Biomechanics of Sports

High School Lesson Plan

Topic
Human mechanics: Sports

Grade Level
9 – 11

Overview
Many athletes, including those on college and Olympic teams, have found their sports performance greatly enhanced by science. The science of human motion is called *biomechanics*. This study of the interaction between the skeletal and muscular systems is taught at middle schools and high schools today.

Introduction
This teaching unit focuses on supporting and extending students' understanding of biomechanics using the issues and examples presented in the QUEST *Biomechanics of Sports* video. Students will tie their knowledge about sports to the study of physical sports performance and what athletes do to improve their performance. **Note:** The QUEST *Biomechanics of Sports* lessons and activities do not represent specific diagnoses or recommendations by physicians.

Time Allotment
Four to eight 45-minute class periods.

Accessing Prior Knowledge
Students should be aware that science can be applied to human physical systems.

Concepts to Clarify
Although high school students tend to believe that they have a good understanding of the overall functioning of human systems, particularly the skeletal and muscular systems, they usually do not have a solid understanding of the interaction of multiple systems. Encourage students to think about the interaction of these systems in the human body, especially during sports.

QUEST: Investigating Our World is a regional public television series seen on Maine Public Broadcasting Network, Vermont Public Television, and New Hampshire Public Television

Major funding for Quest is provided by the National Science Foundation. Additional support is provided by Irving Woodlands and by gifts to More Connected, More Maine. The Campaign for Maine Public Broadcasting Network's Programming.

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CONNECTIONS TO THE STANDARDS

Note: This QUEST program tackles issues that are not well articulated as learning goals in state and national standards for students in grades 9-12. Nevertheless, it represents an emerging field of science and can be presented as the application of both science and career possibilities to students in high school.

Maine Learning Results	New Hampshire Curriculum Framework	Vermont Learning Standards	National Science Education Standards	Benchmarks for Science Literacy
C. Cells Grades 5-8 Describe how the body's system work together. Grades 9-12 Analyze the impacts of various scientific or technological developments.	**Life Science** 3d – Curriculum Standard 4: Discuss using observation, experimentation and modeling, the connections between the structure and function of cells, tissues, organs and organ systems.	**The Human Body** Grades 5-8 7.14bb. Demonstrate an understanding of the body systems and coordination of physical functions. Grades 9-12 7.14ddd. Identify, explain and analyze the pattern of human development.	**Content Standards** (9-12) Science in Personal and Social Perspectives 1. Personal and Community Health Personal choice concerning fitness and health involves multiple factors.	**Chapter 6B: Human Development** Grades 6-8 (no 9-12) Various body changes occur as adults age.

Materials Needed

- TV and VCR
- QUEST *Biomechanics of Sports* video
- Chart paper and markers
- 1 tape measure for every 2 students
- Stopwatch with sweep second hand
- Strides, Speed and Age Graphs
- Library or computer(s) with Internet access for student research
- Student Handout 1: Stride, Speed, and Age
- Student Handout 2: Press Release About Teen Sports Injuries
- Student Handout 3: *QUEST at Home*: Sports in Your Community

1. Introducing the Concepts

Step 1

Ask students to identify sports they either watch or play themselves. Itemize these sports on chart paper or the whiteboard. Next, ask students what they think athletes do to improve their performance without drugs. On new chart paper or on the board, record students' ideas about performance-enhancing activities for (a) high school, (b) Olympic, and (c) professional athletes. Keep students' responses for each category of athlete in three separate lists. Then have students compare and contrast the lists. You can also compare and contrast different sports by asking the following questions:

- Which parts of the body are used in each of these activities?
- Where are the major stress points on each of these parts of the body?
- Do all sports require the same level of conditioning?

Help students come up with appropriate examples that support their responses. Discuss the differences that the class has identified and why these differences exist.

Step 2

If you have not already done so, highlight the strategies that students have listed for improving athletic performance that include personal behaviors or choices – such as not drinking or not taking performance-enhancing drugs. This would be a good time to discuss the concept of responsible behavior if you choose to pursue the topic in more depth with the class.

2. Exploring the Concepts

Step 1

Show the QUEST *Biomechanics of Sports* video through the swimming segment (approximately the first half of the film). Elicit reactions from students by asking the following questions:

- Which parts of the film did you already know something about?
- What surprised you?
- What do you want to learn more about?
- How does the field of biomechanics seem to be redefining the world of sports?

Step 2

Discuss the following sports-related situation with the class:

For runners to increase their speed over a specific distance, they can do two things. First, they can increase the number of strides they make over a given distance while not decreasing the length of

their stride. Or, they can increase the length of their stride without decreasing the number of strides over a given distance. Someone with longer legs should probably try to increase the number of strides over a distance; someone with shorter legs should try to increase his or her stride.

Through the example above, help students reach the conclusion that differences in our physical makeup can make some people naturally better disposed than others to excel at certain sports.

Step 3

The following activity allows students to use measurements to make some predictions about their classmates and help them to run faster. (**Note:** Because of differences in students' bodies and individual sensitivities, students should not be required to be measured.)

Have students pair up. For each pair, have one student measure the other's stride. This is the distance from a specific point on the floor to the end of the student's natural leg stride. Students should record their data and then add it to a class chart.

Student should then organize their data in ways that highlight which groups of students could increase their speed by increasing their stride, and which students should increase their number of strides. Compare and discuss these findings.

Step 4

As an extension, have the class do some calculations about the speed of various runners. You can take the class outside and have several students run 100 meters as others time them. Have still other students count the number of strides over the given distance. Then use the following equations:

To find Stride Frequency: Number of Strides / Time (seconds) = Stride Frequency

To find Speed: Stride Frequency X Stride Length = Speed

If you do not want to time actual students, you can do the same calculation using the following problems.

1. A runner's stride is 1.5 m and her frequency is 2 strides/s. Calculate her average speed. What would her time be for a 200-m race?

2. A runner maintains a constant speed of 6.0 m/s. If his stride length is 1.4 m, what is his stride frequency?

3. If the runner in question #2 increases his stride length to 1.5 m without changing his stride frequency, what will his new speed be?

4. If a marching band has a frequency of 1.8 strides/s and if the stride length is 0.5 m, what is the band's marching speed?

3. Developing the Concepts

Step 1

Discuss with the class the fact that the human body changes as it ages. Ask students the following question: "Why do you think some athletes, such as gymnasts, can only compete in their early and late teens, while others, such as hockey players, can compete as 30 year-olds at the international level?" Emphasize that different sports require different functions from the body, and that, as the body ages, its ability to maintain a high level of performance changes. Have students discuss what they know about the age of particular athletes and their chosen sports.

Step 2

The following activity examines some research on a runner's stride and speed as related to age.

Distribute copies of Student Handout 1: Stride, Speed, and Age. Examine the first graph with students (Stride Length vs. Age). Elicit a general statement about the graph, and help students come up with specific examples to support their statement. Make sure they are aware of the range of ages in the data to clarify the population in the study.

Have students predict why there is a difference in stride, speed, and age in people. (The answer is because of the stride-number of steps relationship.) Ask, "Will this population have reduced strides, reduced steps, or both? Why will this be the case?" Discuss students' responses.

Step 3

Examine the next graph with the class (Speed vs. Age). Discuss what students see in the graph. Is the relationship between speed and age the same for men and women?

Step 4

To extend this activity, you can choose one of the following options:

1. Have students complete Student Handout 3: *QUEST at Home* as a way to find more data about age and sports.

2. Have students do research on the flexibility of bones in humans. How does age affect bone flexibility? How might this affect the performance of the human body in sports?

3. Ask for volunteers from the class who are willing to have their strides measured. Compare the strides of athletes with those of non-athletes. Also compare the types of sport these students are involved in. Does a given sport require the performance of the legs more than the arms? Are there differences in the volunteers' strides? Why? What could one group do to improve their stride? (Caution: This activity can embarrass students. Be careful to use student volunteers, and do not make generalizations about athletes versus non-athletes. Only talk about the findings from the students you have actually measured.)

4. Synthesizing the Concepts

Step 1

Ask students to think back to the first segment of the QUEST *Biomechanics of Sports* video. Tell them that in the next segment they should look for information about how biomechanics can help with athletic injuries. Students should also watch for information about careers in sports medicine.

Show the remainder of the film.

Step 2

After the viewing, ask students the following questions:

- What surprised you in this segment of the video?
- What do you want to learn more about?
- What have you learned from this segment about how biomechanics is redefining sports?

Extend the activity further by leading a discussion about the ethics of encouraging young people to push their bodies beyond what might be considered normal.

Step 3

Explain to the class that the typical sports injury is generally not severe. Sprains, strains, contusions, abrasions, and lacerations make up 60 percent of all sports injuries to children. Fractures account for less than 15 percent of injuries. Generally, the younger the child, the less severe the injury from sports (except in the very young). However, it is also true that the more rapidly a child grows, the more susceptible he or she is to injury at bone growth sites (knee, heel, shoulder, elbow, hip, and back).

Tell students that the reason for this susceptibility is because growth occurs at the upper and lower end of the long bones of the skeleton. One half to one inch below the end of the bones is the growth center, where cartilage-like cells will harden and eventually make up bone mass. It is this vulnerable area that is the weakest part of the skeleton, and most prone to injury, especially in young adolescents. When children stop growing, fractures decrease for a period until the bones become harder at a later age.

Step 5

Distribute copies of Student Handout 2: Press Release About Teen Sports Injuries. Read and discuss the press release with the class. It describes common teen sports injuries and offers recommendations about strategies for preventing them. The article canalso be found at:
http://www.uche.edu/ocomm/newsreleases02/feb02/teen_sports.html

Step 5

Inform students that specific sports/recreational activities yield specific injuries. A partial list of some sports/activities and their related injuries can be found below. Have students select these and additional sports (of either their choice or yours) to research. They should pay particular attention to the specific nature of the injuries related to each sport and how to prevent them.

■ **Soccer** is the most popular sport in the world and the fastest growing team sport in the U.S. Soccer players who are hit by the ball, fall, and/or come into contact with other players often suffer bruises, as well as knee, ankle, and shin injuries.

■ **Gymnastics** is a growing sport in the U.S., with training starting as early as age three. Although the risk of injury seems proportionate to the skill of the athlete, the most injuries occur during floor exercises and tumbling. Other injuries result from upsets on the balance beam and uneven parallel bars. The most common injuries to gymnasts are spinal injuries.

■ **Playground equipment**, although not associated with a sport, is responsible for an estimated 125,000 injuries annually. Three quarters of all playground injuries happen on swings and monkey bars. Injuries on slides and seesaws account for the remaining fourth (data from the U.S. Consumer Product Safety Commission).

■ Children who complain of elbow pain are likely to be suffering from an overuse syndrome. **Little League Elbow**, for example, results in pain, stiffness, and reduced range of motion. A characteristic complaint of single-sport athletes, particularly baseball players, this injury is directly related to the frequency and intensity of the pitch. Swimmers and skaters may also be at risk for developing an overuse syndrome because of repetitive stress on particular joints.

■ **Osgood-Schlatter's Disease** is not a disease process, but a mechanical injury of the knee at the junction of the kneecap tendon and the tibia. It occurs in children and young adolescents who have most likely experienced microtrauma or overuse from repetitive kneeling, running, and jumping activities.

■ Children rarely complain about **back pain**, but if it persists, restricts activities, or interrupts sleep, it is a concern that should be considered seriously. After a physician has ruled out serious disease or a systemic cause of pediatric back pain, you may find that the child's complaints are due to soft tissue injuries, overuse syndromes, or postural irregularities.

5. Extending the Concepts

Quest at Home

Distribute copies of Student Handout 3: *QUEST at Home*. Review the handout with students before they take them home. Agree upon a due date for students to return to class with their research findings.

Community Connections

Depending on where you live, research your community for people who are involved in coaching children. 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.

If you are fortunate, you may have a high level athlete in your community who would also be able to help.

Invite someone from your community to speak to your class about the way in which coaches or trainers use the body shape/structure to help athletes improve their performance. Students can also ask questions about the speaker's career and what is involved in preparing for that career.

Try this investigation. It would seem that common sense would say that a characteristic such as the length of someone's legs determines their natural stride length when they run. Do some research with your friends. Ask some classmates or friends in your neighborhood to serve as volunteers. Design an investigation to identify and test the effect of leg length, or other body characteristics, on stride length and frequency during walking and/or running.

Design the investigation to test just one idea at a time about the length of people legs and their stride. Then answer the following questions:

1. Do long-legged people have greater stride length?
2. Can long-legged people maintain the same stride frequency when running as people with shorter legs?
3. Do long-legged people have higher running speeds?

Record your results and see what changing someone stride does to their speed.

Career Opportunities

Tell students that there are many careers involving some aspect of biomechanics. These careers range from coaching to the practice of sports medicine. Some of these related careers include:

Athletic coaches (working with athletes from age five through adult)
Trainer for sport teams and individuals (from age 15 through adult)
Biomechanics researcher
Community recreation instructor or director
Medical technician
Physical therapist
Orthopedic surgeon

Resources

http://kidshealth.org/parent/nutrition_fit/fitness/sports_safety.html
This Web site provides information about children's sport injuries, prevention, and other information. Sponsored by KidsHealth, it is the largest and most visited site on the Web in the category of doctor-approved health information about children from before birth through adolescence.

http://www.safekids.org/tier3_cd.cfm?folder_id=540&content_item_id=9530
This site is sponsored by the National Kids Safety Campaign. It contains references to many resources.

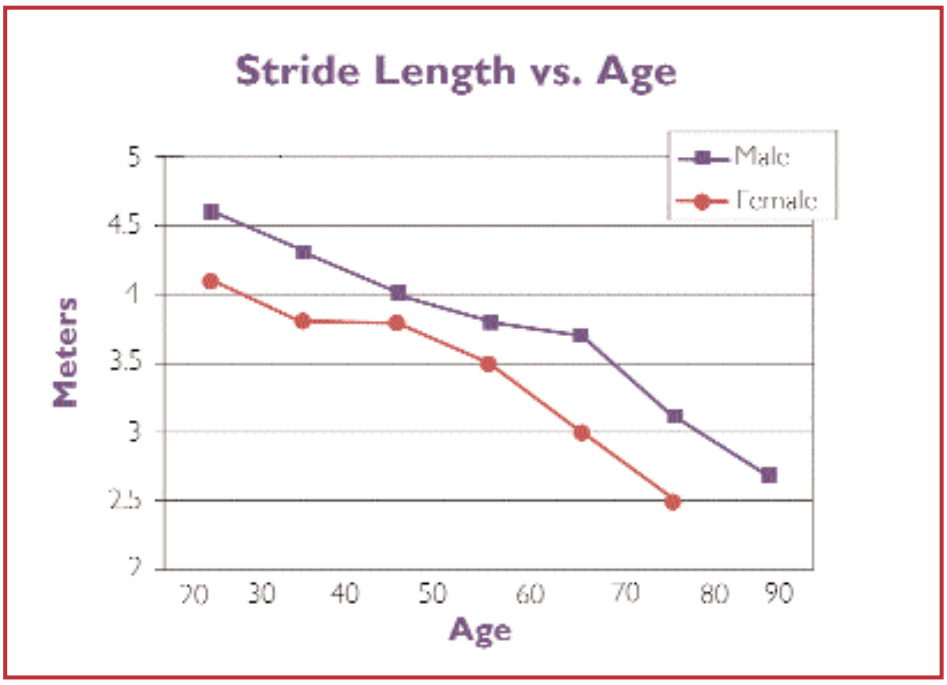
http://www.nlm.nih.gov/medlineplus/sportsinjuries.html
MEDLINE is a resource to other sites that discuss the prevention of sport injuries as well as gender and age-related sports injuries.

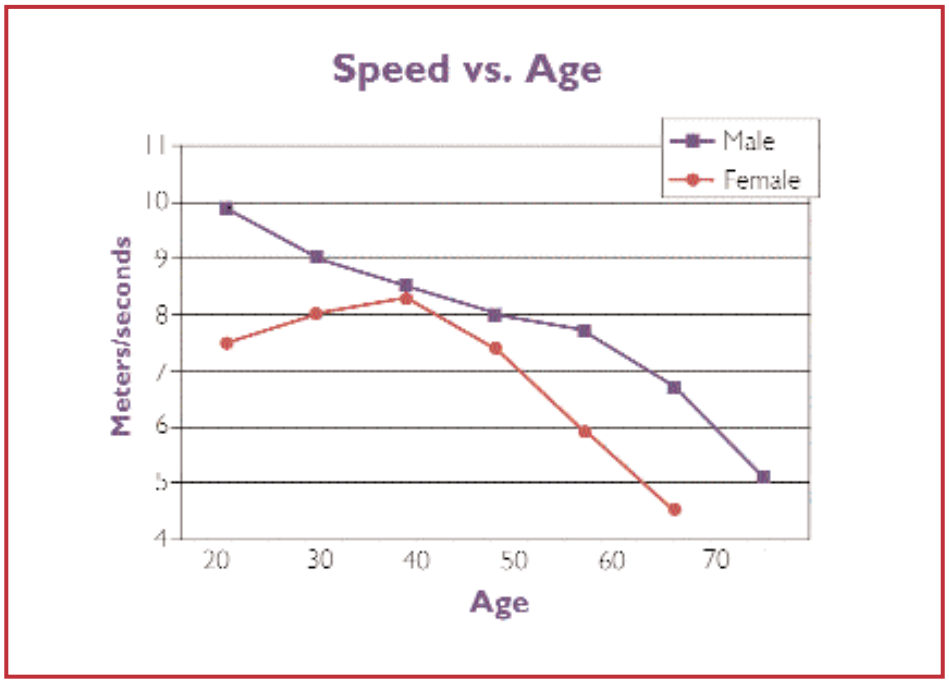
http://www.niams.nih.gov/hi/topics/childsports/child_sports.htm
The National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS) and the National Institutes of Health host this site. It has good resources on specific sports and injury prevention.

http://www.aafla.org/6oic/curriculum2.htm
The Amateur Athletic Foundation of Los Angeles has an Olympic Curriculum Guide. It contains thematic lesson plans that are related to the Olympic Games and youth sports, provided as both PDF and HTML files.

http://www.fi.edu/tfi/exhibits/sportschallenge/home.html
The Sports Challenge is an exhibit at the Franklin Institute. This site contains an explanation of the Challenge approach, which involves using science to increase one's proficiency in different sports. There is a teacher's guide that can be downloaded.

Stride, Speed, and Age





Press Release About Teen Sports Injuries

Teen Athletes Need Special Attention, UConn Sports Medicine Expert Says

Farmington, Conn. – For coaches and teen athletes, "no pain, no gain" is an outdated war cry, according to a sports medicine expert at the University of Connecticut Health Center. Thousands of sports injuries can be avoided every year if parents and coaches help athletes steer clear of overuse injuries.

"Playing on teams and participating in organized sports can be a great experience for kids. They can develop skills, achieve goals, foster healthy habits and enhance their self-esteem. But overdoing it can be a serious problem," said Carl Nissen, M.D., an orthopedic surgeon at UConn Health Center.

"Playing sports should not be painful. And when it is, that's the body's way of saying something needs to be changed," he added.

An estimated $800,000 is spent on children's sports injuries every year, Dr. Nissen said, and the severity of these injuries increases as athletes enter their teen years. Many injuries are caused by overly rigorous training. Children and teens are particularly vulnerable to injuries because they are still growing, he explained. "Over-training can damage the growth plates, which are the relatively soft areas of development where bone growth occurs on children. Growth plates are susceptible to injury because they can be weaker than the nearby ligaments and tendons," he said.

To help prevent injuries in teens and children, Dr. Nissen recommends the following steps:

- Young athletes should start new sports slowly and gradually. They should participate in pre-season training and slowly prepare for a sports season. "Try not to go from zero to 100 overnight," he said. Dr. Nissen encourages parents to schedule pre-participation physical exams for their athletes each year. These are more extensive than regular, physical exams and are specifically geared toward young athletes.
- Make sure equipment is in good repair. Without appropriate equipment, the risk of injury increases.
- Parents and coaches need to watch for early signs of injury. Some examples include complaints about pain and fatigue, or a sudden, decreased interest in their sport.

For young children under the age of 10, Dr. Nissen recommends at least one day off from their sport per week. Older athletes, ages 10 to 15, who are focusing on one sport, should take a month or two away from that sport over the course of a year. During this time, Dr. Nissen recommends cross training.

He said teen athletes are more likely to sustain injuries to their knees and ankles. One of the most common knee problems, patellofemoral malalignment, is marked by sharp pain in the joint between the knee-cap, the patella, and the thigh bone, the femur. Patellofemoral pain is usually resolved with conservative therapy, like rest and the use of anti-inflammatory medicines.

Younger athletes and baseball players are more prone to elbow and shoulder injuries. Damage is caused to the muscles and tendons around the shoulder by repetitive over-arm motions, such as swimming or throwing.

Osteochondritis dissecans, also known as Little League Elbow, is a complication caused by repetitive stress – like the whipping motion of a pitcher's throw – to the skeletally immature elbow. Treatment often includes rest and anti-inflammatory medicines. Surgery is only considered when other measures fail to bring relief.

"Though it's not always a popular choice for teens or their coaches, the key to recovery for many of the overuse injuries is adequate rest," Dr. Nissen stressed.

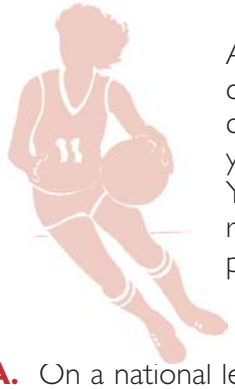
The University of Connecticut Health Center includes the schools of medicine and dental medicine, John Dempsey Hospital, the UConn Medical Group, UConn Health Partners and University Dentists. Founded in 1961, the Health Center pursues a mission of providing outstanding health care education in an environment of exemplary patient care, research and public service.

Note: News professionals are invited to visit the Office of Communications homepage at *http://www.uchc.edu/ocomm/* for archived news releases and other information.

Sports in Your Community

You're on a Quest!

Sports injuries occur just as everyday accidents do. They are accidents, which no one plans on and no one wants. However, it is possible to estimate the number of sports injuries that will potentially occur by using previous findings.



After watching the QUEST *Biomechanics of Sports*, you know that some sports tend to cause a large number of injuries. You will be conducting some research with your community recreation department. You will be estimating the number of injuries in one of your community recreation department's sports programs. You will also be finding out what records the community recreation department has on injuries in various sports programs.

A. On a national level, one in every three children involved in sports suffe a related sports injury yearly. Find out if you have similar injury rates in your community.

To do this, follow the steps listed below:

1. Find the number of children registered in a specific sports program through your community recreation department.
2. Estimate the number of injuries you think have occurred for that sport.
3. Compare your figures with those kept by the community recreation department.
4. Find out whether some community sports programs have involved more injuries than others. Which ones are they?

B. As a follow-up and extension, discuss with your community recreation department director (or other staff member) how they handle injuries and what safety measures they have in place.

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