Biomechanical characteristics of various sports - Part 1

Welcome to Module 7, Application of Human Movement Science Principles in Sport. Right, before we start understanding the movement characteristics of sport, let's try and look at needs analysis. So, the learning outcomes for this module would be to try and understand what needs analysis is and its implication in sport and movement characteristics of varied sport. So, we will be looking at different examples and what are the underlying movement characteristics of these to study the biomechanical principles. So, in order to do sports performance analysis, we need to understand the underlying movement characteristics that make the sport. So, biomechanical performance analysis in such scenarios involves the application of mechanical principles and mathematical principles, as we have looked at in the previous modules, to understand and optimize movement performance.

So, what does it involve? We have looked at in Module 5 the different tools, techniques, and approaches that can be utilized to understand and study movement. So, it involves data collection using those approaches, data analysis techniques, a lot of statistical analysis, machine learning as we will be looking at a little more in Module 8. And then once that you have collected all of this data and analyzed all of this data, we will then be looking at different interpretations of understanding the underlying patterns. So, these patterns could be related to performance, risk of injury or injury.

So, these processes require knowledge and understanding of the appropriate tools, techniques, statistical approaches as we just spoke about, and biomechanical understanding of the underlying movement. So, for us it is extremely important to understand the next concept that we are going to look at which is needs analysis. So, what is needs analysis and what is its implication? Needs analysis as the word suggests is the need. So, what is our need? What is our aim? Why are we looking at a particular movement? And what is the requirement of that sport or what is the need for that sport? So, looking at the definition, movement needs analysis, what does it involve? It involves systematic assessment of the mechanical aspects of human movement in various activities and sport. So, the aim here is to identify the physical demands, movement patterns, force production, joint stability, equipment requirements.

So, all of these are quite important for us to understand before we start dissecting sport performance analysis. So, it is necessary to optimize performance and reduce the risk of injury. So, what are its implications? So, comprehensive movement needs analysis, right, allows coaches. So, it is extremely important for coaches, trainers, sports scientists to develop tailored training programs, right. So, it helps us to develop individualized programs, it helps us to optimize performance, look at the need for equipment modifications.

So, based on your anthropometric measurements as we looked at in the previous modules, assess injury risks, if there are any discrepancies and there is a certain movement that is required, probably not advisable for that individual. Also look at injury prevention strategies, right. So, if there are any specific strategies that we can opt for to prevent injuries that address the specific mechanical requirements. So, these mechanical requirements or mechanical needs as we call it, are quite important to know before we delve into performance analysis. So, what does needs analysis look at? So, it looks at or gives us a good understanding of movement patterns, so kinematic understanding.

Analyzing the specific movement patterns that are involved in performing various skills and techniques allows us to develop a deeper understanding, right, and to develop strategies for performance enhancement and risk identification, right. So, it is very important to understand the underlying movement patterns. So, let us look at some examples. So, where would kinematic understanding be extremely important? Let us look at an example of basketball. So, in basketball, the kinematics of shooting are extremely important.

So, what would you look at? The optimal release point. So, as you can see in this figure, the angle of release or the body position at release, the release point, the shooting arc trajectory. So, you are looking at what is this trajectory. It gives us an understanding of what is the probability of the ball landing in the basket, right. So, it helps us improve shooting accuracy.

So, all of these variables that you collect regarding or all these variables that you collect, which are kinematics of shooting, help us to improve performance in terms of accuracy. You would also add upper body joint angles, body positioning as we discussed during a jump shot for example, right. So, to understand what is the most efficient technique to get the ball in, is to understand efficient shooting technique. Another such example would be for wheelchair basketball, right. Now able body versus wheelchair, what are the examples and what are some of the implications? Let us have a look at that.

So, for kinematics of shooting in such case, we need to understand individualized kinematic patterns here. Now, why would that be? It depends on what the disability is, where the disability is. There would be variations in mobility, variations and so there could be mobility impairments for example, that would require customized training programs, right, specifically for these athletes. It would also require equipment adaptations. You might have different specs of the wheelchair that you might need to change and need to adapt to.

And of course, all of these then lead to shooting accuracy. Let us look at another characteristic which is force distribution. So how important would it be for us to understand and why? So assessing the distribution and magnitude, both are important. So distribution, magnitude of force that is generated across the different body segments during

specific movements is extremely crucial, right. So how is force generated? How is it transmitted then into the n tangential product? It's extremely important for us to know that.

Let us take an example of golf, right. So as you can look at the golf swing here, there is a segmental transfer or force that is happening throughout these body segments, right, and then end into the ball. So assessing the distribution and magnitude of forces during the golf swing can help us optimize swing technique. Why would we need to optimize swing technique? For maximum power. So, if you're going for a distance shot, it would be maximum power and, of course, improved accuracy.

So your swing, all of your swing mechanics from your follow-through to your backswing to the amount of force that you generate and you transmit, all of that would depend on the shot that you're playing, right. So, for us to understand which shot you're playing, what is the underlying movement pattern, what are the force distributions, all of that is extremely crucial. So, analyzing the forces exerted on the club and the transmission of forces in the body gives us an insight as we've looked at into how golfers can generate more club speed, right. That's for distance shots. So this is for, oops, this is for long shots or to achieve distance as well and to achieve optimal ball trajectory.

Let's look at the characteristic of joint stability and mobility. Now why would this be important, right, in your needs analysis? So evaluating the joint stability and mobility during different sporting movements gives you an understanding, right, of what's the requirement. Do you require more stability in certain aspects? So then that would inform your strength and conditioning coaches to be able to design training programs accordingly, right. So it's crucial to identify potential areas of vulnerability so we can better prepare to avoid injuries, right. So we can better prepare for susceptibility of risk of injury.

So, for example, assessing joint loads, right? So if we can pre-assess the joint loads that your body is going to go through or goes through over repeated workload, we can then prepare the body well or prepare the athlete well to withstand these forces, right. So assessing joint load becomes then crucial to design strength training programs as it assures us adequate muscular strength. So, adequate muscular strength then reduces the risk of injury in such segments. So let's look at an example of tennis.

So analyzing the stress loading on the shoulder joint, on the wrist joint, on, you know, your lower back, so important joints on your lower back, during serve or any of the groundstrokes, so like, for example, in this picture, it is a forehand, that assists us in the implementation of specific strength and conditioning protocols or mobility exercises, right. So, for example, as you can see here, if you are going for a wider stance and a wider stride in this scenario, you will require good hip mobility, right, and to be able to execute muscular strength through that hip range of motion as well. Now if you don't have that hip range of motion in the first place, you are risking an overuse injury by repeating the same

movement again and again. Another characteristic would be to achieve good biomechanical efficiency and energy conservation. So why would this be important? So, for example, bowling, right, like fast bowling, we will be looking at a few more examples, but let's take an example of fast bowling.

So you are running down the crease, and you have generated all of this linear momentum during your run-up, right, a long run-up or a speed run-up, depending on what you prefer. So, to be able to just waste it going laterally rather than going towards the target is not going to help you achieve good efficiency, right? You will be losing the energy that you have produced by dissipating it by going lateral or deviating from your target line. So that's why biomechanical efficiency and energy conservation to understand the needs is extremely important. So evaluating the efficiency of movement patterns is important.

So we minimize the energy expenditure, right. So if you minimize the energy expenditure, of course, your body would require less strength or less or optimal, you will be executing it with optimal technique and comparatively less strength. So that will help you optimize your end goal or your performance as well. Let's look at an example of soccer, right. So evaluating the biomechanical efficiency of soccer players, right, what will we be looking at? The running patterns, right, because they run with the ball.

So in the running patterns, you would look at stride length. So these are your, this becomes your variable of interest. Right, so that becomes your variable of interest that can help you optimize the energy expenditure during matches, right. So you are consuming less energy, and you are more efficient or more, you have more endurance capacity here on. So that helps us in development of endurance training protocols, right.

So what is the requirement? How much are you spending, right? And it also depends on your position on the field as well. So different position, so midfielder would be different to say, for example, a person who's playing forward, right. So your endurance protocols, your energy expenditure would be different to your position, different to where and how long are you going to be carrying the ball and what distance would you be carrying the ball. So all of these factors are extremely important for us to understand, so that we take a note of biomechanical efficiency. So overall the game here is to reduce fatigue as we looked at, right, so to optimize fatigue reduction.

Another characteristic would be equipment and gear optimization, right. So a lot of the sport would require an external equipment or gear, right. So how do we optimize this? So why would there be an importance of understanding movement to design equipment? So the assessment of the interactions, your interaction, the body's interaction with the equipment to perform a certain movement is extremely important to enhance performance and minimize the risk of musculoskeletal injuries, right. So for example, if you take tennis as a sport, if you're looking at different rackets, what is the anthropometry of your hand?

You know, what's the span of your fingers, for example, how long are they? What's the width? Right, that will help you decide what's the grip size for the racket you would need or how heavy would you need, right. So all of these characteristics are extremely important for us to optimize our choice of equipment or gear.

Let's look at an example in swimming. So your swimsuit design, right, so individualized streamlined apparel is designed for swimming. So why do we have these improvements in the swim costumes and in the cap and in your swimming goggles, right? It is all to reduce drag, right, so you can efficiently move or you can move quicker. So once you reduce the drag, it helps you improve your performance, right. So in that way, you can use your equipment to also improve your efficiency.

Another example would be cycling, right. So in cycling, you have your aerodynamic bicycles, right, or specialized gear. For example, the helmet or your cycling shorts, right. So the impact also of the bike design. There's a lot that goes into the bike design.

So right from your frame geometry to your saddle height to where your, you know, handles are present to the number of spikes you would have in the wheel to the width of the wheel, you can adjust all of those specs, which are called as equipment specs. All of them are to alter and to optimize your biomechanics so that when you go in for cycling performance, you move towards efficiency. So it helps you reduce air resistance and improve your overall speed during races. So the aim is always to be, you know, to improve performance and to reduce any kind of external environmental factors that are acting on the body. So now that we've looked at needs analysis and the different characteristics of needs analysis and some of the considerations, of course, there are a lot of them, but for the purpose of this module and this course, we'll be just touching on them narratively or briefly.

But you have got a fair bit of an idea now what needs analysis is, why it is important, what are some of the things that you would consider. And we've also looked at some of the examples. So for now, let's move on to sports characteristics. So how do we differentiate sport? Rather than looking at sport as a whole, it's always useful for us to break down things, right? Because sport is a complex activity, it's a complex physical activity. It has all of these different building blocks, different underlying movements that if you understand and if we can plan and teach them in a systematic way, laying the foundation or improving the foundation, we can then reach a quicker improvement or we can then reach better efficiency, quicker efficiency for the athlete, right? So diverse skill sets, as we spoke about, are required for various sports.

So these skill sets, we have looked at previously in the previous module to be fundamental movement skills, right? That then puzzle together or like bits and pieces put together form these complex activities or complex skills that together are performed in sport. So these

provide a foundational understanding of different aspects, right? So what are the different needs or what are the different demands, what are the different characteristics that they can then help you improve athletic performance in each of this discipline. So understanding these skill sets provide insights into the underlying movement patterns and we've also already looked at why it is important for us to understand movement patterns, right? So for example, the importance of technique, the adaptability, precision, control is extremely important for successful performance. So for us to understand what's the underlying technique, how are you going to be adaptable, how are you going to be more precise, we've looked at previous modules of motor control, how learning happens, how do we then apply, we've also looked at how do we break down the skills into phases and sub-phases and event of interest. Now we put all of that information together and categorize the sport depending on what's the demand for that sport, right? So let's look at that.

So you would categorize that based on dominant skill, that's one way of doing it. So what's the dominant skill in your sport, right? Is it based on any movement dominance, right? We'll be looking at these in the upcoming slides. So for now, let's just look at the different categories. So let's look at dominant skills. So how can we categorize sport according to the underlying dominant skill? So are they dominant in limb and hand-eye coordination? And now we'll be also looking at these in detail.

Are they dominant in reactive ability and agility? So is your sport requiring a lot of reactive ability and agility from the athlete? Is the requirement endurance and stamina, right? Now bear in mind that it could be a combination of these things, but we are talking about what's the dominant skill set that is required. Is it dominant in strength and power, right? Or body weight? So is body weight a characteristic that is extremely important? How about balance and coordination? Some sport are quite dominant in requiring balance and coordination as a skill set. Or you could also have team coordination and communication. Now all of these, let's look at some of the examples. But before we move on to that, let's look at what kind of characteristics would be for movement dominance, right? So is it single-movement oriented? Or is it repetitive movement-oriented? It's important for us to understand.

You'll get a gist into where we are moving towards. Why are we categorizing sport in a particular way? It's all for an easier breakdown, an easier understanding. It's literally breaking down your, say for example, your para into sentences. So your paragraph into sentences, your sentences further down into words, and your words down into syllables. So if you can break down your sport and your movement all the way down to the building blocks, that's the way we start teaching.

That's the way we can create a good foundation and design your training program. So when an athlete approaches you or comes to you, you can then start training them for long term athlete development for end goal efficiency. Back again to movement dominance, it

could be single movement oriented, it could be repetitive movement oriented, could be a combination of single and repetitive, so combination of movements and it also could be based on incoming target. Now let's start looking at each of these and some examples for these as well.

So limb and hand-eye coordination. The first sport that comes to our mind when we look at limb and hand-eye coordination is tennis or any kind of racket sport. So where would limb and hand-eye coordination here be dominant? So dominant skill set would be, along with this coordination, balance and agility. So if you look at the picture here, he is in the middle of the serve, so you can identify that this is an event in time, of course, and the athlete is almost about to execute or impact the ball for it to be served. So, if you pause at this moment, you can see that there is balance, good control, and limb and hand-eye coordination for you to strike the ball. So athletes need to coordinate their limb movements with their visual perception to accurately hit the ball as we saw in this picture.

Another example would be badminton, another racket sport. So instead of a ball here, you would have a shuttle. So dominant again on hand-eye coordination, you would also require quick reflexes and the ability to maintain spatial awareness. So they are always on the move, it's a pretty fast sport as you're aware of, they need to recover quick, and they need to maintain their entire awareness of where they are in space, where they need to recover back so that they can then plan their next move. They also need to have spatial awareness of the opponent, right, to strategically be able to place the shuttle.

So visual perception, as we looked at in the previous slide, spatial awareness, quick reflexes, and hand-eye coordination are some of the extreme important skills that you will see for a badminton player during their fast-paced rallies.