INTRODUCTION TO THE STUDY OF KINESIOLOGY

OUTLINE

- The Nature of Kinesiology
  - The SEE Principle
  - Methods of Study
- Components of a Kinesiological Analysis
  - Description of the Motor Skill
  - Anatomical Analysis
  - Mechanical Analysis
  - Prescription for Improvement of Performance
- Laboratory Experiences

OBJECTIVES

At the conclusion of this chapter, the student should be able to:

1. Define kinesiology and explain its importance to the student of human motion.
2. Describe the major components of a kinesiological analysis.
3. Prepare a description of a selected motor skill, breaking it down into component phases and identifying starting and ending points.
4. Determine the simultaneous-sequential nature of a variety of movement skills.
5. Classify motor skills using the classification system presented.
6. State the mechanical purpose of a variety of movement skills.

THE NATURE OF KINESIOLOGY

Kinesiology, as it is known in physical education, athletic training, physical therapy, orthopedics, and physical medicine, is the study of human movement from the point of view of the physical sciences. The study of the human body as a machine for the performance of work has its foundations in three major areas of study—namely, mechanics, anatomy, and physiology; more specifically, biomechanics, musculoskeletal anatomy, and neuromuscular physiology. The accumulated knowledge of these three fields forms the foundation for the study of human movement.

Some authorities refer to kinesiology as a science in its own right; others claim that it should be called a study rather than a true science because the principles on which it is based are derived from basic sciences such as anatomy, physiology, and physics. In any event, its unique contribution is that it selects from many sciences those principles that are pertinent to human motion and systematizes their application. However it may be categorized, to the inquiring student it is a door opening into a whole new world of discovery and appreciation. Human motion, which most of us have taken for granted all our lives, is seen through new eyes. One who gives it any thought whatever cannot help being impressed not only by the beauty of human motion but also by its apparently infinite possibilities, its meaningfulness, its orderliness, its adaptability to the surrounding environment. Nothing is haphazard; nothing is left to chance. Every structure that participates in the movements of the body does so according to physical and physiological principles. The student of kinesiology, like the student of anatomy, physiology, psychology, genetics, and other biological sciences, can only look with wonder at the intricate mechanism of the body.

The SEE Principle

Kinesiology is not studied merely to incite our interest in a fascinating and mysterious subject. It has a useful purpose. We study kinesiology to improve performance by learning how to analyze the movements of the human body and to discover their underlying principles. The study of kinesiology is an essential part of the educational experience of students of physical education, dance, sport, and physical medicine. Knowledge of kinesiology has a threefold purpose for practitioners in any of these fields. It should enable them to help their students or clients perform with optimum safety, effectiveness, and efficiency (SEE). Safety is becoming a greater concern of all movement professionals. It is imperative to structure the movements of students or clients to avoid doing harm to the body. At the same time, both the educator and the therapist set goals for effective performance. We judge the effectiveness
of a performance by success or failure in meeting those goals. And in producing an effective performance, the movement specialist also strives with the student or client to achieve the movement goal with the least amount of effort, as efficiently as possible. Safety, effectiveness, and efficiency, then, are the underlying aims in all of our uses of kinesiology for the analysis and modification of human movement.

Kinesiology helps prepare physical educators, coaches, and fitness professionals to teach effective performance in both fundamental and specialized motor skills. Furthermore, it enables them to evaluate exercises and activities from the point of view of their effect on the human structure. The human body improves with use (within limits), provided it is used in accordance with the principles of efficient human motion. The function of kinesiology in physical education, therefore, is to contribute not only to successful participation in various physical activities but also to the improvement of the human structure through the intelligent selection of activities and the efficient use of the body.

The physical or occupational therapist and the athletic trainer are primarily concerned with the effect that exercises and other techniques of physical medicine have on the body. He or she is concerned particularly with the restoration of impaired function and with methods of compensating for lost function. Although effective performance remains a primary goal, to the therapist “effective performance” refers not so much to skillful performance in athletic activities as to adequate performance in the activities associated with daily living. Whereas the educator applies knowledge of kinesiology chiefly to the movements of the normal body, the therapist is concerned with the movements of a body that has suffered an impairment in function.

Methods of Study

Once the study of kinesiology is begun, one of the most satisfactory ways of proceeding is by supplementing book study with laboratory experimentation. It is a truism that we learn best by doing. Laboratory experiences should include two types of activity. The first type consists of experiments performed under controlled conditions. Activities in this category are selected to help the student gain insight into and understand the nature and complexity of human motion. Although the emphasis is primarily on qualitative analysis in beginning study, some quantification of data is appropriate, as is the use of “laboratory type” instruments. Especially useful is the video recorder, whose use enables the careful and prolonged study of a very small moment in the performance of a technique and permits the observation of detail unavailable to the naked eye. In more advanced study, the use of advanced measurement methodology and more advanced electronic equipment such as electromyography, force-sensing instruments, and computer simulation are common. As these technologies become more sophisticated, so does our ability to use them to increase the depth of our knowledge and understanding of human motion.

The second type of laboratory experience should consist of practice in analysis under the conditions that exist every day in the gymnasium or clinic. Only through practice under these conditions will the student learn how to apply a knowledge of kinesiology and develop the qualitative skills necessary for accurate observation, diagnosis, and treatment of faulty motor performance.

Whatever method of teaching or study is employed, the student should keep in mind the aims of kinesiology study and the intended applications for what will be learned. The analysis of motion is not an end in itself but rather a means of learning new movement patterns and improving the safety, effectiveness, and efficiency of old ones. This is as true for the physical therapist teaching amputees and paraplegics to walk again as it is for the physical educator teaching a sport technique. Finally, it must be remembered that the skill itself is of less importance than the one who practices it. Kinesiology serves only half its purpose when it provides information of value for learning or teaching motor skills. It must also serve
to lay the foundation for perfecting, repairing, and keeping in good condition that incomparable mechanism—the human body.

COMPONENTS OF A KINESIOLOGICAL ANALYSIS

In any formal field of study, the task of analysis must proceed along a logical and structured plan. This plan must be constructed so that it is both appropriate to the activity and can be readily applied by the practitioner. The teacher, therapist, trainer, athlete, and coach all benefit from knowing how to conduct a kinesiological analysis of a motor skill. The teaching of motor skills, whether it takes place in the clinic, in the fitness facility, or on the playing field, consists of presenting a skill and knowing what points to emphasize. It also largely consists of diagnosing difficulties, correcting errors, and eliminating actions that limit performance. The specialist in motor skills must also be aware of the types of injuries that are likely to occur during a particular activity and how to prevent them. To accurately prescribe the movements necessary for rehabilitation, the therapist or trainer must know joint structure and exercise tolerances. An athlete in training must understand the kinesiological factors involved in performance to optimize training effects while guarding against deleterious actions. These tasks that, on the surface, may seem simple can indeed be quite complex, if for no other reason than that motor skills themselves are complex. An effective aid in helping one understand the basic elements and requirements of a motor skill is a systematic kinesiological analysis.

The tools needed for the execution of a detailed kinesiological analysis are introduced in subsequent chapters. The anatomical components of human movements—the bones, joints, muscles, and related portions of the nervous system—and the mechanical portions of the nervous system—and the mechanical bases for human motion are presented. The basic movements of the body segments are described, and it is shown how the observation of both anatomical and mechanical principles contributes to the efficient use of the body in the performance of motor skills. A kinesiological analysis is the application of this information to assessing the effectiveness of a given motor performance. It consists of

1. describing a skill in a logical and systematic fashion by breaking it down into its constituent elements;
2. evaluating the performance of the skill by determining whether and how the related anatomical and mechanical principles have been violated; and
3. prescribing corrections based on an appropriate identification of the cause or causes.

The basic components for the kinesiological analysis of a motor skill are outlined in Table 1.1. In this type of analysis the emphasis is on a qualitative assessment of the performance, which may be conducted with the assistance of videotapes, digital images, or the naked eye. In any case, the analyst must use a systematic approach in the observation of the performance. Have someone demonstrate the movement to be analyzed both before and at frequent intervals throughout the analysis. In lieu of this, a video or digital recording is an excellent substitute. If this is not available, a series of still shots or even a single photograph or sketch is helpful. In the initial stages of learning analysis procedures, movement may appear rapid and confusing. With the aid of recording equipment and with much practice, the analyst will gain the skills required for an accurate and systematic approach to observation.

Description of the Motor Skill

The description of the motor skill being analyzed consists of four elements that together help the analyst focus on the essential nature of the skill.

Primary Purpose of a Motor Skill

The first step in the description phase of the analysis is to identify the primary purpose of the movement. Without a clear understanding of why the movement is being performed, it is
TABLE 1.1 Outline for a Kinesiological Analysis

<table>
<thead>
<tr>
<th>A. Description of the motor skill performance</th>
</tr>
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<tbody>
<tr>
<td>1. Primary purpose of the skill</td>
</tr>
<tr>
<td>2. Movement phases</td>
</tr>
<tr>
<td>3. Classification of the skill</td>
</tr>
<tr>
<td>4. Simultaneous-sequential nature of the motion</td>
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</tbody>
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<table>
<thead>
<tr>
<th>B. Anatomical analysis</th>
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</thead>
<tbody>
<tr>
<td>1. Joint actions and segment motions</td>
</tr>
<tr>
<td>2. Muscle participation and form of contraction</td>
</tr>
<tr>
<td>3. Neuromuscular considerations</td>
</tr>
<tr>
<td>4. Anatomical principles related to effective and safe performance</td>
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<tr>
<th>C. Mechanical analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Underlying mechanics objective(s)</td>
</tr>
<tr>
<td>2. Nature of forces causing or impeding motion</td>
</tr>
<tr>
<td>3. Identify the critical elements</td>
</tr>
<tr>
<td>4. Mechanical principles that apply concerning</td>
</tr>
<tr>
<td>a. safety</td>
</tr>
<tr>
<td>b. effectiveness</td>
</tr>
<tr>
<td>c. efficiency</td>
</tr>
<tr>
<td>5. Identification of errors</td>
</tr>
<tr>
<td>a. What are the errors?</td>
</tr>
<tr>
<td>b. What are the sources of error?</td>
</tr>
<tr>
<td>D. Prescriptions for improvement of performance</td>
</tr>
<tr>
<td>indicate how the performance should be</td>
</tr>
<tr>
<td>changed so that the principles are no longer</td>
</tr>
<tr>
<td>violated.</td>
</tr>
</tbody>
</table>

virtually impossible to evaluate its effectiveness. In this statement of purpose, applicable references to speed, accuracy, form, and distance should be included. For example, the purpose of the 50-meter backstroke is to cover the course in the shortest amount of time. Speed is a major factor. The purpose of swinging an ax is to split a piece of wood. Both speed and accuracy are critical elements if the wood is to be safely split into kindling. The purpose of the springboard dive is to execute the motion according to a prescribed form. Neither speed nor accuracy is stressed; success is measured on appearance alone. The purpose of putting in golf is to sink the ball into the cup from a relatively short distance away. The prime determinant of success in putting is accuracy (Figure 1.1).

Movement Phases
It is often beneficial to break down a motion into separate parts, or “phases.” Often these phases are fairly obvious, based on the motion. For example, a throw has a windup phase, a throwing phase where the arm comes forward, and a follow-through phase after release (Figure 1.2). In some skills, the phases are not as obvious; but to make the analysis manageable, some sort of division should be made.

It is critical that the appropriate starting and ending points for each phase be identified. Two primary factors must be considered in the choice of starting point. The first factor is to consider when in the motion the analysis should begin. Many movement skills are discrete; that is, they have a very definite beginning and ending. In such movements the starting point for analysis is fairly obvious—at the beginning of the first phase—as in a throwing skill, which starts with the windup. Other skills are more continuous in nature, either because they are done in a repetitive manner or because one movement flows immediately into the next. Walking is a good example of a cyclical skill, whereas many team sports include movements that change constantly.

In a continuous movement situation, the analyst must carefully choose a starting point that will give adequate information about the movement of interest while not ignoring the resultant effects of the previous movement. In walking, many analysts start the first phase of the analysis as the toe leaves the ground and end the last phase when that same toe is about to leave the ground in the next step cycle; others start the phase as the heel strikes the floor and end with the subsequent heel strike.

Classification of the Motor Skills
Motor skills take many forms and are used for many purposes. The therapist is interested in
using physical skills and exercise to rehabilitate individuals for independent living or work; the teacher uses motor skills for health, learning, and play; the athlete and coach strive to produce near-perfect performance. Each practitioner requires an understanding of the body and mechanical laws that govern motion. A classification scheme is important because it permits the variety of potential movement skills to be organized into a manageable grouping. This manner of organization facilitates the recognition of commonalities across movements. It also fosters increased understanding by enabling one to focus on either differences or similarities in movement patterns, as the situation demands. Classification of movement patterns and skills provides further clues as to the nature of both the anatomical and mechanical requirements of a particular group of skills.

The following system for classifying motor skills takes into account the objective of the skill, the medium in which the skill occurs, and the nature of the motion.

Classification of Motor Skill Patterns
I. Maintaining erect posture
II. Movement for exercise and fitness

Figure 1.1  Examples of the primary purpose of a motion: (a) maximum speed; (b) following a prescribed pattern; (c) optimum speed and accuracy; (d) maximum accuracy.
III. Giving motion
   A. To external objects
      1. Pushing and pulling
         a. Lifting and carrying
         b. Punching
      2. Throwing, striking, and kicking
         A. Supported by the ground or other resistant surface
            a. Locomotion on foot
            b. Locomotion on wheels, blades, and runners
            c. Rotary locomotion
         B. Suspended and free of support
            a. Swinging activities on trapeze, flying rings, or similar equipment
            b. Hand traveling on traveling rings or horizontal ladder
            c. Unsupported (i.e., projected into or falling through the air)
            d. Weightlessness
   3. Supported by water
      a. Swimming
      b. Aquatic stunts
      c. Boating

IV. Receiving impact
   A. From one’s own body in landing from a jump or fall
   B. From external objects in catching, trapping, spotting, or intercepting

The four major headings in this outline are maintaining erect posture, movement for exercise and fitness, giving motion, and receiving impact. Some may question the reason for treating the maintenance of erect posture as a major category instead of including it under giving motion to one’s own body. The rationale for this decision is that the emphasis here is on adjusting to the immediate environment rather than on making a movement in the sense that one usually interprets this concept. With one exception, the adjustments are made from a stationary position, the exception...
being a shift in stance necessitated by standing on a moving base. This action does not involve moving from one place to another but only widening the stance and facing in a different direction to maintain balance. The erect posture then becomes the foundation and starting point for subsequent dynamic postures and motions.

The initial step in the classification of movement is to determine in which major category the skill belongs, and then in which secondary, and possibly tertiary, category. A forehand drive in tennis, for instance, belongs in the primary category of giving motion to an external object and in the secondary one of striking. Turning a cartwheel is a form of giving motion to one’s own body while it is supported by the ground and is classified further as rotary locomotion.

In addition to pinpointing the exact categories to which the skill belongs, a number of other factors should be considered. Many skills consist of a series of phases that cut across different categories, and these must be considered separately. The tennis serve, like the forehand drive, is a form of striking; but it also involves tossing the ball, a push pattern skill that should not be overlooked.

Vaults over a gymnastic box or horse consist of the approach, the placement of the hands, the momentary support by the hands, and the push-off from the box. This phase is followed by the projection of the body, together with the necessary adjustments of the bodily segments, and finally by the landing, which involves movements of the upper extremities and trunk as well as of the lower extremities. In pole vaulting and rock climbing, there is a smooth transition from pulling to pushing. In hurdling, repeated alternation occurs between the run and the hurdles with no break in rhythm. In many basketball shots for the basket, the shot is accompanied by a jump. All phases of the skill should be included in the analysis.

In many skills, especially those involving either the giving or the receiving of a force of appreciable magnitude, the ability to maintain balance is an all-important feature. Maintaining balance effectively means observing the principles of balance and posture adjustment as well as those relating to the specific form of giving motion or receiving impact. Lifting a heavy weight from the floor or down from a shelf is a good example of a motion-giving activity whose effectiveness depends largely on the maintenance of a posture that favors lifting.

The standing long jump shown in Figure 1.3 is a skill that belongs in the major category of giving motion to one’s own body. The initial phases before the takeoff, landing, and recovery phases belong in the secondary category of movement on a solid base, whereas the flight phase is an activity of the unsupported category.

**Simultaneous-Sequential Nature of the Motion**

Because it is comprised of joints and levers, the body can move in a wonderful variety of ways. To simplify the complexities of such a wide range of possibilities, it is important to understand that when motions are combined, bodily movements may be classified as occurring on a continuum ranging from the simultaneous to the sequential use of the body segments. The simultaneous use of the body segments, where the various segments move as one, is exemplified by motions such as pushing, pulling, or lifting objects. In a simultaneous movement pattern, all of the movement is directed along a straight line. Simultaneous use of body segments is the only way it is anatomically possible to move the hand or foot in a straight line. This straight-line application of force by the hand or foot is the most advantageous method to use when overcoming heavy or large objects or external forces such as those encountered in pushing file cabinets and lifting weights. In addition, when accuracy is important, such as in putting in golf, lunging in fencing (movement of the arm and weapon), and punching, it is more effective to involve the segments in a simultaneous fashion.

When it is important to have maximum speed at impact or release, a sequential use of the body segments is appropriate. The use of the segments in an orderly sequence so that subsequent segments are accelerated at the appropriate time
to create the highest possible speed is critical in activities exemplified by throwing, striking movements such as batting or the golf drive, and kicking. Sequential movements produce forces applied so that the final segment moves along a curved path. The farther this curved path is from the center of the motion, the greater will be the speed of the throwing, striking, or kicking segment.

Motions may occur anywhere along this simultaneous-sequential continuum, or they may combine the two basic forms (Figure 1.4). The skill of putting the shot, for example, involves the sequential use of the lower extremities and trunk followed by the simultaneous use of the upper extremity to safely move the relatively large weight of the shot. For our purposes, simultaneous motions and those combination motions that occur at the simultaneous end of the continuum are classified as push-pull motions, and those at the other end, the sequential end, are classified as throwing, striking, and kicking patterns.

To clarify the nature of the motion at any given point in the performance, it is desirable to break down the total movement into phases for analysis. Using the standing long jump (see Figure 1.3) as an example, an analysis of the nature of the motion might be as follows:

1. Preparatory phase—simultaneous motion of the joints of the lower extremity, into a semi-squat position
2. Execution (force) phase—simultaneous extension of the segments in a forward-upward direction
3. Flight (unsupported) phase—sequential motion of the lower body to “whip” the legs forward
4. Landing phase—simultaneous flexion of the lower extremity to take up the shock of the landing forces

Having now described the motor skill by clarifying the primary purpose, classifying the skill, and establishing the simultaneous-sequential nature of the skill, analysis of the performance is the next, and critical, step. In evaluating the motion from the starting point, the analyst must then consider to what extent the performer conforms to the anatomical and mechanical requirements necessary to achieve the stated purpose of the motion. Failure to perform in accordance with the principles that govern motion will produce a less than optimal performance. For this reason, the analyst should be conversant with the anatomical and mechanical principles that are critical for the movement skill in question.

Anatomical Analysis

The anatomical analysis of a movement should include an examination of the skeletal joint action, a description of segment motion, an account of the muscle participation, and an identification of the neuromuscular mechanisms involved. Anatomical analysis involves analysis of a process rather than a product. That is, it is a review of how the body accomplishes the task rather than an in-depth examination of the results. It should attempt to give specific answers to the following questions:

1. Which joints are involved, and what are their exact movements in the motor skill?
   For each phase of the technique and for each joint participating in the phase, the precise joint action and segment being moved should be identified and recorded, as was done for the sample analysis of the force phase of the standing long jump shown in Table 1.2.
2. Are any of the joints used to the limit of their range of motion?
3. Which muscles are responsible for the joint actions, and what is the nature of their contraction?
   The muscular action is identified for each joint movement and recorded next to the joint actions in Table 1.2. This implies identifying not only the muscles that are contracting but also their precise function in the movement and the kind of contraction they are undergoing. Identification of the force causing the motion facilitates the subsequent identification of the muscle and type of contraction involved.
4. Which neuromuscular mechanisms are likely to help or hinder the action, and what is the nature of their involvement?
<table>
<thead>
<tr>
<th>Name of Joint</th>
<th>Starting Position</th>
<th>Observed Joint Action</th>
<th>Segment Being Moved</th>
<th>Force for Movement</th>
<th>Main Muscle Groups Active</th>
<th>Kind of Contraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metatarso-phalangeal</td>
<td>Extended</td>
<td>Hyperextension/flexion</td>
<td>Foot</td>
<td>Muscle</td>
<td>Extensors/flexors</td>
<td>Concentric</td>
</tr>
<tr>
<td>Ankle</td>
<td>Dorsiflexed</td>
<td>Plantar flexion</td>
<td>Lower leg</td>
<td>Muscle</td>
<td>Plantar flexors</td>
<td>Concentric</td>
</tr>
<tr>
<td>Knee</td>
<td>Flexed</td>
<td>Extension</td>
<td>Thighs</td>
<td>Muscle</td>
<td>Extensors</td>
<td>Concentric</td>
</tr>
<tr>
<td>Hip</td>
<td>Flexed</td>
<td>Extension</td>
<td>Pelvis</td>
<td>Muscle</td>
<td>Extensors</td>
<td>Concentric</td>
</tr>
<tr>
<td>Pelvis</td>
<td>Decreased tilt</td>
<td>Increased tilt</td>
<td>Trunk</td>
<td>Muscle</td>
<td>Spinal extensors</td>
<td>Concentric</td>
</tr>
<tr>
<td>Lumbar spine</td>
<td>Flexion</td>
<td>Extension</td>
<td>Trunk</td>
<td>Muscle</td>
<td>Spinal extensors</td>
<td>Concentric</td>
</tr>
<tr>
<td>Thoracic spine</td>
<td>Slight flexion</td>
<td>Extension</td>
<td>Trunk</td>
<td>Muscle</td>
<td>Spinal flexors</td>
<td>Concentric</td>
</tr>
<tr>
<td>Cervical spine</td>
<td>Hyperextended</td>
<td>Flexion</td>
<td>Neck</td>
<td>Muscle</td>
<td>Upward rotators</td>
<td>Concentric</td>
</tr>
<tr>
<td>Shoulder girdle</td>
<td>Upward tilt</td>
<td>Upward rotation, abduction</td>
<td>Shoulder girdle</td>
<td>Muscle</td>
<td>Abductors</td>
<td>Concentric</td>
</tr>
<tr>
<td>Shoulder joint</td>
<td>Hyperextension,</td>
<td>Flexion</td>
<td>Upper extremity</td>
<td>Muscle</td>
<td>Flexors</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>medial rotation</td>
<td>—</td>
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<td>—</td>
</tr>
<tr>
<td>Elbow</td>
<td>Extended</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Extensors</td>
<td>Static</td>
</tr>
<tr>
<td>Radioulnar</td>
<td>Pronated</td>
<td>—</td>
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<td>—</td>
</tr>
<tr>
<td>Wrist</td>
<td>Extended</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Extensors</td>
<td>Static</td>
</tr>
<tr>
<td>Phalanges</td>
<td>Extended</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Extensors</td>
<td>Static</td>
</tr>
</tbody>
</table>

The muscle-response patterns of well-learned motor skills involve the integrated action of many reflexes and the inhibition of others. After repeated viewing of the performance “live” or on a recording, the student should name and discuss the reflexes that could be acting at various points in each phase.

5. Which anatomical principles contribute to maximal efficiency and accuracy in the performance of the motor skill?

6. Which principles are directly related to the avoidance of injury?

In any analysis, a set of anatomical principles governing the safe and effective performance of the movement skill must be considered. These principles take into account the structure and function of the human body, human tolerance of both internal and external stresses, and the efficiency of movement patterns. Hudson (1995) has also suggested that it is critical to examine such core concepts as range of motion, the number of body parts involved, the nature of the body parts involved, and the coordination of the movement. In addition, it is important to look at the alignment of the body and the reflexes that might be utilized. Anatomical principles of motion then stipulate the way in which each of these core concepts apply to a specific movement. In particular, anatomical principles speak to the qualities associated with each of these concepts.

**Mechanical Analysis**

In performing a mechanical analysis of a motor skill, the human body is often viewed as a “machine,” subject to the same laws and mechanical principles that govern the actions of any other machine. The mechanical analysis of human performance involves the identification of laws and principles that help explain the most appropriate form for the execution of the activity and identify the mechanical reasons for success or failure.

To assess the mechanical nature of a technique and use this information in helping performers choose movements that will result in skillful motion, the analyzer should attempt to identify those principles and laws that verify the actions as desirable. Once the movement is classified according to an outline such as that on pages 6-7, the analyst should determine exactly how and when the movements of the performance do or do not satisfy the standards of good performance as explained by the laws and principles of mechanics. Once this process is accomplished, a greater depth of understanding of the skill is achieved, and the basis for making change is founded on sound knowledge and understanding of the reasons “why.”

**Underlying Mechanics Objective**

To explain the mechanical factors that contribute most to performance, it is first necessary to define clearly the purpose or objective of the motion involved. The focus of the statement of mechanical objective will be on the desired outcome of the motion, which is necessary to measure effectiveness. Several systems have been proposed for the classification of mechanical objectives of human movement. A synthesis of many of those systems is presented here as a simplified set of objectives.

The underlying objective of a motion may be

1. Balance
   a. Regain stability
   b. Attain mobility

2. Locomotion
   a. Travel from point to point
   b. Travel a prescribed distance
   c. Travel a prescribed pattern

3. Projection
   a. For maximum height
   b. For maximum range
   c. For maximum accuracy
   d. For optimum speed and accuracy

4. Manipulation
   a. Of objects
   b. To reproduce a pattern
   c. Of a resistance
CHAPTER 1  Introduction to the Study of Kinesiology

5. Maximum effort
   a. Maximum speed
   b. Maximum power
   c. Maximum force

Each of these underlying mechanical objectives requires consideration of different but overlapping sets of mechanical factors. The standing long jump, for instance, has the underlying mechanical objective of projection of the body for maximum range (distance). The question now becomes one of determining what must be done in mechanical terms to produce the maximum distance. Because the distance traveled is in the air, the body becomes a projectile, and those factors that cause the projectile to travel the farthest are those that must be considered.

Nature of the Forces Causing or Impeding Motion

To accurately analyze the efficiency with which a motor skill is performed, the analyst must be aware of the kind of motion being performed (classification and simultaneous-sequential nature) and the forces that are acting to cause, modify, or prevent that motion. Pushing and pulling forces, weight and resistance, and twisting and turning forces must all be identified and their effects noted. Muscle force applied through the joints' range of motion to propel the body through the air for maximum distance is a force-causing motion. A force-resisting motion is the resistance force offered by the weight of the jumper. Impact with the ground at the end of the jump will produce a force-stopping motion. Other impeding forces might be produced by lack of strength or limited range of motion.

Identification of Critical Elements

Knowing what to examine and what to measure is an important part of any kinesiological analysis. In every motor skill, there is a set of critical elements. The elements of the movement that contribute most to safety, effectiveness, and efficiency need to be identified so that appropriate attention may be given to them. The critical elements of a motor skill are very dependent upon the mechanical purpose of the motion. As an example, in the overhand throw the mechanical purpose may be projection for maximum distance. The initial critical element, therefore, would be the velocity of the ball at release. As we learn later in this text, velocity includes both the speed of the ball at release and the angle at which it is thrown. These two factors determine where the ball goes. Once this primary critical element has been identified, the analyst must then determine what is critical in developing this primary element. In the throw example, we should recognize that the push off the ground, the rotation of the left hip, the speed of arm motion, the range of motion used, and the adequate transfer of momentum are all critical elements of the performance.

Mechanical Principles

Identification of the mechanical principles related to the execution of the skill is the next step in establishing causes of error in the performance of the skill. Safety, effectiveness, and efficiency must be dealt with at this point. It is important that the student recognize how the application of forces affects each aspect of the SEE principle. Which forces are likely to produce injury if applied incorrectly? How much or how little force in what direction will produce the desired result? What must be done to ensure that there is no wasted motion?

The critical elements identified in the previous step will help determine the mechanical principles that apply to a given motor skill. In fact, critical elements and mechanical principles are highly interdependent and should be examined together. Focusing on these principles and how they relate to the skill suggests the potential sources of error. Each movement phase must be considered in turn. The core concepts from which these principles are derived include considerations of the speed of the movement, the forces involved in the movement, balance, direction, and timing, and the pressure of
air or water. If the motion involves projecting something into the air, the concepts of extension at release (or contact), path of the object, and spin must also be considered. Once again, the primary concern is the quality of each of these factors that is required for an optimum performance. In deriving mechanical principles, one might discuss how much speed or how much force, as well as the direction of the force. It might become important to know how much air pressure is acting or what angle produces the best path of a thrown object.

**Identification of Errors**

Diagnosing the cause of an error is difficult because the cause may be far removed from the observed effect. The purpose in identifying the mechanical principles is to locate potential sources for error. Given the purpose of the skill, which of the principles, if violated, has the greatest potential for limiting performance? How? These are the most troublesome questions to answer. Without quantitative data, it is difficult to make any selection with certainty. And even with the support of such data, which indeed can provide us with much useful information, we still cannot be certain. At this time, no general method is available to identify and establish the order of importance for those factors that limit performance. One must rely primarily on knowledge of the technique and the principles of mechanics that apply.

As a general rule, it is probably most beneficial to start seeking sources of error at that point where the initial force is applied. In most movements on land, this point is where the feet are in contact with the ground. To produce a motion, it is usually necessary to push against the ground. This initial push contributes greatly to the force developed in the motion. It is wise to focus the attention here first rather than at the end point of the sum total of all the segmental movements that are taking place.

Again, using the example of the standing long jump, we know that speed and direction are the two most important factors in performance. The direction is governed by the direction of the jumper's takeoff. It appears, then, that this takeoff might be the best place to start. The speed and direction of the jump depend on the speed, force, and direction of the push against the ground. The faster the legs can move, the greater will be the push off the ground.

**Prescription for Improvement of Performance**

After the performance has been described in anatomical and mechanical detail and the causes for error have been identified, the analyst must decide on the appropriate strategy for effecting change in the performance so that it conforms to the anatomical and mechanical ideal. Now the analyst becomes an instructor who must decide not only what must be done, but how best to communicate that information to the performer in a manner that makes sense. The task is like that of a physician who uses vast medical knowledge to prescribe bed rest as the best cure for an ailment. The cure may be simple, but the complexities attached to knowing what to do, and why, and then making that information understandable to the patient are far from simple. The instructor of motor skills needs to develop ability as a prescriber as well as an analyst. Both talents will improve with practice. As more systematic analyses are performed, the analyst becomes aware of characteristics common to groups of skills. Common errors and their causes will emerge for related skills as well as similar or common prescriptions appropriate for correcting the errors. The important thing to remember is to concentrate on the causes of errors, not on the resultant symptoms. Before the physician can prescribe for a limping gait, the cause must be known and the viable options for treatment identified. Before an instructor of motor skills can prescribe for improvement of a standing long jump or any other motor performance, the cause(s) for the error must be known and the valid options for correction determined.
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