Historical perspectives in kinesiology

Why We Study Kinesiology. As one of the most innovative and exciting areas in the health care field, muscle testing through kinesiology has given professionals feedback tools to identify multiple aspects of human movement ranging from injury cause and rehabilitation to sports performance. Just think for a moment about how bicycle designs or helmets have changed in the past 10-20 years. Much is this is due to the study of kinesiology. To comprehensively understand human movement, we must approach the topic from a comprehensive point of view which means a physiological, biomechanical, psychological, and sociological perspective. However, in studying kinesiology not only will you begin to understand how and why we move, but gain knowledge on how we can optimize the human potential for movement and skilled performance, the use of different materials and fabrics, and the role of body balance for overall movement health.

Kinesiology is a way of studying human movement from two perspectives; theoretical and applied. Each day we accomplish a variety of skills and tasks by calling on a vast array of motor skills. We drive cars, ride bicycles, paint houses, and type of keyboards. All of these skills are studied within the field of kinesiology. Tools are designed and redesigned, hockey sticks are made from new materials, cars are redesigned with more aerodynamics, and your armchair is home if more ergonomically built. To do any and all of these things we must consider the body and how it moves. Unconsciously, we select the muscles which are going to be most effective for the task at hand. The more we are able to recruit muscle groups, the more effective and stronger we become at performing that skill and movement. Moreover, the kinesiology repertoire is not limited to sports and human activities. The field covers everywhere from the study of movement to the anatomical aspects of humans and athletes, and because biomechanics affects all aspects of our daily function, the field of study extends far beyond sports performance. This book focuses on human biomechanics which focuses mainly on humans involved in movement, sports and exercise. We might define sports and exercise biomechanics as the study of forces and their effects on humans in exercise and sport.

As we have defined previously, kinesiology is the study of human movement. Kinesiology is the study referring to the whole area of human movement Included in this field is the study of biomechanics, or the study of motion. Kinesiology and Sports Biomechanics overlap to provide you with the knowledge you need to understand the mechanical aspects involved in everyday movements and also the techniques of sports. In both situations, similar questions arise, such as; " why is this technique working better than the other ones I have tried?' and " Would my performance be enhanced if I fine-tuned a certain skill?" Studying kinesiology will also allow you to know how and where to find answers to these questions. And in answering these questions you will be using biomechanics to improve your performance both in everyday life and perhaps more directly, your athletic skills and ability.

An example of some questions the knowledgeable biomechanist might answer include the following:

What is the safest way to lift and move this heavy object?

What movement is the most economical? And is it possible to judge this based on visual observation?

At what distance should a ball be thrown for maximum power?

What change in body mechanics can be made to increase stability in the elderly?

What allows some individuals to carry out a specific task while others are unable to perform the very same task?

These questions provide a foundation for indentifying, analyzing and solving problems related to human movement. Regardless of the questions asked, investigations and experiments in the kinesiology and biomechanics field are leading us to design products and address problems in everyday life and sports.

However, kinesiology is by no means a modern day science. Mechanics and forces in human work have long been studied in many walks of life ranging from transport, to battles to buildings. This is quite evident historically if you consider structures like the Pyramids, the great castles of medieval times, carts and horses for travel and of course bicycles. Therefore, history is rich with individual contributions to this field. I think you will be surprised to see of the great names of artists, designers, and craftsmen who have made instrumental contributions to the field and are therefore part of the great collection of kinesiologists in history.

Understanding the Historical Development and Contributions in Kinesiology

Kinesiology is a combination of the Greek word " kinein" (to move) and " logos" (discourse). Its long history spans the lives of Archimedes (287-212 BC), Galen (131-201 AD, deemed " the father of sports medicine"), Leonardo da Vinci, Galileo, Newton, on up to modern times and Dr. George Goodhart, who brought into our language the concept of ' Applied Kinesiology' in 1964.

Kinesiology is regarded as both an art form and a science; it is regarded as a science because it has rules, methods, principles and logical techniques while it also involves intuitions, feelings and practice which also make it an art form. Within the history of kinesiology much of the context consists of the history of sport biomechanics. The origin of kinesiology was first used in the 19th century, but it wasn't until the 1960's that biomechanics evolved as a more structured discipline and became popular. However, as aforementioned, the origins of kinesiology can be traced back thousands of years to ancient Roman Times and the gladiators and chariot races.

One of the earliest works of exercise and sport biomechanics appeared in 1912 in The Baseball Magazine. This article described a study analyzing the pitching speed of a professional pitcher by the name of Walter Johnson. Following the publication of this article, the field and research of sport biomechanics truly began and a host of other studies in sports such as swimming, cycling and track and field began to appear. The start of the 1930's introduced the use of video cameras in filming and analyzing skills of sport. With the use of this technology, biomechanists were able to slow down the activity and look more intently at the athletes techniques and therefore, could more specifically make the necessary adjustments to positively enhance the performance. A perusal through the history books will show a noticeable improvement in world records for many sports in the 1950s-1960s. The technology that was developed for World War II soon carried over into other disciplines, and sports was one of these areas. It wasn't until the 1960's that the actual term and involvement in biomechanics research really started to become popular. In this decade came the introduction of the first Biomechanics seminar with the beginning of newly published Biomechanics Journals published and presented at these conferences.

In the 1970's and 1980's, many biomechanics organizations were formed and there was an increase in the number of publications of sport biomechanics' journals. The field of study has continued to increase rapidly over the past few decades. However, while great strides have been in recent decades, much foundation work was already laid. It is important to note and recognize these individuals who made marked contributions to the field. Not only is it important to recognize these accomplishments but also to put into context the rich history of kinesiology.

Great Kinesiologists in History

Aristotle (384-322 BC)

Aristotle is known as " The Father of Kinesiology". In fact, he is pretty much considered the first biomechanist. He was the first to describe the actions of muscles in his first book on the " Parts of Animals, Movement of Animals, and Progression of Animals." He was the first to subject animals to geometric analysis and then document their findings. He viewed animal bodies as mechanical systems and researched the physiological differences between imagining the performance of an action and actually carrying out that same action. Furthermore, he described the various conditions and problems of moving and pushing a boat; which was a precursor to Newton's Laws of Motion. It was Aristotle, who also was the first to describe and analyze the movements of walking, explaining the transformation of a rotary movement to translatory movements. These describe the general motions of the body from an initial position to a final position. The rotary movement consists of one point of a bone remaining stationary with all other anatomical points tracing an arc or circle around this stable point. Translatory motion, or pure linear, motion is the movement of an entire object occurring at all points on that particular object and includes all points moving the same distance.

With the introduction of basic studies focusing on both animal and human biomechanics, Aristotle raised the importance and application of biomechanics to the musculoskeletal system and has led us to a better understanding of both joint function and dysfunction, resulting in design improvements in human motion structure and performance.

Archimedes (287-212 BC)

Following Aristotle was another renowned Greek scientist. Archimedes (287-212 BC) discovered hydrostatic principles governing floating bodies, which are widely applied today in all areas of aquatics, especially swimming. Archimedes also investigated the laws of leverage and determination of the center of gravity and buoyancy. In physics, buoyancy is the upward force on an object produced by the surrounding fluid in which it is partially immersed, due to the pressure difference of the fluid between the top and bottom of the object. In his treatise ‘ On Floating Bodies’, Archimedes writes about the hydrostatic principle, or the ‘ Archimedes’ Principle’, as it is more commonly known. This principle states that “ the body when immersed in a fluid will experience a buoyancy force equal to the weight of the displaced fluid.” In other words, when a body is partially or fully immersed into a fluid (i. e. a liquid or a gas), then it will experience that upward buoyant force which is equal to the weight of the fluid displaced by the immersed part of the body. Although Archimedes didn’t invent the lever, he wrote one of the earliest known explanations of the principle involved, and he did design the standard block and pulley system which allowed the use of the principle of leverage to lift objects that would have been too heavy to move.

In the first part of his treatise, ‘ On Floating Bodies’, Archimedes describes his law of equilibrium of fluids and demonstrates that water will in fact adapt to a spherical form around a center of gravity. It has been said to be an early attempt to explain the theory that the Earth is round. In his second volume ‘ On the Equilibrium of Planes’, Archimedes stated his ‘ Law of the Lever’. In this Law he explains that “ Equal weights at equal distances are in equilibrium, and equal weights at unequal distances are not in equilibrium but incline towards the weight which is at the greatest distance.” It was with the use of these principles that he derived to calculate the centers of gravity of various geometric figures. His contributions continue to guide modern day mechanics and the study of levers.

Research Note:

EUREKA! I have found it. This term is most famously attributed to the ancient Greek scholar Archimedes; he reportedly proclaimed, “ Eureka!” when he stepped into a bath and noticed that the water level rose – he suddenly understood that the volume of water displaced must be equal to the volume of the part of his body he had submerged. This meant that the volume of irregular objects could be calculated with precision, a previously intractable problem. He is said to have been so eager to share his realization that he leapt out of his bathtub and ran through the streets of Syracuse naked.

The story goes that a king at the time, ‘ Hiero II of Syracuse’, wanted a gold crown but didn’t trust the goldsmith to use 100% gold. He needed a way of checking whether or not the crown was indeed all gold. Archimedes’ insight led to the solution of a problem posed by Hiero of Syracuse, on how to assess the purity of an irregular golden crown. Equipment for weighing objects already existed, and now that Archimedes could also measure volume, their ratio would give the object’s density, an important indicator of purity. Archimedes was able to determine how much water should be displaced for a crown made of gold for a given size and weight. The crown was designed as a gift to the gods in the shape of a wreath and therefore could not be disturbed. Archimedes ultimately concluded that the goldsmith had substituted some gold with silver in making the crown.

Galen (131-201 BC)

Galen, a Roman citizen, is widely considered to be the first team physician in history. His essay ‘ De Motu Musculorum’ is the first textbook on kinesiology. In this book he distinguished the difference between motor and sensory nerves, described agonist and antagonist muscle relationships, described tonus, and introduced terms diarthrosis and synarthrosis. Galen believed and taught that the contractions of muscles are a result of the passing of “

animal spirits” from the brain through the nerves of the muscles. Some writers suggest that along with Galen being the first author of a textbook on kinesiology that he also is considered as “ the father of sports medicine.

Da Vinci (1452-1519 AD)

We all know of Leonardo Da Vinci for his great works of art. But his contributions in the field of kinesiology are also noteworthy. Following the works of Galen, kinesiology and biomechanics lay pretty much untouched until the 15th century when Leonardo Da Vinci (1452-1519 AD) advanced our knowledge further. As an artist, engineer and scientist, he was mainly interested in the structure of the human body as it relates to performance, center of gravity and the balance and center of resistance. Da Vinci was the first to record scientific data on the human gait. He used letters to identify muscles and nerves in the human body that he would retrieve from graveyards in the middle of the night. In his collection of human gait data, he described the mechanics of the body during standing, walking uphill and downhill, rising from a sitting position, and jumping. In order to demonstrate the progression action and interaction of various muscles during movement, he developed theories on the functional anatomy by attaching cords to a skeleton at the origin and insertion points of the muscles. His theories and teachings remain commonplace and true to this day.

Galileo (1564-1643 AD)

Galileo followed Da Vinci, and was the first to propose the “ Law or Inertia”, or what is better known as Newton’s First Law. His theoretical and experimental work on the bodies of motion was a precursor of the classical mechanics developed by Sir Isaac Newton.

Galileo’s Principle of Inertia stated: “ A body moving on a level surface will continue in the same direction at constant speed unless disturbed.” It was this principle that was later incorporated into Newton’s laws of motion. The basic framework for Newton’s laws of motion also came from Galileo’s basic principle of relativity, in which he stated that “ the laws of physics are the same in any system that is moving at a constant speed in a straight line, regardless of speed or direction. Hence, there is no absolute motion or absolute rest. Galileo was also very well recognized as the founder of classical mechanics and the applications of variables such as space, time and velocity. He determined the correct mathematical law for acceleration: the total distance covered (starting from rest) is proportional to the square of the time. Galileo also concluded that objects will retain their velocity unless a force or friction acts upon them.

Galileo was a little contraindicated in his thinking and strongly defended heliocentrism; the belief that the sun is at the center of the solar system. Because of his belief in this theory, he claimed it was not contrary to the Scripture passages, and in 1616 he traveled to Rome to try and persuade the Catholic Church authorities not to ban and criticize his ideas. Galileo forged on and in 1632 published his book, ‘ Dialogue Concerning the Two Chief World Systems’. As a result Galileo lost much support and became alienated and admonished by the church. Rome supported by one of its biggest and most powerful defenders, Pope Paul V, put Galileo on trial on suspicion of heresy in 1633. As a result Galileo spent the remainder of his life under house arrest albeit back in his home near Florence. It was during this time that he dedicated his time to one of his greatest works, ‘ Two New Sciences’.

In these writings he summarized on the two sciences now called kinematics and strength of materials. The book received great praise from Sir Isaac Newton and Albert Einstein in later years. As a result of this work Galileo is often referred to as the “ father of modern physics”. As an interesting side note, by the time Galileo started to write his new sciences text he was blind!

Borelli (1608-1679 AD)

Giovanni Borelli was a Renaissance Italian physiologist, physicist and mathematician. As a student of Galileo he contributed to the modern principle of scientific investigation through continuing the testing of hypotheses against observation.

His largest achievements are those specifically related to his investigation into biomechanics. His studies originated with the biomechanics of animals. Borelli was the author of ‘ De Motu Animalium I and II’, although he did not live to see the publication of this work. Borelli first suggested that ‘ muscles do not exercise vital movement otherwise than by contracting.’ And he was also the first to deny corpuscular influence on the movements of muscles. He demonstrated this by using scientific experiments to show that living muscle do not release corpuscles into water when cut. He also discovered that forward motion requires movement of the body’s center of gravity, with a swinging of the limbs in order to maintain ones balance. Since it seems that everyone gets a title, Borelli is labeled as the ‘ father of modern biomechanics’.

Newton (1642-1727 AD)

Newton was/is arguably the most influential scientist in history. Newton published one of the most influential and original pieces of scientific hypotheses called “ Principia Mathematica Philosophae Naturalis.” Published in 1686, it is a three-volume work containing the statements of Newton’s laws of motion. His three laws comprise the “ foundation for modern dynamics”, which express the relationships between the interaction of forces and their outcomes. Newton’s laws can be summarized as follows:

Law of Inertia: Every body continues in its state of rest or motion, in a straight line unless it is compelled to change that state by interacting forces impressed upon it (originally proposed by Galileo).

Law of Momentum (Force = Mass x Acceleration): The change of motion is proportional to the motivational force applied and occurs in the direction of the right line in which that force is applied.

Law of Interaction: For every action there is always an equal and opposite reaction.

The application of these three laws can be best demonstrated using an example of the mechanics of a discus thrower. While the thrower is pivoting, he must grasp the disc firmly (exert centripetal force) to prevent it from flying out of his hand. In accordance with the third law, the discus exerts an equal and opposite reaction (centrifugal force). When the discus thrower releases his grip the centripetal force no longer interacts with the discus and the object flies in a direct line similar to its former circular path. The distance that the discus covers is proportionate to the motive force placed upon it, in accordance with the second law. The trajectory of the discus is affected by gravity, wind, velocity, and other forces that may alter its state of motion, as stated by the first law.

According to Newton, changes of motion are generally considered as a measure of the force that produces them. This is where the idea of measuring force by the product of mass and acceleration originated from. So, therefore, the greater the speed in which the discus thrower spins, the greater the acceleration that will be applied to the mass of the discus, and therefore the farther it will fly before gravity returns it back to earth, and the greater the force to have been applied to the discus.

Hunter (1728-1793 AD)

John Hunter was instrumental in summarizing the current state of knowledge in the field at that time. His lecture series summarized all that was known about kinesiology at the end of the 18th century, emphasizing that muscular function could be studied only by observations of living person. In these lecture series Hunter defined muscular function in major detail, including the origin and insertion and shapes of muscles, two-joint muscle problems, contraction and relaxation, strength, hypertrophy, the mechanical arrangement of muscle fibers along with many other aspects of the study. Hunter declared that " muscle, while endowed with life, is fitted for self-motion, and is the only part of the body so fitted."

Thus we can see a rich and detailed history of big names exists that have played a role in our field of study. Their contributions laid the foundations for early study and advancement. All in all knowledge progressed slowly for a long time and it wasn't until advances in measurement technology such as cameras and computers that more large and innovative steps were made.

Recent Advancements in Research

Research in the field of kinesiology and sport biomechanics has steadily increased throughout the 20th and 21st centuries. This increase in popularity is due in large part to the ease of data collection and analysis of films and video cameras by way of the evolution of modernizing digital cameras. Of course the creation of computers has been monumental. In the past two decades research in exercise and sports science and mechanics has been much more thoroughly covered. All kinds of movements, both sporting and non-sporting, have been recorded, digitized, analyzsed, and as a result new forms of movement have evolved. All made possible by the camera.

Pioneer Cinematographers

Today, many Kinesiologists use cinematography to record sports and exercise movements that need to be reviewed and analyzed. This allows them to break down the biomechanics of the motion and therefore make the necessary changes to improve the athletes' performance. Cinematography is from the Greek words kinesis (movement) and grapho (to record). Modern technology literally allows the collection of thousands of data points within seconds providing volumes of information on very specific phases of movement.

Muybridge (1831-1904 AD)

Eadweard Muybridge was an English photographer who was well known for his early use of cameras to capture motion, particularly in horses and horse racing which was very popular at the time. Advancement of knowledge concerning body mechanics was greatly advanced by Muybridge's works using serial photography. Using cinematographic pictures to study human motion was highly recommended by an astronomer who had once used serial photos for other research studies. Although recommended to use photography to study human movement, Muybridge's passion was in horses. In 1882 Muybridge produced the book ' The Horse in Motion' and in 1887 he wrote ' Animal Locomotion' in eleven volumes, in which several of his photographic sequences were published. Muybridge's work and photographs projected images allowing everyone to see real stances in real movements. His work and photography provided the first insights into specific phase of movement.

Marey (1830-1904 AD)

Etienne-Jules Marey is widely considered to be a pioneer of photography. It was through his photographs that he studied the movement of the body. He was convinced that movement was the most important of human functions and that all other functions were merely support in order to accomplish a specific movement. He described and photographed these methods for his research and work which he recorded in his books ' Du Mouvement Dans Les Fonctions de La Vie and ' Le Mouvement' in 1894. These photographic techniques opened way for further experimental studies and are still considered a major importance in the study of human gait. Marey's work also revolutionized aspects of medicine, particularly cardiology, where his photography was used to show the movement of blood. This knowledge was ultimately developed into chronophotography.

What is interesting that Marey (a Frenchman) and Muybridge (an Englishman) benefited a lot from each others work as there own obsessions set about to confirm that each other was indeed correct with their theories. When Marey published La Machine Animale in 1873 (translated as “ Animal Mechanism”) Muybridge carried out his “ Photographic Investigation” in Palo Alto, California, to test Marey’s hypotheses and ultimately proved that Marey was right when he wrote that a galloping horse for a brief moment had all four hooves off the ground thus settling a dispute between walking and running or more correctly cantering and galloping. Muybridge published his photos in 1879 with some public attention.

Understanding the Importance of Kinesiology in Everyday Life

Today there are many different forms of specialized Kinesiology and more are being introduced as new more specific areas of study evolve. From a biomechanical perspective, we take on ambitious tasks daily that require strength, force, balance and discipline in addition to many other mechanical functions of the body. With the vast array of daily movements people need help in improving human movement. Kinesiology requires the knowledge of why and how the human body moves. It is an important science in solving the problems of human movement and the skills necessary to perform the movements effectively and safely.

The Equipment Design Revolution

There is hardly an area of sports or exercise that has not been affected by the combination field of kinesiology and materials. In fact, you can now study this area of sports equipment design as a university degree. One could argue that no matter what area of sport and exercise you select new materials and kinesiological studies have changed the game. Consider the following:

Safety helmets have benefited from new plastics.

Protective padding is better with new foams and lighter plastics.

Bicycles are lighter and stronger with new carbons.

Tennis rackets are lighter and more powerful with carbon and titanium (as are golf clubs).

Safety straps use Velcro.

Lighter metals make up components on bats, bikes and skis.

New rubbers and plastics are used in new playing surfaces.

Running shoes are lighter, breathe more and more elastic.

Balls spin more, have more grip, and come in many colors.

We could continue with this list for a long time constantly identifying areas of improvement both in performance and safety. More people can now participate in sports because new equipment has made is safer and easier. For example, consider new shaped skis (photo) that have made it easier to turn and stop on difficult terrain. We have oversized golf clubs that allow us to hit the ball straighter and further. No area is left unaffected. Even more remarkable is that kinesiology and materials study has made it possible to people with no legs or arms to run, jump and play racquet sports.

Research Note:

The Olympic Games in 1896 were for able-bodied athletes. The Paralympics began in 1948 when Sir Ludwig Guttman organized a sports event for WWII veterans who had a spinal cord injury. The first competition was in Stoke, England. Four years later the Dutch joined in and the movement began. At the Rome Olympics in 1960 the movement expanded to include other disabilities and was called the Paralympics. In 1976, the first Paralympic winter games took place in Sweden. In 2008 in Beijing, over 4000 Paralympians competed. Many of their performances have been made possible by our field of study. So not only are humans with no legs running, in some cases they are outperforming able-bodied athletes.

In 1992, Joe Gaetani, a paraplegic, set new world records in 100m (12. 23 secs) and 200m (26. 82 secs) in the Paralympics. Gaetani’s legs were made from a new composite material of carbon fiber and epoxy pylon. The flexibility and weight of these materials is far superior to traditional wood or metal. At the same games Tony Volpentest won gold in the 100m and 200m even though hew was born with no feet.

Of course much of the advancement in materials has come from the engineering field and then gets translated and applied into the sports field by kinesiologists. However, it is the overall collaborative effort that allows for these impressive advances. There is perhaps no area that has benefited more than athlete safety.

Improving Safety

If you have ever watched an old football movie you will remember that the helmets were made of leather. Old cycling helmets were made from foam and rubber. There was no molding for correct fit. Mouthguards are now custom fitted, as are lenses, ski boots, skates, etc. All these design features improve participant safety and comfort. Equipment can now be designed to not only fit better by considering body dimensions but also perform and protect better under stress. Shoulder pads flex and move like shoulders; football pants have padding in specific locations; shin guards can cover the knee and allow flexion, etc. The field of kinesiology has been instrumental in the design and assessment of these advances, allowing for both greater comfort and safety. Thus it is easier to understand that a student in this field has limitless options to apply their skills. Consider this: anytime someone builds a product you wear, sit in or ride on, you must consider body anthropometrics. Thus our knowledge and skills are widely applied.

Sample Problem Solving in Kinesiology

In problem solving approaches to kinesiology and biomechanics, the desired relies on proper decision making to allow for comfort and safety as the outcome. This approach to good decision making includes one that is efficient, systematic and structured.

If one can define part of the problem in biomechanical terms, one could better describe the outcome of the movement and therefore increase the positive outcome of their performance. Look at the following questions that all ask relevant questions you might be asked to answer.

How can an athletic shoe be designed to reduce injuries on artificial turf?

How do forces summate to produce maximum power in a golf swing?

What is the best anatomical posture for sprinter running the 400 meter dash?

What is the best body position for swimming the breaststroke?

At what angle should a discus or javelin be thrown to achieve maximum distance?

What is the best shape for an aerodynamic helmet to reduce drag?

These are all examples of questions that relate to the kinematic characteristics of pure human movement and the mechanics involved. As we have already identified kinematics spans both quantitative and qualitative types of analysis. Quite often your problem solving ability will require the application of both quantitative and qualitati