Biomechanics of Sports

Middle Level Lesson Plan

Topic The human body: Skeletal and muscular systems

Grade Level 7-8

Overview

Biomechanics is the formal study of how the body moves. This field has become increasingly useful in the world of sports, helping athletes improve their performance while reducing the number of injuries. Biomechanics has also played a role in the trend toward increased athletic practice and repetition of physical exercise routines. This trend can have ramifications at different stages of human life. For example, during adolescence, when the body is still developing, it can react in particular ways to repeated motions and can suffer specific injuries typical to each sport.

Introduction

This unit of study will give middle-school students an opportunity to apply their conceptual understanding of the organization, structure, and function of the human body to situations in which some body systems work together to support human motion. After designing and implementing a strategy for collecting data about bone and tendon/ligament development at various age levels, students will observe a body in motion. They will then create a model that represents the motion-related systems functioning as one system. This experience will also provide an opportunity for students to reflect on the usefulness of models as a way to explain the way the world works.

Time Allotment

Six 45-minute class periods.

Prior Knowledge of Students

Student should have a basic understanding of the organization of the human body. They should be familiar with the specific structure and function of the tissues of the human body that relate to human movement, particularly bones and related tissues, voluntary muscle cells and related tissues, and the connective tissues, including ligaments and tendons.

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Concepts to Clarify

Benchmarks for Science Literacy mentions that students may have little knowledge of internal bodily organs and think of the contents of the body in simplistic ways. Being clear about the different systems and how they interact can help in their knowledge about the body systems.

CONNECTIONS TO THE STANDARDS

Maine Learning Results	New Hampshire Curriculum Framework	Vermont Learning Standards	National Science Education Standards	Benchmarks for Science Literacy
C. Cells Grades 5-8 C5. Describe how body systems work together.	Life Science 3d--Curriculum Standards: End of Grade 10 4. Discuss, using observation, experimentation and modeling, the connections between the structure and function of cells, tissues, organs and organ systems. Unifying Themes and Concepts 6c. Curriculum Standards End of Grade 10 5. Illustrate how models allow scientists to better understand the natural world.	Organisms, Evolution and Interdependence Grades 5 – 8 7.13.aa. Identify, model and explain the structure and function (e.g., cells, tissues, organs, systems) of organisms, both as individual entities and as components of larger systems.	Content Standards (5 – 8) Life Science 1. Structure and Function in Living Systems The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control and coordination and for protection from disease. These systems interact with one another.	Chapter 6C: Basic Functions (6 – 8) Essay, p. 137 Students can now develop more sophisticated understandings of how organs and organ systems work together…Asking "What if" questions can stimulate students to reflect on connections among organs.

Materials Needed

- TV and VCR
- QUEST: *Biomechanics of Sports* video
- Chart paper and markers
- Student Handout 1: The Body in Motion Through the Ages, Part 1
- Student Handout 2: The Body in Motion Through the Ages, Part 2
- Student Handout 3: *QUEST at Home:* Sticks and Stones: Are All Broken Bones Equal?
- Diagrams of human muscular and skeletal systems can be located at: *http://www.innerbody.com/htm/body.html*
- Diagrams of the major skeletal muscles and of the major bones of the skeleton (Close-up diagrams and pictures of the skeletal and muscular system can be located at: *http://www.innerbody.com/htm/body.html* and *http://www.mnsu.edu/emuseum/biology/humananatomy/skeletal/skeletalsystem.html*)
- X-rays of major bones of the body – if possible, including prebreak and postbreak film from the same person. (Hospitals, clinics, and doctors' offices will frequently donate old X-rays as long as they are able to eliminate any identifying information.)
- Video camera and blank videotape(s) or digital movie camera
- Pipe cleaners (at least 25 per pair of students)
- Chicken bones (optional)
- Vinegar (optional)

1. Introducing the Concepts

Step 1

Decide whether you will have students work individually or in pairs. Then provide each student, or pair of students, with a diagram of each of the muscular and the skeletal systems. Explain that students will be learning more about an area of science called *biomechanics* – the study of how the body moves. Tell students that they will be studying how some major organ systems of the body function together and how they influence each other.

Step 2

Begin the lesson by having students brainstorm, first individually and then as a class, a list of the sports with which they are familiar. They can extend their list by considering various Olympic sports.
Have each student, or student pair, select a different sport. (You may also choose to assign sports to students.) Ask them to look at their diagrams of the major skeletal bones in the human body. Each student/student pair should identify which bones are *primarily* involved in their particular sport. Explain to the class that, although all of the bones in the body will be moving during any sport activity, they should focus on the *major movements* of their sport. On their diagrams, students should shade in the bones that they have identified. Once they have finished, have each group report their results to the class. Have them act out the movements involved in their selected sport. Record the names of each sport and its related bones on chart paper.

Step 3

Next have students look at their diagrams of the muscular system. Ask, "Which muscles are primarily responsible for any one given motion? How do the muscular and skeletal systems work together to make this motion? How do individual bone cells contribute to these motions? How do individual muscle cells contribute?"

Have student groups discuss these questions. Then have them record their initial ideas in response to the following questions:

- What if you had a bone that couldn't be broken?
- What would it take for it to be that strong?
- Describe the bone. How would the cells be arranged? What might the bone look like?
- In what ways might that be helpful to the functioning of your body?
- In what ways might it interfere with the functioning of your body?

Step 4 (optional)

As an additional activity on bone structure, you may wish to conduct a demonstration with chicken bones. For this demonstration you will need to collect, clean, and dry some bones from a cooked chicken.

1. Soak about half of each kind of bone in a jar of vinegar for three to four days. The remainder of the bones should remain untouched.
2. After the three to four days have passed, remove the bones that have been soaking in the vinegar. Dry them off. Now you will have a bone collection in which some bones are very flexible (due to the soaking) and others appear "normal."
3. Show students the two types of bones. Have them try to break some. When they come up with varying results, explain (and/or demonstrate) the soaking process you went through with some of the bones.
4. Discuss with the class what the vinegar soak has accomplished. Encourage students to respond to the following questions:

- How are these two sets of bones different?
- Why are some bones soft and flexible? What important mineral does the vinegar deplete? (Help students understand that calcium phosphate is the coating on bones that gives them strength. It is deposited from the center and works outward in a process called calcification.)
- What other parts of your body are made of this calcium phosphate?

2. Exploring the Concepts

Note: This lesson should take two class periods of 45 minutes each. Prior to implementing the lesson, collect a variety of X-rays from a local hospital, clinic, or doctor's office.

Step 1

Explain that one important aspect of biomechanics is learning about when injury will most likely occur. Pose the following questions to the class:

- Which sports are the least likely to result in injuries to your skeletal system?
- Which sports are the most likely?

Have students brainstorm individually, write down their thoughts, and discuss their ideas with a partner. Student pairs should then briefly share their ideas with the whole class.

Step 2

Watch the first half of the QUEST *Biomechanics of Sports* video. Have students focus in particular on the information about the structure and function of cells/tissues/organs and organ systems that are related to the body's movement (skeletal system/bones, muscular system/muscles, tendons, and ligaments). While watching the video, students should record information related to the body systems that are responsible for movement and how they relate to young athletes and to injuries.

Step 3

Using the X-rays you have gathered, show students examples of broken bones. Display the X-rays on a window for the duration of this teaching unit so that students can continue to observe them.

Step 4

Prior to showing the next half of the QUEST *Biomechanics of Sports* video, ask students to look for information that will help them answer the following discussion questions:

- Which kinds of injuries are the most likely to occur during sports activities?
- Do you think that younger athletes are more likely or less likely to suffer from sports injuries? Why?

Show the second half of the video.

Step 5

After the viewing, debrief with students by having them share what they've learned about body tissues/organs/systems as related to movement, including such ideas as:

- Human body development over time
- The fact that the skeletal system develops most of its bone density during childhood.
- Body proportions and how they continually change through early adulthood, so that child athletes must constantly relearn how their bodies work

If students do not volunteer these ideas on their own, review some of the facts included in the video to prompt them:

- More than one third of students who participate in sports will suffer some injury.

- 60 percent of those injuries occur in basketball, football, and baseball. (Discuss why this is so.)
- 31 percent of sports injuries occur in children between the ages of 5 and 14 years.
- Swimming is relatively injury-free due to the cushioning of water.
- Broken bones heal by developing a bony callus where the fracture was; some believe that this makes the bone even stronger.

Conclude the lesson by again observing some of the X-rays you have brought in to class. Show one or more locations where a broken bone has healed. Ask students if they can see whether the bone appears to be stronger.

3. Developing the Concepts

Step 1

Distribute copies of Student Handout 1: The Body in Motion Through the Ages, Part 1. Carefully review the directions with students. Review the organs related to movement, having students respond to the following questions:

- What are the names of the organs related to movement? *(bones, muscles, tendons, ligaments)*
- What is each of these organs like in terms of cellular structure and tissue organization?
- How does each one function to support the body's movement?

Step 2

Have students take out the diagrams of skeletal and muscular systems that they used in the first activity (Introducing the Concepts). Divide the class into small groups of four students each. Then have each group tackle the questions contained on Student Handout 1: Body in Motion Through the Ages, Part 1.

Provide support as needed for each segment of the activity. For example, you might offer suggestions of major bone segments that can be measured and compared, such as the radius and humerus compared with the full arm length, or the tibia and fibula compared with the full leg. (Note: It will be helpful preparation for a later activity if you can encourage different groups to consider studying different combinations of bones so that the class as a whole will have data for all major body sections.)

Step 3

Have students develop their data table drafts based on the questions listed in part C of Student Handout 1. Help them to make any necessary adjustments to their tables based on the requirements of this activity. Have each group make a data collection plan; then have groups share their plans with each other. Discuss each group's approach to the data collection.

Either allow students to collect their data during school time by visiting classrooms of different age levels (if your school has a wide range of grade levels), or arrange for them to collect data as homework, using family members and neighbors as test subjects.

Step 4

Upon returning with their results, students should complete their data tables. Review these tables to ensure that the information has been recorded correctly. Then provide students with Student Handout 2: The Body in Motion Through the Ages, Part 2.

Step 5

Provide any necessary support to help students draw their conclusions as instructed on Student Handout 2. If time allows, have student groups present the visual representations of their findings to the rest of the class.

To wrap up the session, have the whole class discuss their conclusions about how these key body systems relate to movement and function, and how the structure of these organs at different age levels might affect their function.

4. Synthesizing and Applying the Concepts

Note: The following study of motion sequence can be done as a whole-class activity or in smaller groups, depending on time and resources (e.g., the availability of camera equipment). This activity will take several class sessions to complete, but the results are well worth it!

The activities that follow will allow students to apply their basic knowledge of structure and function of the organs related to movement in a new situation. They will have to consider how those organs contribute to the particular motions required for various activities. Students will be using videotape or digital movie cameras to design, record, and explain representative models of the human body in motion.

Step 1

Introduce the activity by explaining to the class that they will be analyzing motion in a way that is similar to the work of many coaches and trainers – by carefully observing a person's motions on film.

Tell students that their task will be to collect some visual data by recording a human subject in motion. They will then be using that information on a frame-by-frame basis, along with their previous measurements from Student Handouts 1 and 2. Students will create pipe-cleaner models that can be used to demonstrate how the body's motion-related systems function together.

Step 2

Have teams (or the whole class, depending on how you have chosen to implement the lesson) brainstorm a variety of simple motions that they might study. Record all ideas on chart paper or the board. Examples could include sports-related activities as well as everyday motions, such as hitting a baseball, kicking a soccer ball, walking, or tooth-brushing. From the brainstormed list, have teams (or the class) each identify the series of movements involved in one simple motion that they will study and model.

Step 3

Once students have chosen a motion to study, have them identify key elements of the motion-related body systems they will study and model (e.g., legs, arms, and torso; head, neck, and torso; etc.) Teams should then use a video or digital movie camera to record their specific motion.

Step 4

Allow all teams enough time to analyze their motions frame by frame, either using the "still frame" function of the VCR or the single frames from a digital movie. Students' analyses should include a sketch of the motion captured in each frame, along with a written description of the key joints, bones, muscles, and connective tissue involved in that segment of the motion.

Step 5

Using these "storyboard" sketches and notes, along with the measurements from the previous activity, have each team create a pipe-cleaner model that demonstrates the correct proportions and motions from their series of movements. Have each team evaluate their own model, responding to the following questions:

1. Does the model demonstrate your motion accurately?
2. Does the model match the data (measurements) that you collected earlier?

Student teams should present their models to the rest of the class. After presenting and then critiquing each other's models, they should then have a class discussion (or you may choose to assign a written essay) in response to two questions:

1. Does the model represent all of the ways in which the body systems related to motion work together?
2. What are the limitations of these models in terms of demonstrating the "real world" situations that they were designed to illustrate?

5. Extending the Concepts

Quest at Home

Distribute copies of Student Handout 3: *QUEST at Home* – Sticks and Stones: Are All Broken Bones Equal?. Review the handout with students before they take their copies home. Agree upon a due date for students to return to class with their findings.

Community Connections

■ Have students find out about the sports curriculum at your local college or university. Students can research whether classes are offered in biomechanics, kinesiology, exercise physiology, or sports medicine. They can also ask to review any pertinent course descriptions or class outlines and lessons.

■ Students in your class who are athletes might think about whether there are any college or university programs that might be able to help their sports performance. Encourage them to visit some college Web sites using the address listed below.

This site defines *sports medicine* and *athletic trainer* and provides insight into the roles, careers, and backgrounds of some professionals in the field of sports medicine (including three athletic trainers from high schools in southern New Hampshire). Photographs provide a glimpse of the work environment of athletic trainers.
http://www.accesssportsmed.com/athletic/index.htm

The University of Southern Maine's Sports Medicine Program is a link that provides a description of sports medicine. It also includes links to academic majors (describing requirements and programs of study for people who would like to study sports medicine) and student resources, including many links to sites about athletic training, exercise physiology, and health fitness.
http://www.usm.maine.edu/sportsmed

The University of New England's Physical Therapy Program site describes the program of study for UNE's physical therapy program. It also provides links to information about careers in physical therapy, as well as curriculum and admissions requirements.
http://www.une.edu/chp/pt/index.html

Norwich University Sports Medicine Program. This link provides a glimpse at the program of study, including a matrix of courses that a typical four-year student would take in order to graduate with a degree in sports medicine from this college in Vermont.
http://www.norwich.edu/mathsci/biology/sprt_med.html

Career Opportunities

There are many careers that involve some knowledge of biomechanics, ranging from coaching to the practice of sports medicine. Some of these careers include the following:

- **Coaching/Training:** Coaching may involve athletes from the age of five through adults, from basic recreation programs to professional sports. Training can pertain to both sports teams (community, recreational, or regional) and individuals from age fifteen through adults.

- **Sports Directors:** This can include community recreation instructors and directors, as well as school and college athletic directors.

- **Medicine:** Jobs in sports medicine include technicians, physical therapists, doctors, orthopedic surgeons, and biomechanics researchers.

People in these careers may live in your community. Find out if they do and invite them into the classroom to talk about their work, and the preparation they needed to pursue the career. The type of people you might look for would be community recreation technical trainers (not just parents who coach youth sports), college sport trainers, highly qualified college coaches, or YMCA/YWCA fitness specialists, sports medicine or family doctors.

Resources

http://www.uchc.edu/ocomm/newsreleases02/feb02/teen_sports.html

Preventing Teen Sports Injuries

This article, from the University of Connecticut's Health Center Web page, describes common teen sports injuries and offers recommendations about strategies for preventing them.

http://childrenshosp-richmond.org/families/sports/understanding.htm

Children's Hospital, Richmond Virginia

An article at this site called "Understanding Teens' Sports Injuries" explains the issues around teen involvement in sports and includes links for families to other related subjects, such as physical therapy for children.

http://www.aafla.org/6oic/curriculum2.htm

Amateur Athletic Foundation of Los Angeles *Olympic Curriculum Guide*

Thematic lesson plans that are related to the Olympic Games are provided as both PDF and HTML files.

http://www.zoology.ubc.ca/labs/biomaterials

University of British Columbia *Biomaterials Home Page*

This site introduces teachers to one application of biomechanics, the study of biomaterials (the mechanical function of biological materials and structures). Links from this site include a variety of studies that are being conducted on materials that are produced by organisms such as fish, jellyfish, and spiders. Properties of these materials, such as stiffness, strength, and toughness, are under investigation and may have an impact on how human injuries are treated.

The Body in Motion Through the Ages

Part 1

Challenge Questions

In the QUEST *Biomechanics of Sports* video, you learned that young athletes constantly need to relearn how to move their "new" bodies as they grow and change.

- In what ways do the organ systems related to movement change over the years between the ages of 5 and 14?

- In what ways might these changes affect how the body systems work together to create efficient movement?

The Skeletal System

- Do all of the body's bones grow at the same rate at the same time? Explain.

- Do they remain the same size relative to each other and to the height of the human body? Explain.

Collect some data to explore these questions. Here's how:

1. Identify some key individual bones that you will measure and compare in people of different ages (such as the major bones of the arm or of the leg).
2. Decide exactly where each measurement will begin and end. (**Hint:** It might be helpful to identify an exact beginning and ending location based on key joints where the bone meets another bone.)
3. Remember that you will also need to take measurements of the organism as a whole so that you can compare the growth of your selected bones to the whole organism. In addition to height, what other larger measurement might you need?

The Muscular System

- It is said that the growth and development of tendons and ligaments lags behind skeletal growth. Is this true? Explain why.

A. Figure out a way to compare the functioning of tendons and ligaments of people at different ages. How might you compare ***flexibility*** as an indicator of this tissue development? Here's how:

1. Identify some key joints where flexibility can be measured easily.
2. Decide exactly how these measurements will be taken on each of your human subjects.

3. Decide how you will account for the differences in flexibility that could be caused by simply more or less participation in various sports activities, regardless of age or development.

B. Finally, a couple of suggestions for both studies:

You will need to locate human subjects for your study. Decide ahead of time what the characteristics of these subjects will be.

- What key ages will you study in order to represent body growth and development?
- How many subjects will you have from each age group?
- How will you account for the flexibility issue?

C. You will also need to design a data table to collect your information. With your team, draft a data table design. Then use the following questions to help you determine where the table might need to be adjusted.

- Does your data table allow you to record important categories of information about each subject (like age, total height, length of each key bone, and length of the larger part that it belongs to)?
- Does the data table include the units of measurement that you will use?
- Would it be helpful to have a place to record other notes or observations about each subject? (For example, you might want to record information about the flexibility of each subject, such as his or her level of participation in sports. You may even wish to find groups of people who participate in a certain sport and compare them with people who do not participate in any sport.)
- Will the design of your table help you to compare the measurement results from groups of subjects at each different age level?

The Body in Motion Through the Ages

Part 2

Conclusions

In order to form some conclusions about the growth and development of various organs related to movement, you will need to analyze the data that you have collected. Considering the following questions will help you come to your conclusions:

- What percentage of total body height and total organ length (e.g., total arm or total leg length) does each bone make up?
- In general, how do those percentages compare among people of different ages?
- How does flexibility of key joints compare among people of different ages?

Presentation

With your team, create a visual representation of your results that you can share with the class.

Possible visual representations for you to consider include:

- A **chart** that compares average measurements for different ages.
- **Scale drawings** that demonstrate the average measurements for a typical person of each age level that you studied.

Once you have designed your visual representation, plan a five-minute presentation to share your results.

Your teacher will include your results in a later group discussion that will help your whole class combine its data to come to some conclusions about the topic you have studied.

Sports in Your Community

You're on a Quest!

Sticks and Stones: Are All Broken Bones Equal?

Have you or someone you know ever broken a bone? Have you ever wondered how medical techniques have changed over the years to help people heal and recover from bone injuries?

In this activity, you will interview family members, friends, and neighbors who have had broken bones. It will be most interesting if you can find people representing a variety of ages, including some who may have had broken bones during different decades over the past 50 years. Also see if you can find people who have undergone a variety of medical techniques to treat their injuries, such as artificial replacement bones and joints, pins in their bones, electronic equipment to relieve pain, and so on.

A. Collect information about each broken bone situation. Ask your research "patients" the following questions:

- Which bone did you break?
- What were you doing when it happened?
- Did any other organs (such as muscles, tendons, ligaments) suffer injury?
- What medical treatments were used on you to promote healing?
- What did it feel like right after the break? What did it feel like at different times during the healing process?
- How long did it take your bone to heal?
- What special exercises or other healing regimens did you have to follow?

B. Once you have collected some stories, think about all that you've learned. Does it seem as if some bones are easier to heal than others? Are ligaments more challenging or less challenging than bones in terms of overcoming injury?

C. Share your results with your classmates.

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