An introduction to kinesiology

ASSIGN BUSTER

In this chapter, basic kinesiology definitions are introduced and problem-solving approaches in kinesiology tasks are classified as quantitative or qualitative movement analysis.

Definition: Derived from the Greek word “ kinesis” meaning motion and the suffix

-ology or -logy from the Greek “ logos” or “ logia” (meaning field of study). It is the scientific study of the anatomy, physiology, and mechanics of body movement.

Introduction to Kinesiology

You might think that kinesiology is a modern day science, however, you will find out in this text that the practice, study and application of kinesiology can be traced back thousands of years to ancient Roman times. In fact, many aspects of physical movement training are documented in chariot races and gladiator fights, where fighters trained and chose between different weapons, wheel sizes etc. Throughout history, particular in wars there are abundant examples of the use of kinesiology to improve fighting, fitness and protection.

Kinesiology encompasses human anatomy, physiology, biomechanics, exercise physiology, exercise psychology and sociology, history, and philosophy of sport. Kinesiology is the study of human movement across a range of tasks including exercise, daily living, play, sport, and work.

The primary aims of general kinesiology are 1) Understanding the human body’s physiological and psychological responses to acute short-term

physical activity. 2) Understanding the various adaptations to the human body to chronic or long-term physical activity.

3) Understanding the cultural, social, and historical importance of physical activity.

4) Understanding the mechanical qualities of movement. 5) Understanding the processes that control movement and the factors that affect the acquisition of more skills, and

6) Understanding the psychological effects of physical activity on human behavior.

In this text we are mostly interested in kinesiology as it relates to human movement. So, we will focus more on joints, bones, muscles, levers, forces etc. as opposed to the social or psychological implications.

Key Kinesiology Terms

Biomechanics: The science and study of the mechanics of a living body. It is an examination of the forces exerted by muscles and gravity on the skeletal structure and the effects produced by such forces. Biomechanics, as a sports science, applies the laws of mechanics and physics to human performance in order to gain a greater understanding of performance in athletic events through modeling, simulation, and measurement. For example, the forces generated during acceleration of a 100m running race.

Mechanics: A branch of physics that deals with the effects of energy and forces on the motion of physical objects. Mechanics, in the field of sports studies, is concerned with the behavior of physical bodies when subjected to

forces or displacements, and the subsequent effect of those bodies on their environment. For example, the study of materials used in hockey sticks or tennis rackets.

Statics: The study of objects in a constant state of motion, which means they may be in motion or stationary. Statics is a branch of physics that is concerned with the analysis of various loads on physical systems. For example, the forces required to lift an Olympic barbell.

Dynamics: The study of objects subjected to acceleration/deceleration.

Dynamics is from the branch of classical mechanics in physics which is involved with the motion of bodies; it is divided into two other branches, kinematics and kinetics. An example for this category would be the flight speed and path of a baseball after it has been struck.

Kinematics: The study and measurement of motion.

The variables of kinematics describe the motion of objects in respect to space and time without considering the effects of forces that bring out the motion. Two types of applications are applied in kinematics. First, translational (or curvilinear kinematics), which is the description of the motion in space of a point along a trajectory. This path can be linear, or curved. There are three basic concepts that are required for understanding translational motion; displacement, velocity and acceleration. (These concepts will be reviewed in later chapters).

Secondly, there are rotational motion kinematics which describe the rotation of an object and involves the definition and use of the following three

quantities: angular position, angular velocity and angular acceleration. Kinematics has application in studying the acceleration of a cyclist or throwing a javelin, where there is a change in the position of the object over time.

Kinetics: The study of the forces that act to produce motion.

Kinetics, as opposed to kinematics, is concerned with the motion of bodies under the action of forces. A branch from the study of human biomechanics, a kinetic analysis may include questions such as whether the amount of force the muscles are producing is optimal for the intended purpose of the movement. The term kinetics is not widely used today and is often collectively studied under the term dynamics.

Anthropometrics: The study of the human body dimensions.

Anthropometrics are related to the dimensions and the weights of body segments. Factors include size, shape, weight and other important considerations in a kinetic analysis. For example, you will notice that basketball players are generally tall and gymnasts are generally short. These anthropometrics, or body shapes, create advantages within certain sports.

Kinesiology: Literally, “ the study of human movement”.

Quantitative and Qualitative Measurement

Within the field of kinesiology we evaluate and score performances in two main ways. For example, we may time a runner over 100M and we give a 10M diver a score based on how much we liked the dive. We refer to these assessments as either quantitative or qualitative. Quantitative simply refers

to empirical or hard numbers, while qualitative refers is more subjective and evaluates form and style regardless of the elements of time of distance etc. Let us look at each in more detail.

Qualitative Analysis

Definition: Describes the human movement based on its constituent elements.

The word qualitative refers to a description and analysis of a human movement based on and involving non-numeric terminology. Many professions involving scientific research use qualitative analysis as a thorough and detailed way of improving human movement and performance. Good qualitative analysis uses all the senses to gather information about the strengths and weaknesses of the movement. The most commonly used approach of qualitative analysis is through basic visual observation. It is through this observation that information on a specific motion is gained, recorded and analyzed. This analysis can also help identify various mechanical factors that may or may not need to be altered in an effort to improve performance in the given activity. The ability for a scientist, coach and athlete to be able to observe the performance in slow motion is a valuable tool for improving ones performance. The details of qualitative analyses vary. Generally, one can simply state a movement as ‘ a woman was running quickly down the track’. It might also be stated that the same woman is running quickly down the track on the balls of their feet, leaning slightly to the right. This alternate way of describing the same movement is providing a more detailed qualitative analysis of the movement.

Qualitative problems arise during our everyday daily activities, with a large part of our lives being devoted to the solution of problems. Sport and performance are no different.

To effectively analyze a movement, it is necessary to start off with a framework and list of questions. The questions stated can either be more of a simple and general question or can also contain a much more detailed and specific questions. Below are some examples of both general and specific questions.

Table 1. 1: General vs. Specific Qualitative Analysis

General

Specific

– Is the movement performed with proper execution?

-Is the release of the swing taking place at the instant of full arm extension?

-Why is this sprinter not getting a faster time?

-Does the strengthening of the quadriceps significantly improve hip rotation and turnover speed?

Planning and Performing a Qualitative Analysis

Once you have identified the question(s) the next step is to collect the data. For the coach, therapist or PE teacher, this is qualitative visual observation data. The movement is first carefully observed and written or mental notes are made. Planning is required to ensure observation is done from optimal

distance and perspective. As the level and complexity of the skill increase, the level of planning increases.

In planning a qualitative analysis, a process occurs with the main goal being a further refinement of the original question. The first and final step both lead to refinement of the original question being asked.

Figure 1. 1: Qualitative Analysis Process

(*Referenced and re-created from Basic Biomechanics by Susan J. Hall)

Following this procedure in carrying out a qualitative analysis will allow the researcher to optimally collect observations. Throughout the analysis, one usually finds questions will constantly arise. Laying out the foundation of the analysis will prevent faulty or inadequate information.

Procedures for Qualitative Analysis

First and foremost, the procedure begins with identifying the problem or question. Whether the analyst is looking to answer a question pertaining to a how a sprinter’s gait is negatively impacting their running style, why a baseball player is having difficulty making contact with the ball, or why a tennis player is having wrist pain. The ability to answer these questions begins with biomechanical knowledge.

Once the problem is identified there are two main steps. Firstly, make proper decisions necessary to carry out the analysis and secondly to observe and collect the observations from the performer’s movement. When a movement is executed, the analyst needs to determine the appropriate way to fully

optimize the viewing process. This decision is determined depending upon whether the analyst is going to rely on basic visual observation or will they be using a video camera. Videotape allows both the analyst and the performer to view the movement, as well as repeated viewings. Details like viewing angle, environmental modifications, slow-motion, etc. are all factors that play into the decision making process.

It is from the videotaping of the performance that the analyst and the performer can both sit down and begin to collect observations. Feedback from the video, analyst and performer are all collected, and reviewed. Despite the main question being stated in the beginning, occasionally other questions may arise during the collection process. Observations made may suggest new questions. This is when the analyst needs to go back and focus on the critical aspects of the movement and the biomechanical error that was first identified.

Finally, once all movements and performances have been carefully observed, the analyst begins to interpret the observations. The expert analyst is highly knowledgeable in biomechanical movements and is able to identify and diagnose errors. With all the combined information that was collected in the performance the analysis can now end the analysis, make refinements to the main question and/or problem and finally assess, correct and improve the human movement.

Both knowledge of the specific biomechanical purposes of the movement and careful planning are necessary for effective qualitative analysis.

Quantitative Analysis

The second form of analysis is quantitative analysis.

Definition: The use of measurable variables (e. g. size, time, number) to describe performances.

In quantitative analysis we classify features, count them, and even construct more complex statistical models in an attempt to explain what is observed. The goals of quantitative analysis are to provide precise descriptions of the mechanisms of human problem solving, the causes of error, differences between skill performance and with the intent to improve human performance. We use variables such as force, speed, distance and time.

The quantitative approach helps to eliminate subjective description and relies on data from the use of different instruments. It is generally a more scientific, publishable, and predictable analysis than the qualitative approach that implies that the movement is described without the use of numbers. This approach is widely used in coaching and during the teaching of sports skills.

Nine-Step Quantitative Problem Solving

A simple procedure for approaching and solving quantitative problems involves nine sequential steps. The following provides a summary of the procedure for solving such problems. Solving numerical problems is a critical part work in the kinesiology field and should be carefully approached.

Carefully read and review the given problem.

Write down information given; write what you need to find. Where units of measurement are needed (convert them as necessary) and list them in order.

Draw out and diagram the situation given and provide both the unknown and known information

Identify formula’s that will be useful in solving the problem.

Chose the logical formula that will be used.

Insert and substitute measurements and relevant information correctly into the formula chosen.

Solve the equation.

Check to be sure your answer is reasonable, that you include proper units of measurement, and the answer is complete.

Highlight the answer.

(Revised from Basic Biomechanics by Susan J. Hall)

Example of Quantitative Problem:

Answers to these types of questions can assist coaches in making decisions about when and how to instruct players in given situations.

Q: A baseball player hits a triple to left field. As he approaches 3rd base, he notices the incoming throw to the catcher is wild and decides to go to home plate. The catcher retrieves the ball 5m from the plate and runs to the plate

at 8m/s. The runner is now 10m from the plate and running at 12m/s. Who reaches the plate first and how much faster?

Using the Nine step process above, we can begin to solve this problem.

Step 1: Carefully read and review the problem

Step 2: Write down information given:

Base runner’s speed = m/s

Catcher’s speed = 8m/s

Distance of base runner from plate = 10m

Distance of catcher from plate = 5m

Step 3: Draw a diagram of the situation of the problem.

Step 4: Identify possible formula’s to be used to solve the problem.

Step 5: Chose the logical formula that will be used to solve the problem

Time = distance/speed

Step 6: Insert and substitute the given information into the formula.

Time = distance/speed

Catcher: time = 5m/8m. s

Base runner: time = 10m/12m. s

Step 7: Solve the Equation

A: Catcher

Time = 5m / 8m/s = 0. 625sec.

Runner:

Time = 10m /12m/s = 0. 83sec.

Step 8: Check that the answer is complete and reasonable.

Step 9: Highlight the answer

Runner reaches home plate 0. 21 seconds slower than the catcher!

Could this be a qualitative example also?

Yes, the umpire could actually call the runner safe. This is his decision and in this case is the wrong one.

Research Note:

The reliability differences between qualitative and quantitative assessments were perhaps no more clearly illustrated in the 2002 Winter Olympics Pairs Skating competition. In the pairs competition, Yelena Berezhnaya and Anton Sikharulidze of Russia had won the short program over Jamie Salé and David Pelletier of Canada. In the free skating, Berezhnaya/Sikharulidze made a minor (but obvious) technical error when Sikharulidze stepped out of a double axel. Meanwhile, Salé/Pelletier skated a flawless program, albeit one that many experts considered to be of lesser difficulty than that of the Russians.

The Canadians were the clear crowd favorite; they left the ice to a round of stormy applause and everyone believed they had won Gold. The Canadians received three 5. 9s for technical merit, while the Russians received mostly 5. 8s and 5. 7s. However, for presentation, the Canadians received four 5. 9s to the Russians' seven. Presentation was weighted more heavily than technical merit at the time; the Canadians needed at least five 5. 9s to overtake the Russians for first. There was obvious disagreement from the crowd; loud chants of " Six! Six! Six!" gave way to a chorus of boos when the presentation marks came out. As it turned out, this margin held until the end, giving the gold medal to the Russians. Salé/Pelletier accepted their silver medal with grace but open disappointment. It was the 11th consecutive time (dating to 1960) that a pair from the Soviet Union, the Unified Team, or Russia had taken the gold in the pairs competition.

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There was immediate suspicion of cheating. Judges from Russia, the People's Republic of China, Poland, Ukraine, and France had placed the Russians first; judges from the United States, Canada, Germany, and Japan chose the Canadians. Suspicion fell almost immediately on the French judge, Marie-Reine Le Gougne. When Le Gougne returned to the officials' hotel, she was immediately confronted by Sally Stapleford, chair of the International Skating

Union’s Technical Committee. Le Gougne had an emotional breakdown in which she said that she had been pressured by the head of the French skating organization, Didier Gailhaguet, to vote for the Russian pair regardless of how the others performed.

She repeated this at the post-event judges’ meeting the next day. It was alleged that this was part of a deal to get an advantage for French couple Marina Anissina and Gwendal Peizerat in the ice dance competition that was to follow a few days later. However, in a signed statement, Le Gougne denied taking part in such a deal and also stated that she had truly believed the Russian pair deserved to win.

On February 15, Cinquanta and IOC President, at the time, Jacques Rogge, in a joint press conference, announced that Salé and Pelletier’s silver medal would be upgraded to gold. Berezhnaya and Sikharulidze were allowed to keep their gold medal as well, since there was no proof of impropriety on their part, and many felt that they, in fact, deserved it, as was the opinion of four of the other eight judges on the panel. Both pairs’ point totals were thrown out. Le Gougne was suspended effective immediately for “ misconduct.

Which is better? Quantitative or Qualitative? You decide!

So Quantitative or Qualitative? Obviously there are strengths and weaknesses for both. Here are some advantages to quantitative measurement.

Quantitative methodologies are appropriate to measure overt behaviors.

They are reliable in measuring descriptive aspects, such as time to travel a distance.

Quantitative methodologies allow direct comparison and replication.

Reliability and validity may be determined more objectively than with qualitative techniques.

In quantitative research your aim is to determine the relationship between one thing (an independent variable) and another (a dependent or outcome variable) in a population. Quantitative research designs are either descriptive (subjects usually measured once) or experimental (subjects measured before and after a treatment). A descriptive study establishes only associations between variables. An experiment establishes causality. Studies aimed at quantifying relationships are of two types, descriptive and experimental. In a descriptive study, no attempt is made to change behavior or conditions (you measure things as they are). In an experimental study you take measurements, try some sort of intervention, and then take measurements again to see what happened.

Problem:

Can you list five examples each of qualitative and quantitative assessments of a skill etc.

Qualitative versus Quantitative Measurement of Human Movement

The qualitative and quantitative analysis of human movement is composed of many parts. Both require the knowledge of the movements desired, the

characteristics involved, and the ability to view a performance and analyze whether the human movement does in fact incorporate the specific characteristics. The analysis of human movement may be either qualitative or quantitative, and both play an important role in the biomechanical analysis of human movement..

Classifying kinesiology tasks as quantitative or qualitative is an effective approach in understanding basic biomechanical concepts in kinesiology. Analyzing human movement is an essential process of problem solving. Whether the performance being analyzed is qualitative or quantitative they both include identifying the performance, observing and studying, and finally answering the problem or question.

Quantitative measurements are taken and used to quantify movement or performance, whereas qualitative performance or movement is observed and subjectively evaluated without the use of measurement for quantification.

An observer, for example, might qualitatively state ‘ that was a good throw’ where a second observer might quantitatively state the javelin was thrown at sixty-five meters.

Qualitative analysis should not be regarded as merely general descriptions, as it can also involve detailed description. Both quantitative and qualitative description play important roles in the biomechanical analysis of human movement, with quantitative techniques mainly being used by biomechanist researchers in attempting to answer specific questions and qualitative

observations and description mainly are used by a wider range of people including clinicians, coaches and PE teachers.

There are advantages and disadvantages of both measurement techniques. However, the objectivity of quantitative measurement tends to make it more reliable and you don’t end up with a performer scoring fewer points because of the color of their uniform as you might in qualitative assessment.

Table 1. 2: Quantitative vs. Qualitative Analysis

Quantitative

Qualitative

Three Feet

Good

Two Cents

Bad

Twenty Dollars

Heavy

Fifteen Seconds

Fast

Table 1. 3: QUANTITATIVE or QUALITATIVE ANALYSIS?

Quantitative Analysis

Qualitative Analysis

Impact forces during running.

X

Carpal Tunnel Syndrome

X

Aerodynamics of clothing

X

Release angles for projectiles

X

Occupational demands

X

X

Review Problems

1. Determine whether these measures require quantitative or qualitative analysis.

– Friction on a bobsled runner blade _____

– a toothache _____

– acceleration of a projectile _____

– rotational speed of baseball _____

– perceived difficulty chopping wood _____

– a headache _____

– wind speed _____

2. Can you now think of six examples on your own that fit each measurement. Give a one-line definition to accompany & clarify your example. An example is provided for each measurement.

Qualitative

Motivation (motivation can be extrinsic or intrinsic and difficult to quantify).

_

_

_

_

_

Quantitative

Vertical jump height (this variable can be absolutely measured in cms).

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_

_

_

_

3. Can you identify 4 examples of situation that represent dynamics and statics?

Dynamics

A skater gliding on the ice.

_

_

_

Statics

A chair sitting on the floor.

_

_

_