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HUMAN HEALTH
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HOW THE SCIENCE BEHIND VIDEO GAMES HELPS KIDS WALK

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Did you know that some of the same technology used to make video games and movie special effects can help scientists better understand human movement? During motion capture, also called mocap, small reflective balls, or markers as they are called, are placed on specific points of a person's body. Mocap systems work using multiple cameras around the room that track the motion of the markers as a person walks, runs, jumps, or plays. The information gathered during mocap can be used to help doctors decide the best possible care to improve a child's walking. It can also be used to determine when someone is ready to go back to sports after an injury, to help prevent people from getting injuries in the first place, or to improve their sports performance.

MOCAP: MEASURING MOTION OF THE HUMAN BODY

We all move every day. Some of us can walk or run. Other people use wheelchairs to move from place to place. Whether you are walking to school, throwing a softball, brushing your teeth, or eating a piece of pizza, you are moving at least one part of your body. Scientists who study how people move while walking, running, exercising, or just going about the day are called **biomechanists**. Biomechanics is the name for the study of human movement.

BIOMECHANIST

A scientist who studies human movement, which is also called biomechanics.

Have you ever noticed that the main characters in animated movies or video games look and move like real-life actors? There is a good chance that a technique called **motion capture (mocap** for short) was used to create these graphics. Characters like The Hulk, animated movies like *Happy Feet* and *The Polar Express*, and video games such as Guitar Hero and FIFA 22 have all used mocap on live actors to generate realistic movement of the animated characters.

MOTION CAPTURE (MOCAP)

A method used to record movement using one or motion cameras of multiple sensors placed on a person's body.

Mocap is a method to digitally record movement. It can be done using one or more cameras, or with a series of sensors worn on a person's body. Mocap tracks each part of the body that we want to measure and can take measurements between 100 and 250 times per second. This provides a detailed description of how a person's body is moving in three dimensions (3D): forward and backward, side-to-side, and up and down. In movies and video games, mocap makes the characters appear very lifelike by mimicking real-life movements.

TYPES OF MOCAP

Movement can be measured in lots of ways. The best way to measure motion depends on what we want to look at. For example, at a track and field meet, we can measure how fast a person can run, or how far or high a person can jump. That type of motion analysis looks at the movement of the person's entire body. But to understand how a person moves so fast or jumps so far, biomechanists want to look at specific **joint** movements. A joint is where two or more bones in the body meet. For example, your ankle joint has three bones: the lower leg bones, called the tibia and fibula, and the ankle bone, called the talus. In our track example, a biomechanist might ask questions like "How much is the runner's knee bending when they land with each step? How much did their hips or ankles extend as they pushed off the ground?".

JOINT

A part of the body where two different bones meet and interact with each other.

The easiest way to measure this motion is with a simple video camera. However, if the camera is not perfectly lined up with the body, the motion data measured from the camera images might not be accurate. The camera measures best when the images are right in the middle of the screen. Since the camera is at an angle from something at the edge of its view, the position of the body may be under- or over-estimated.

3D mocap can measure motion more accurately, using 1 of three ways. The first method uses special cameras all around the room to

OPTICAL MOTION CAPTURE

A type of motion capture that uses several camera views to recreate 3D positions of markers placed on a person or object.

MARKERLESS MOTION CAPTURE

A type of motion capture that uses multiple camera views to recreate the 3D position of a person or object, without the use of special markers on the body.

INERTIAL MOTION CAPTURE

A type of motion capture that uses special sensors placed on each part of the body to track movement without the use of cameras.

track small, reflective balls, called markers. The markers are placed on specific parts of a person's body to estimate the person's movements (Figure 1). When two or more cameras see a marker, the 3D location of the marker can be tracked by computer software. This is called **optical motion capture** [1]. The second method uses a series of cameras, but without markers. This method is called **markerless motion capture**. This technology uses advanced computer programs to track body shapes (legs and arms, for example). These methods also use color and depth and they combine multiple camera views to track the person's motion. The last method, called **inertial motion capture**, measures motion by placing a sensor on each part of the body. This method does not require any cameras. Instead, each sensor detects changes in the speed and direction of the body, like how you feel a push or pull when riding in a car as it speeds up, slows down, or turns a corner.

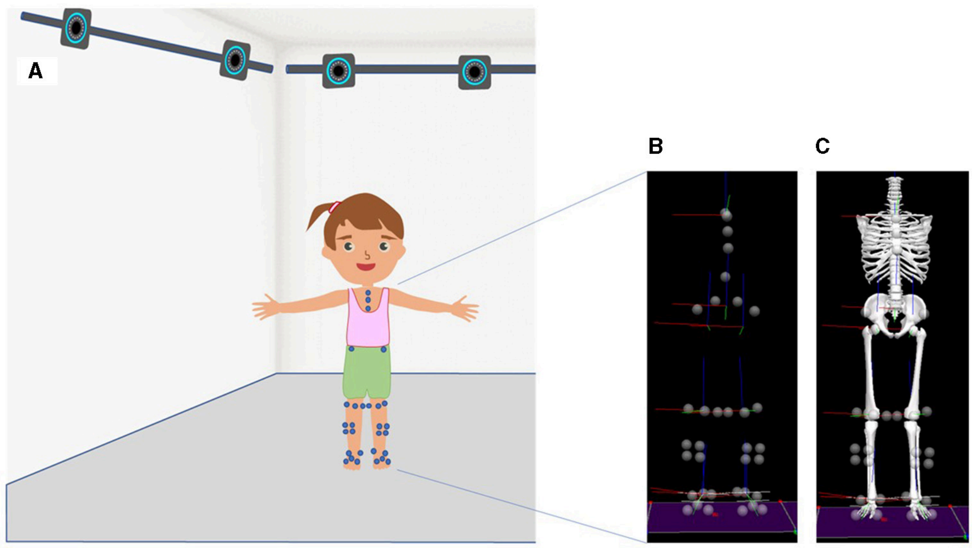

Figure 1

Figure 1

(A) Special mocap markers (blue dots) are placed on specific parts of the person's body. They stand, walk, run, or perform other tasks in the mocap room. Special cameras track the motion of the markers. **(B)** The mocap cameras and computer recreate each marker (gray dots) in 3D on the computer. **(C)** A skeleton model is created from the mocap markers, which moves exactly like the person does.

Each of these mocap systems can measure where one part of the body is compared to another. This is called relative motion. Optical and markerless mocap also give absolute motion, or how the part of the body is moving by itself. Some systems measure the motion in more detail, or at a higher rate of speed. Picking the right mocap system is an important step for biomechanists.

MOCAP TO HELP PATIENTS MOVE EASIER

Some kids have health conditions that limit their ability to walk, run, or do other everyday movements. They may need an artificial leg, a leg brace, or walking aids like crutches. Sometimes a doctor or physical therapist can help improve a child's ability to walk by changing how much a joint moves or by increasing the child's muscle strength. 3D mocap can help the doctor or physical therapist identify which joints or muscles are having trouble when the child moves [2]. They can use these data to decide the best treatment to improve the patient's movements. Many mocap tests are designed to help children walk better, often using optical mocap systems. During each testing session, the mocap staff applies the markers and asks the child to walk. Additional tests, like jumping, running, or sitting, are used to test movement during other daily activities the child may do.

These testing sessions usually involve more than just mocap—they may also measure the forces involved in creating and controlling motion. For example, every time you take a step, your foot applies a force on the ground. Per the laws of physics, the ground reacts by creating an equal and opposite force on your foot. This is called the **ground reaction force**. During mocap sessions, patients walk on special force-sensing plates in the floor that measure this ground reaction force. Biomechanists use the ground reaction force and the position and movement of each joint to determine how much force is generated at the hip, knee, and ankle. Inside the body, forces are also created when muscles contract. Small sensors placed on the surface of the skin over the muscle can measure the electrical activity produced when the muscle is contracting. These sensors do not cause the muscle to contract, they simply "listen" to determine when the muscle is "on". As a muscle contracts, its forces help to bend or straighten joints.

GROUND REACTION FORCE

A force from the ground on the body. It is equal to the force applied by a person onto the ground.

MOCAP TO HELP ATHLETES RECOVER AND/OR PREVENT INJURIES

There are some doctors, physical therapists, and biomechanists who treat sports injuries. They use mocap to determine when injured patients are ready to go back to playing sports. For example, a soccer player may hurt their knee and tear a ligament. A **ligament** is like a rubber band that connects two bones (Figure 2). Its job is to help keep the bones together and prevent them from moving too much in a certain direction. Sometimes when a person lands from a jump, their leg or body is not in a good position. This can create a large force at the knee joint, which causes the ligament to tear. This ligament injury usually requires surgery and a lot of recovery exercises with a physical therapist.

LIGAMENT

A part of the body that connects and holds two different bones together.

Doctors must determine if an injured player's knees and muscles are strong enough and have enough motion to return to playing sports [3]. This can be done by measuring the motion when the patient runs, changes directions, or jumps. Mocap answers these questions and helps the patient get back to playing their favorite sports. Doctors and physical therapists use these same tests to measure motion in athletes without injuries, to determine if they are at high risk of getting hurt. Athletes whose movements and forces are similar on the left and right

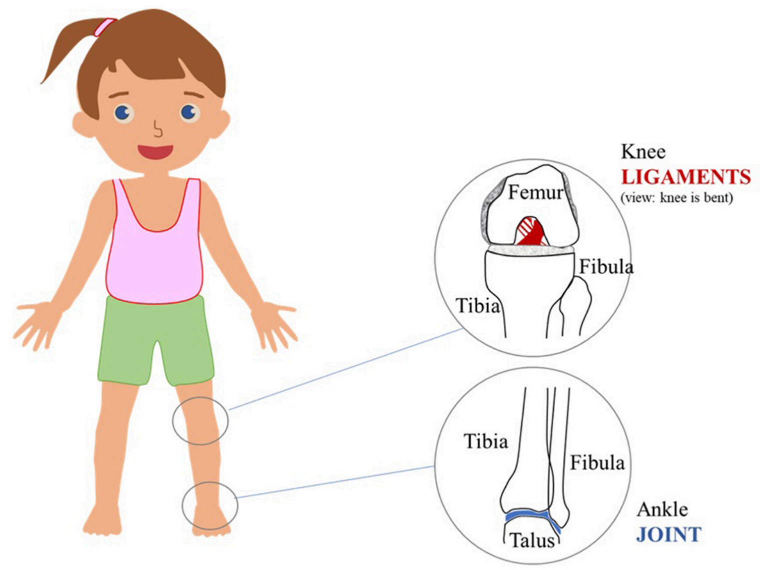

Figure 2

Figure 2

A ligament acts like a rubber band, holding two bones together. A joint is the area where two (or more) bones meet.

sides and within a healthy range of motion are at a lower risk of getting hurt (Figure 3).

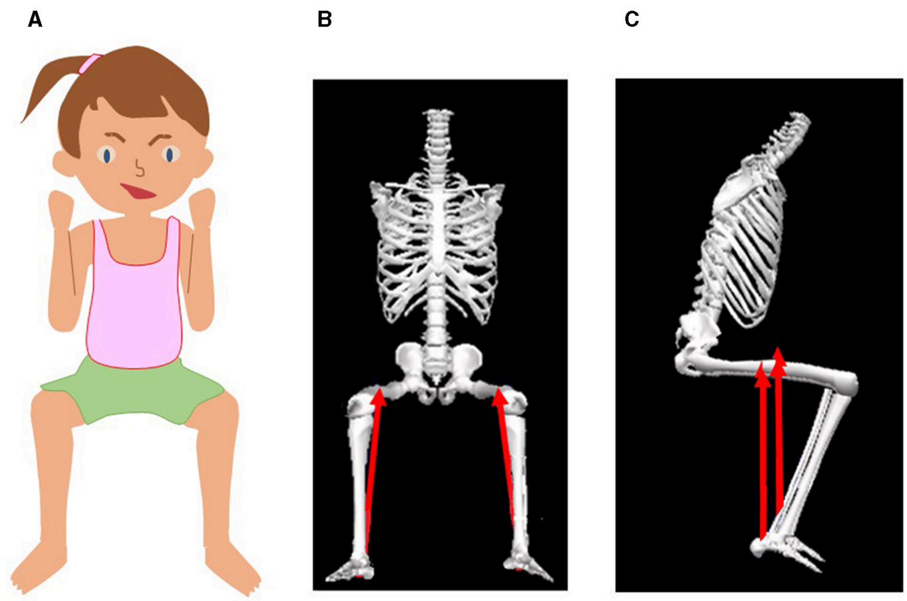

Figure 3

Figure 3

(A) The patient performs a challenging movement, like a squat, while wearing mocap markers (not shown). **(B)** Using a computer-generated skeleton, scientists and doctors look to see if the ground reaction force (red arrows) is the same height and direction on both sides of the body. In this case, they are. **(C)** They also examine the position of the legs and the hip, knee, and ankle joints to see if they are the same on both sides of the body. Again, in this example, they are.

MOCAP TAKE HOME MESSAGE

Motion capture is often used to make our favorite video games and movie special effects. This same technology is used to understand how the human body moves. Mocap systems measure motion in 3D and can take more than 100 measurements per second. This high detail allows biomechanists to see exactly where limitations in motion impact someone's ability to walk and move. The forces that cause human motion, both inside and outside of the body, are also important to describe why a person is having difficulty with specific movements. Doctors use this information to help people move easier, recover from an injury, or prevent injuries.

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Prisha is an avid reader of fantasy and mystery who also likes mathematics, specifically algebra and trigonometry. She is also really interested in the sciences, biology and chemistry especially, and how technology could be applied to those fields in the future. In her free time she writes fiction, does yoga, bakes, and engages in art.

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Hi, my name is Zuri. I am passionate about entrepreneurship, enjoy public speaking, and I am currently having fun coding with Python to build a smart voice assistant. In my spare time, I like photography, ice skating, experimenting with new foods, and spending time with friends and family.

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Matthew Parrett is a biomechanist at Nationwide Children's Hospital. He has a master's degree in kinesiology and is involved in research with a main focus on studying how people walk and move. Matthew also helps gather and process information specific to each patient, to better understand their needs and improve

their care. He is interested in how problems with muscles and nerves can affect a person's balance and stability. His goal is to learn more about how to keep people stable, correct their posture when needed, and ultimately, prevent them from slipping, tripping, or falling.