Moving and Learning in Physical Education: An Interdisciplinary Approach

Applied Biomechanics in an Instructional Setting

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Through the application of core concepts, people can learn to move more skillfully and more safely.

How do biomechanists explain, analyze, and interpret movement in an instructional setting? When I am the biomechanist in question, I use a particular form of applied biomechanics. In my view, applied biomechanics is the science of how people move better. By better I mean more skillfully and more safely. In the material that follows, I will be placing more emphasis on skill rather than safety. However, there are many parallels between skillful and safe movement, and learning about skill can be a good way to learn about safety.

Most biomechanists, it seems, prefer to take things apart, but I believe that applied biomechanics requires an integrated approach. Accordingly, I will share a few features of my paradigm of applied biomechanics before I discuss it in relation to a middle school football lesson.

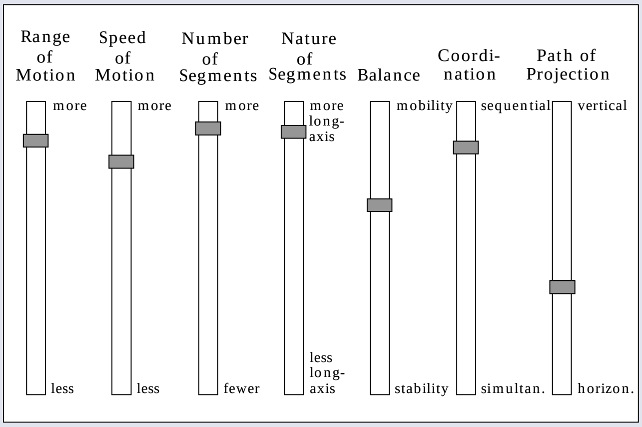
Paradigm

The first feature of the paradigm concerns the questions we ask. In general, we ask one of three questions ranging from applied to basic: (1) How do people move better? (2) How do better (i.e., more skillful or safer) people move? (3) How do people move? Ideally the information we use at the applied level is connected to and grounded on solid information at the other levels. Unfortunately our research literature on these questions is relatively weak and spotty. As a consequence, when we consider how people move better or how better people move, I believe that most of us tend to rely on intuitive and informal knowledge rather than on formal knowledge based on research. Thus each of us may be using individually constructed models of expertise to inform our decisions.

The second feature of the paradigm pertains to our conceptualization of skillfulness. I choose to represent skillfulness on a continuum, with nominal skill at the low end and optimal skill at the high end. The problem comes when we lack a coherent model of skill beneath the expert level and therefore can only recommend the expert's technique.

The third feature of the paradigm consists of the following components: the force field, the mover, and the movement. We can take the narrow, physical view of forces (e.g., gravity) and movers (e.g., muscles). Or we can take a broader view of forces (e.g., society) and movers (e.g., mental states). With these components we can highlight either cause or effect. That is, the force field and the mover interact to cause movement, and

Figure 1. Movement Mixing Board with Core Concepts as Sliders



the movement can have either a beneficial or a detrimental effect on the mover. Allowing for individual differences, we can say that the movement we see emerges from the specific context of a given mover in a given force field.

The fourth feature of the paradigm of applied biomechanics is the union between theory and practice. With theory we are able to make generic predictions of what will happen in various scenarios. In practice we are able to make specific observations, suggested by theory, that lead to interpretation and action. Although it cannot be presented here, I will be using an applied theoretical model that links the purposes of movement with specific observations. In this model the purposes are based on the magnitude, direction, and point of application of force. For example, the amount of force that is needed can range from submaximal to maximal. In addition, more force is needed to move a heavy object or body compared to a light object or body segment. As for direction of force, an object can be projected vertically or horizontally or in between. Also, the stability or mobility of a body is related to the direction of force.

The observation scheme in this model is based on 10 core concepts (Hudson, 1995). From what I can tell, these concepts seem to arise naturally for most people from our experiences as embodied movers. Moreover these concepts apply to a greater or lesser extent to essentially all forms of movement. Once these concepts are brought to the foreground of consciousness, my students and I have found them to be quite powerful. In fact, these concepts are the thread that links the various features of the paradigm of applied biomechanics.

The core concepts are range of motion, speed of motion, number of segments, nature of segments (e.g., plane of movement), balance, coordination, extension at release/contact, compactness, path of projection, and spin. The first six concepts apply to virtually every gross human movement. The other four are more apt to apply when there is a projectile.

As we observe a particular mover, we can make qualitative or quantitative measurements for each relevant concept. Let us use a visual metaphor of a musician's mixing board to help us keep track of our assessments. The mixing board consists of several "sliders," with each slider representing a particular attribute of music. As illustrated in figure 1, we can convert the mixing board from music to movement and represent each core concept with a slider. The position of each slider indicates quality or quantity. Once we have made our observations and set our sliders for a particular mover, we can compare the pattern of sliders with those of an expert (i.e., a better mover). Then, depending on where our mover ranks on the skill or safety continuum, we can recommend a change on a selected core concept.

What pattern of sliders would we predict for an expert who is throwing a light object (e.g., a baseball) maximally? We would expect to observe near maximal range and speed of motion and number of segments, long-axis rotation, substantial forward weight shift (i.e., more mobility than stability in balance), and sequential coordination. However, if the object were heavier (e.g., a football), we would expect each of these sliders to move down just a fraction.

Analysis

Now let us look at three students as they throw a football pass. A tall boy is seen in figure 2a. From the tracing of the path of the ball, we can see that he has used a relatively large range of motion during the propulsive phase of the throw. In addition, he stepped into the throw (i.e., he used his legs to increase the number of segments, and he shifted his weight to gain mobility with his balance). The tall boy also demonstrated quite a bit of long-axis rotation (which exemplifies the nature of segmental usage) in his trunk and right arm. He used a reasonably sequential pattern of coordination by stepping, then turning his trunk, then rotating his arm. All of these factors helped him generate speed on the ball, though he seemed to be throwing with somewhat less than maximum speed. The path of projection of the ball was about 30 degrees. The mixing board version of his throw appears in figure 1.

A stout boy is shown in figure 2b. In contrast to the tall boy, he used less range of motion, less trunk rotation, and less medial (i.e., long-axis) rotation of the arm. He did use his legs to some extent as he shifted his weight. In general, he looked like he "pushed" the ball more than "threw" it; this is an indication of a somewhat more simultaneous coordination pattern. The speed of his segmental actions and the speed of the ball were less than that of the tall boy. Notice how close to horizontal the path of the ball is before release. The path of projection of the ball after release was about 15 degrees.

A short girl is depicted in figure 2c. She is similar to the stout boy in her number of segments and balance, but she used less long-axis rotation and range of motion. Her coordination pattern was simple but mostly sequential. She generated about 10 percent less speed than the stout boy, but this may be more related to size than technique.

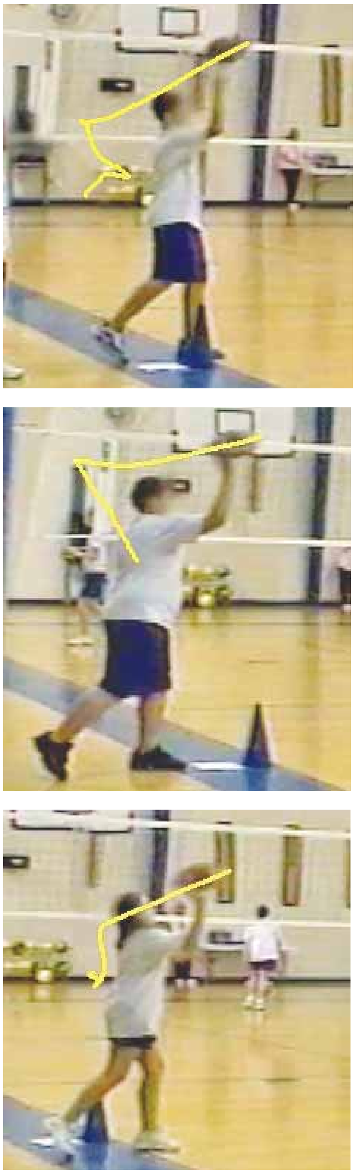
In figure 3 we see a thin girl who is running. Do you notice anything about her right leg? She seems to have excessive

Figure 2. Students A, B, and C at the Point of Ball Release

A

B

C



The tracing represents the path of the ball before release.

Figure 3. Excessive Long-Axis Rotation

The girl on the right has excessive long-axis rotation in her right leg

long-axis rotation during the swing and the weight-bearing phases of the run. The latter is what we call pronation, and it is an invitation to injury.

Application

Now we can make some interpretations from our observations. In general, most throwers demonstrated less-than-expert core concepts compared to what we would expect in a near-maximal activity. There are a few reasons besides basic lack of skill that could account for this. For example, even an expert will move a few sliders down when the situation is relatively submaximal. When accuracy is important, the tendency is to be more conservative and move some sliders down. The need for safety is also a good reason to move some sliders down.

In this instructional setting, the receivers were not too far away, and there was a premium on accuracy. Thus it is not surprising that each student demonstrated reduced usage of some core concepts. What we cannot tell, however, is whether this reduced usage was due to the context or due to a shortage of skill. Could these students, in different circumstances, incorporate substantial long-axis rotation and sequential coordination while moving with near-maximal speed?

As for actions, we usually ask, “Which core concept is the best point for intervention?” In this case it would be helpful to see some near-maximal throws before deciding where improvements in movement are most likely to occur. Nevertheless, for each of these students, long-axis rotation will be key at some point. Long-axis rotation is necessary for speed and skill in the relatively light, fast activity of passing a football. However, long-axis rotation is associated with injury when it is used inappropriately.

Once we have established a potential core concept for intervention, we must decide which direction to move the slider (i.e., whether to recommend more or less of that concept to the mover). In the present examples, the throwers could use more long-axis rotation, and the runner could use less.

Then, after deciding what change is desirable, we must choose what to say to the mover to elicit that change. Often a simple modification in the context of movement is all that is necessary. For example, having the receivers run deeper routes might elicit more skillful throws with more long-axis rotation.

Reference

Hudson, J. L. (1995). Core concepts of kinesiology. *Journal of Physical Education, Recreation & Dance*, *66*(5), 54-55, 59-60.

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