PHYSICS OF SPORTS: AN INTERACTIVE VIDEODISC FOR ANALYZING THE MOTION OF ATHLETES

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Physics teachers have long used visual media to show how principles of physics are applied to everyday events. Visual presentation seems to motivate the students and improve their understanding of the concepts being taught. The approach taken in most of these presentations has been a qualitative one. Few quantitative visual presentations have been used in instructional settings, particularly in the laboratory, with some notable exceptions (Super-8 Film Series for Project Physics, 1971). The difficulty of working with films and slides limits the amount of quantitative information that can be acquired from them.

The availability of the interactive videodisc as a visual medium has created a vastly different situation, however. The relative ease of operation allows the instructor to use it in settings where other visual media could not be accommodated. Videodisc technology allows the student to search for any frame (picture) by inserting a few commands on the keypad. Motion can be viewed at rates ranging from one frame at a time to the normal speed of 30 frames per second. Searches occur rapidly, unlike those with videotape. Additionally, the amount of time during which one frame may be displayed is essentially unlimited. Measurements can be taken directly from the monitor, thereby facilitating the student's ability to obtain quantitative information.

The videodisc has a built-in timing device. Each video frame is separated by 1/30th of a second. Frames are individually numbered and each frame number can be presented on the monitor making it possible to determine the time in seconds by simple subtraction and division. If an object of known dimension is displayed, measurements can be made with a ruler placed on the screen and appropriate scaling completed.

Several videodiscs that use video material from events impossible to duplicate in the instructional lab are currently available (Fuller, Zollman and Campbell, 1982; and Ivy and Hume, 1985). Students analyze motion in terms of the principles of physics by using measurements taken from the video scenes. Details on the development and use of these videodiscs are available (Zollman and Fuller, 1982; Hurly, 1986).

Hardware systems to accommodate the interactive video lessons vary in complexity from a simple stand-alone player to a sophisticated computer which controls the video output of the system and overlays computer graphics on the video images (Zollman, 1985). Material developed for physics instruction tends to involve computer control of the video but does not include the sophisticated overlay of the graphics and video. Primarily in reaction to the cost of sophisticated systems, physics teachers who have developed software have used hardware systems that include small microcomputers, video players and two screens—one for videodisc output and one for computer output. Lessons written to accompany these hardware systems have generally been developed for introductory classes. They range in length from small sections of a lesson to rather complete packages designed to be used in laboratory instructions (Zollman, 1985; Noble and Eck, 1984).

Although videodisc technology and interactive video lessons that emphasize quantitative measurements have been used in recent years to teach difficult concepts in physics and some other fields, their use for teaching concepts in kinesiology and sport biomechanics is rare. Students in the undergraduate kinesiology or biomechanics course generally have had little or no exposure to mechanical physics prior to this class. Typically, these students are presented with mechanical facts, concepts, and principles and asked to make practical applications to real-life movement situations in the course of a semester's time. Students often find it difficult to complete the journey from generalization to application in one giant step. For these students, a journey of several small steps is more educationally sound. Piaget and other learning theorists recognized that some students are concrete thinkers and have difficulty with this process. A Piagetian teaching/learning strategy suggests that presentations of a generalized principle, followed by many examples of specific application, will help the concrete thinker move from concrete to abstract. Current video technology offers the appropriate medium for individualizing and facilitating this process.

The Physics of Sports Videodisc

The general purpose of the "Physics of Sports" videodisc is to present video scenes showing athletes performing events in such a way that students can take measurements directly from the screen. Although the "Physics of Sport" videodisc was primarily designed for use in physics classes, lessons accompanying the disc could be used effectively in kinesiology or biomechanics classes with little or no modification. Once students have measured distance and time and are given the mass of the athlete and implement, physical quantities such as velocity, acceleration, energy, and force can be calculated.

Most of the sporting events recorded for the video were filmed with a fixed camera during staged practices. The physics topics and the sports selected to illustrate them are listed in Table 1. Events in which many people participate were selected; those in which few people participate or which are identified as the "territory" of boys were deemphasized. Thus, the disc has scenes of a batter hitting a slow-pitch softball rather than a baseball. Scenes from competition axe throwing, a sport with relatively few participants but one which demonstrates physics principles nicely, are included as an exception to this rule.

Events were performed similarly to the way in which they would be performed in competition in staged performances for filming and video recording. For example, a staged high jump with a fixed camera is similar to a competition high jump. On the other hand, isolating a passer in football is very difficult during competition and looks much different visually when performed in a one-on-one practice situation. Scenes in which the important aspects of the event are easily visible and measurements could be taken with a ruler were also included. Scenes requiring specialized measuring equipment, such as digitizing pads, were not. Elite athletes, including one NCAA champion, and high school athletes performing during the Junior Olympics National Championships, are the performers.

Written material which provides details of the lessons for the teachers and worksheets for the students accompany the videodisc. The lessons emphasize taking measurements to complete the analysis. Several involve creating models of the athlete's motion followed by a comparison of the modeled motion to actual performance.

Each lesson opens with a physics laboratory scene that is related to the content of the lesson. The audiotrack contains a tutorial narration and a dialogue between two students discussing the topic being presented. The students relate the physical concepts to the athletic events in the lesson and express some concepts as well as common misconceptions. Messages on the videodisc prompt the user to view the athletic event and shows them how to take measurements.

Table 1. Physics Topics and Sports on the Videodisc

Linear Motion in Sports
- Sprinter vs. long distance runner
- Sprint Start-skilled, unskilled and special olympics
- Hurdles
- Falling shuttlecock, balls, and cheerleaders

Projectiles in Sports
- Shot put skilled and unskilled
- Basketball
- Shuttlecock
- Axe Throw
- Flying Softball Bat
- Long Jump
- Pole vault
- High Jump
- Cheerleading

Energy Transformations
- Trampoline
- Pole Vault
- History of the Pole Vault
- Work and Energy
  - Shooting an Arrow
  - Pulling a Bow

Momentum
- Softball hitting
- Football passes and catches

Forces in Sports
- Forces on a Bowstring
- Forces on Cheerleaders
- Volleyball Spike--skilled and unskilled

Modelling Human Motion
- High Jump
- Cheerleaders
- Basketball lay-up

Impulse and Time
- Volleyball dive and roll
- Softball catch

Other events
- Javelin
- Wheelchair race
- Walking race

Analyzing Motion with the Video

The method used to analyze the motion of athletes must take advantage of visual media as much as possible, but should not require such sophisticated equipment that is cost-prohibitive for most colleges and universities. The "Physics of Sports" videodisc requires a videodisc player, a monitor, an acetate sheet, and a marking pen. Any videodisc player that has search and single frame step capabilities will suffice. Thus, consumer-level videodisc players selling for as little as $200 could be used.

Students place the acetate sheet on the front of the monitor and mark the position of the athletes with a pen. If time is an important variable to consider, the frame number is written next to each mark. These data can be recorded quickly, then taken away from the player for further analysis. Thus, one or two videodisc players can serve a normal sized class. The data can be analyzed using traditional methods. Commercially available spreadsheets, such as Lotus 1-2-3 and Visi Calc, could also be used to perform the analysis. The spreadsheet can complete the arithmetic quickly plus generate graphs for the students to consider and interpret.

Conclusions

The use of interactive video to teach mechanical aspects of human movement offers a great opportunity to improve instructional effectiveness in undergraduate courses in kinesiology and biomechanics. The "Physics of Sports" videodisc contains a variety of athletic movements presented in such a way that accurate time-space measurements can be made. A variety of lessons can be constructed to utlize these measurements and complement specific course requirements. The instructional materials may be used with minimal investment in equipment beyond that already available in the typical college or university physical education/sport science department. The instructional capabilities afforded by this visual medium should greatly increase the number of schools involved in interactive videodisc technology.

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