

## Course Introduction

Hello everyone, welcome to this course on Human Movement Science. This is the first module which relates to the introduction to the course. In this course, we will look at the different aspects of the human movement science and its various applications. Specifically, we will be focused on the sports sciences module during this course. So, in this course, we will learn about the basic introduction to the human movement science followed by the history of human movement science, and then we will look at the certain applications which human movement science have. So, when the term human movement science comes, so the first thing comes to our mind is, what is it? So, human movement science is nothing but is an interdisciplinary field which draws its inputs from various fields such as anatomy, physiology, psychology, sociology, engineering, and mathematics.

So, in this way, we can see human movement science has the various principles and inputs from various allied fields that is why it is known as an interdisciplinary field. So, another thing which comes to our mind usually when we talk about human movement science is, so whenever we heard or hear the term human movement science, it comes to our mind that it has to do something with musculoskeletal disorders or high performance athletes which are competing at elite levels. However, while looking at this picture, we can simply say human movement starts or human movement science starts the day we are born and help us in understanding the movement throughout the course of our life, including older age. So, what will happen is during earlier times when a child is born or during earlier childhood times, the parent and family members observe the infants and their limb movements.

So, what will happen is we see sometimes they are moving their limbs randomly, and one of the family members or the parents itself, they found out like the movement is not normal. So, this is again an application of human movement science. However, that application comes under a specific category of human movement science, which is known as qualitative analysis where we do not know exactly the amount with which the deviation is present. However, we can see the difference between normal and abnormal movement patterns. So, what will happen is once we found out there is an abnormal pattern, we will approach a specialized clinician like maybe orthopedics department or neurology department, where they will run some advanced tests and use some advanced equipment for human movement science to make sure or to understand the mechanics or the reason behind that movement disorder.

Slowly when we start walking on our four limbs, then also our parents and family members or friends observe our movements specifically in qualitative way. Once we start going to school and then start participating in sports, so that is the time where actually we start to understand the applications of human movement science. And finally, towards our adulthood and older age, what will happen is we have certain musculoskeletal disorders which might affect or conditions which affect our independent ambulation. For example, knee pain or hip pain, or sometimes have some

issues in the spine. So, this science will help us to understand the mechanics behind those abnormal movements as well as help us to understand the normal movement patterns also.

So, in humans, particularly human movement science is nothing but to see how humans move in different contexts and environments. So, human movement science is also being utilized by teachers, coaches, and therapists, which usually perform biomechanical analysis. During this course, we will understand more about this term what is a biomechanical analysis. So, in layman's terms, biomechanical analysis is nothing but where we use the principle of mechanics or engineering, or physics to understand the basic movement patterns. So, these changes or these tools are used to monitor the changes in our technique or training improvement as well as sometimes, when we have an injury, and we are rehabilitating through that injury, that also helps us to understand the progress through the throughout the rehabilitation process.

So, before moving towards the main course, let us have a look on the history of human movement science. So, human movement science is not very new as we think. So, the Aristotle almost 384 to 322 before Christ, was the first to examine and document about the complex movements such as walking and running, and he published a book named as "On the Motion of Animals", which is being followed by Archimedes, a renowned researcher and scientist. He examined the floating bodies and their movement. His work on equilibrium of planes proved that two magnitudes, whether commensurable or not, balance at distances reciprocal, reciprocally proportional to them.

Galen is a physician of gladiators and he developed the anatomical descriptions and the terminology being used at that time is being used in certain biological fields till today. Leonardo da Vinci, another scientist, which we come across his works in our day-to-day life or during our different levels of studies. So, he also examined the structure and function of human body while performing various activities. He produced 100 of detailed anatomical drawings and studied the mechanical function of musculoskeletal system, as shown in this figure. So, here we can clearly see he provided, or he created detailed anatomical drawings where he depicted musculoskeletal systems while doing certain activities or movement patterns.

Galileo Galilee is another renowned scientist which studied the action of falling bodies laid on the basis for mechanical analysis of movement. He also looked at the human jump, analysis of gait of horses and insects, and also looked at the determination of conditions that allowed the motionless human body to float. Giovanni Alfonso Borrelli is the student of Galileo. He examined the muscular movement and mechanical principles. His work "De Motu Animalium" is the first biomechanical text which combined the sciences of mathematics, physics, and anatomy.

He is regarded as the father of biomechanics, and he demonstrated the geometrical method of describing complex human movements such as jumping, running, flying, and swimming, as shown in the image itself. So, this is the work being done by Borrelli. Although when Borrelli looked at

these things, Newton's laws were not a thing at that time. So, Isaac Newton also developed is very famous for his mechanical laws or which we call Newton's laws of motion, and he is also the founder of calculus, statics, and dynamics. So, he made several contributions that were important for science in general but specifically for biomechanics, his major contribution was the synthesis of many different pieces of the puzzle of mechanics.

For example, statics and dynamics, including the laws of mechanics, so which are known as Newtonian mechanics. So, Newtonian mechanics provided a theory for mechanical analysis as well as improvement in science through development of the process of theory and experimentation. So, when we talk about human motion science, so Edward Muybridge is the first to develop the cinematographical serial pictures to study animals, specifically horses, and then his work includes humans also, as shown over here where the movement has been taken as a simple pictures at different time frames and then those pictures were analyzed to create the cinematographical serial pictures. His contemporary Etienne Jules Marey also used various photographic methods to examine the movement. Similarly, Jules Amar summarized the physical and physiological aspects related to industrial work, and his book named "The Human Motor," which is published in 1920s set the standards for human engineering in United States and Europe.

Nicholas Bernstein examined the walking, running, and jumping. He laid the foundation for the study of motor control and coordination, and A V Hill, a renowned scientist in the muscle mechanics, explained the mechanical and structural function of muscles and also investigated the energy efficiency and energy cost in human movement. Christian Wilhelm Braune and Otto Fischer were the founders of scientific study of human movement, which resulted in the development of prostheses.

During the period from 1966 onwards to the present day which is also known as an era of great growth in biomechanics because it includes development of new societies or journals as well as professional meetings. So, the first international seminar in biomechanics was held in Zurich, Switzerland, in 1967, and Journal of Biomechanics was incorporated in 1968 to disseminate the research works in the field of biomechanics. So, now, since we have looked at the history of human movement science now let us try to understand what is human movement science. So, it is nothing but to understand and optimize the function of human body. So, in this, what we look is how our human body works when we go to work or we play a sport or in general for health and safety also.

This knowledge about mechanisms and methods is helpful to restore and maximize the functional capacity as well as well-being across the lifespan of the human beings. In other words, we can say human movement science explores the causes and consequences of human movement across the lifespan, which includes prevention and treatment of acute and chronic conditions that causes movement disorders or which result in abnormal movements. So, scientifically, if we say it is nothing but a scientific basis of human movement which results in the development of theories

and methods for maintaining health, preventing disability, and improving movement ability in general. So, let us look at the bifurcation of the human movement science. So, human movement science can be broadly classified as kinesiology as well as in two parts as kinesiology and biomechanics.

So, where kinesiology is nothing but functional anatomy and biomechanics includes kinematics and kinetics. So, kinematics includes linear and angular motion study, which includes position, displacement, and velocity, whereas in kinetics, again, we have linear and angular subdivisions which look at the various forces and torques or moments being generated at different body segments or joints of the body. So, let us look at it in another way. So, over here, what we can see is the human movement again can be further classified into kinesiology and biomechanics, where kinesiology mostly looks at the kinetic chain. So, here, what we look at is the skeletal system, the muscular system, and the nervous system, and in general, what we say we will look at the anatomical as well as physiological function of the human body, which includes the motor control part also.

Whereas in biomechanics it includes the principle of physics, specifically the rigid body mechanics, and that can be further subdivided into statics and dynamics. And as we saw in the previous slide these two statics and dynamics can be further studied as kinematics and kinetics. So, since we are introduced with the word biomechanics, so let us look what biomechanics is. So, as we know, it is made up of two words. The first word is bio. So, since bio is included, it means it is related, or it has to do something with living or biological systems.

Whereas mechanics means or involves the analysis of forces and their effects on the body. So, Herbert Hatze, in 1974, defined biomechanics as the study of movement of living things using the science of mechanics. So, mechanics is a sub-branch of physics which deals with the study of the motion itself. So, since we know biomechanics can be further studied as kinematics and kinetics, so now let us look what is kinematics. So, kinematics is nothing but the description of motion without the reference to the causes of motion.

So, in layman's language simply the description of motion or form or technique of the motion which we see usually the coaches or athletes use this term your form is correct or not, whether the technique is good or not. So, over here you can see the red lines over here. So, here we are just describing the lower limbs of this athlete using these two red lines. So this is known as your kinematic analysis. If we are just dealing with the angles, maybe theta or the position of different body segments with respect to the horizontal or vertical positions.

So, that is known as kinematics. So, similarly, if we look at kinetics, it is nothing but description of motion with reference to the cause of motion. In kinematics what we looked at without the reference to the cause of motion, but in kinetics, we look at the description of motion with reference

to the cause of motion. So, the causes of motion are nothing but forces and torques. So, forces which include ground reaction forces and joint forces over here, you can see the blue arrow describes the forces at the knee joint, and the red arrows or rounded arrows shows the torques been produced at your knee and hip joint and here also you can see these blue arrow shows the forces.

So, in other words, it is nothing but the explanation of motion. So, all of us might have heard our coaches or trainers say us the effort is less or you are not using your maximum power. So, over there, they are referring to the kinetics of the motion. So, since human motion analysis has a broad application, now let us look the more important ones, which we will be looking through this course specifically we are more focused towards the sports science applications. So, human movement science have applications in sports science itself, as we were discussing earlier.

It has applications in robotics, followed by an exoskeleton also, computer vision, neuromechanics, animation also, digital twin we will cover these applications one by one. Last but not the least is the clinical application, which utilizes human movement science in extensive ways, particularly for surgical planning as well as rehabilitation process also. Now, let us look at these sub-fields of application of human movement science one by one. So, first of all, we will start with the robotics. So, we have seen a lot of research as well as improvements in the field of robotics from past. I would say, one to two decades.

So, over here, we are now more focused on bipedal. Bipedal means walking on two legs, as shown over here, or quadrupedal, like walking on four limbs for more realistic natural movements and application in real world, such as in emergency responders or to move the articles from one place to another place. Robotics also has applications in medical sciences, particularly for computer-aided surgery. So, over here, human movement science helps us to design more reliable and medical better medical robots which can help us precisely perform the procedures which are required for medical conditions. Similarly, in case of exoskeletons, specifically industrial exoskeletons, for ergonomic workload management to prevent the injuries which results from overuse of your musculoskeletal system. So, over here, you can see a exoskeleton is being borne by a industrial worker over there they will help them to avoid the overuse injuries.

Exoskeletons can also be used in clinical settings known as medical exoskeletons they are specifically used for rehabilitation and management of neurological disease. So, in this case, what will happen is if you get injured so restore the function; an exoskeleton is used to train or to rehabilitate you through the process, or in case of neurological disease, it will help us to regain the impaired movement. In case of computer vision, it is being utilized for pose estimation, whether you are standing, whether you are making a certain specific pose, and applications in gait analysis. So, we will discuss in more detail what gait analysis is. It is nothing but the repetitive movement pattern, for example, jumping gait, walking gait, or running gait. It has also applications in activity recognition through computer vision.

So, over there, whether you are performing a sitting task or whether you are walking, whether you are running so distinguish between different activities, whether you are making a waving movement or you are just making a sign so that will be covered in your gesture recognition. Finally, computer vision also has a lot of applications in fall detection for elderly population. So, if we know the normal movement pattern and then apply the biomechanical inputs in computer vision so that will help us to detect the fall and prevent the catastrophic disaster which follows the falls. And finally it has applications in virtual reality and augmented reality where you can use this for training as well as your entertainment purposes also.

Amata is a common example. Now, let us see how human movement science has applications in neuromechanics. So, neuromechanics has as the name itself neuro means something related to brain and mechanics is as we looked at the effect of forces they are study of forces and their effect on the human body. So, specifically, the researchers who work in neuromechanics how human movement science will help. This knowledge will help clinician to understand the effect of neuronal control on the movement. How we can control the movement of different limbs, and what are the commands which our neurological system is providing? So, this information why this information is helpful because this information helps us to understand the mechanism as well as mechanics of movement and helps in the management of neurological impairments, which results in impaired movement.

And also this has application in sports too if you know the exact neuromechanics, then you can train your mind to perform effectively and optimally. This has application in animation, so all of us has seen this CGI effects where the movies or a performer is being recorded in front of a green screen. So, over there, what will happen is this has application in movies. For example, all the Marvel movies which we see nowadays or Avatar is a very common example, which I am sure all of you have seen, and similarly in video games also. So, you might have seen the video games which kids or even adults play these days.

So, they have better graphics where you can see the movement which they make while you know playing the characters playing in those particular activities resembles more human like movements or if there is an animal that resembles more like a natural movement. So, digital twin it is a new it might be a new term, but digital twin is nothing but to create a digital copy of a system, whether it is a human system or an animal system, or even a physical system. So, specifically, over here, we are concerned about human movement. So, in terms of human movement, the digital twin will help us to understand the movement and create a digital database for normal and abnormal movement. So this will help us to have more research as well as to look for new methods to treat the movement disorders because if we have a digital database, we do not have to do anything invisibly.

So this will help us to reduce the burden of human trials. So, that way, we will have more flexibility in exploring the possible interventions for movement disorders, or in general, this can be utilized for many other applications, such as creating a database for security purposes also. Like our fingerprints, our walking patterns are also very unique. It has clean applications in clinics also specifically as we were discussing specifically in the fields of orthopedics, neurology, physical therapy, and rehabilitation. So, these that this knowledge from human movement science has broad applications in these clinical fields also. So, now let us see how it can help in sports science.

The first thing is performance enhancement. So, in this human movement analysis will help us to analyze as well as understand the mechanics of movement. For example, over here, an athlete is taking a jump shot in a basketball. So, in this case, we will look at the position as well as the effort being utilized by the athlete to perform that activity, which will help us to understand the mechanics and this will help athletes and coaches to identify the areas for improvement. This improvement will result in optimized movement and result in performance enhancement of the athlete. This also helps in developing targeted training programs.

So, once we know or identify the areas for improvement, then we can create a specific program or targeted program to make those certain changes in the performance of an athlete. It also has application in injury prevention, particularly in sports science, because we see there are lot of injuries happening to athletes while during the training or in game itself. So, this knowledge of human movement science will help us to prevent sports injuries. How they will help is by looking at the loads being generated during those specific activities and also in optimizing the technique. It might be possible you are generating more loads as required or putting more effort than required because the technique is not optimized.

So, once we have a proper technique, then you might need to put less effort compared to the effort being, you know, applied during an improper technique. And finally, in sports science, human movement science has applications in rehabilitation also. So, in the rehabilitation process what will happen the knowledge of loads and the correct form will help in early recovery and better management of the rehabilitation process. So, in this case, what we will look at is different loads being applied, like pre and post-injury and during the rehabilitation process, and that will help us to correct the form because if there is a load imbalance and we do not want to overload the injured side. This systematic way will help us to recover early as well as the better management of the injury prevention as well as the rehabilitation process.

With this, I would like to thank you for your time and hope you will enjoy throughout journey with us. Thank you.