominant hand, and the firmer ball should make your muscles fatigue faster.*
- 2 Which is your dominant hand? Why were you able to grip the ball longer with your dominant hand before your muscles fatigued? *Our dominant hand and arm are probably more muscular. You could measure the circumference of the flexed forearm just below the elbow to see if this is true. Because the dominant hand is used more, it will have more endurance and more muscle mass.*
- 3 How did increasing the weight effect the time until your arm muscles fatigued? *It would be expected that the muscles would fatigue faster with more weight.*
- 4 If you tested different people, how can you explain the different levels of muscle endurance? *Every individual will have different times to fatigue. Those with larger muscles should be able to hold the weight or grip for longer, but everyone will eventually reach a point of fatigue.*
- 5 What would happen if your heart was made of the same type of muscle as the muscles in your arms? *If the heart was made of skeletal muscle rather than cardiac muscle, it would fatigue and stop pumping. God has wisely given us different types of muscles to do different jobs.*
- 6 Optional: Use the data from the Hold It! activity to create a bar graph of your results. Plot the time on the y axis (as the dependent variable) and the weight on the x axis (as the independent variable). Use a different color for each person.
- 7 The Bible uses many metaphors to talk about the endurance needed to live a righteous life as a Christian. Read 1 Corinthians 9:24–27 and Hebrews 12:1–6. How can you relate these passages and their metaphors to the activities you performed? *Just like running a race requires endurance in your physical body to overcome fatigue and obstacles, the Christian life is a long race with many trials and obstacles to endure.*
- 8 What things has God given to Christians to help us persevere in the faith? *We have been given the Holy Spirit as our helper, the Bible as a source of truth and encouragement, a Savior as our example, and our families and churches to help us to fight the good fight to the end.*

“And let us not grow weary of doing good, for in due season we will reap, if we do not give up.” Galatians 6:9 (ESV)