EXERCISE AND SPORTS BIOMECHANICS
Week 12
Lecture 58
Expert Discussion with Dr. Saju Joseph

[Hello, everyone! Welcome back to this course on exercise and sports biomechanics].

Today, in our expert discussion, we have Dr. Saju Joseph with us. He is a man with almost 35 years of experience in the field of coaching, biomechanics, strength, and conditioning. on behalf of NPTEL, sir, we welcome you to this course.

First of all, I thank Dr. Viswanath and Dr. Rajini for inviting me as an expert for this NPTEL online education course on exercise and biomechanics. In fact, it is a privilege to attend this online program. Thank you.

Sir! First, we would like to know, based on your journey - **how biomechanics and its technology have changed from when you started until today**?

This has been, if you look into it from the biomechanics perspective, there have been many changes that have taken place since the time we were working with athletes.

Basically, in those days, especially in India, the technology was not available at all. There were many issues in giving corrections to the athletes. We did not even have a video camera, nor software to analyze things and provide feedback. So we had to rely on the naked eye to observe the techniques athletes used to perform.

But then there were people who used to take photographs of the athletes and then project the same thing to the athletes and discuss the technique and how the athlete was performing. This is something we worked on from 1997 to 1998 while preparing for the Asian Games, looking into a discus thrower and also how he is releasing, you know. in those days, we had a good artist with us. The coach had to stop at various positions and then show the mistakes of the athlete—what he was doing. For example, the center line—I mean, the center figure—shows the mistakes of the athlete, whereas this one shows how the athlete has been performing, okay. you could see the diagrams which have been drawn very specifically, and all the movements of the upper and lower extremities have been described. There, we can see the position of one such movement, where the athlete is keeping his foot away from the center of gravity line, okay. Whereas, when you keep the body in line with the center of gravity, the rotation factor is much faster. these small things had to be drawn and explained to the athlete so that they were in a position to perform better. Now, if you look at it from another aspect, there was actually a technique change option which was given.

This is the old technique—how the athlete was doing it—and this is the new technique which the athlete has been executing. And there has been an improvement in performance by almost 3.50 meters. With the old technique, he was doing 60 meters, okay. Here you can see on the right corner, the year 1997—he was throwing 64.5, and in the 1998 Asian Games, he crossed the 65-meter mark, okay. that was actually the way in which

Things were explained to the athlete in terms of biomechanical aspects, okay. Nice, sir. Actually, this is the first time I am seeing a guy who was there with us. He was a very good drawing expert. The coaches used to stand in one particular position and show the movement, and he used to draw because See, the problem was that the athletes were Punjabis, and the guy who was coaching was also a Russian expert. When he is actually explaining things in terms of the technique and the biomechanical aspects, when we are trying to explain in terms of the movements, it was all quite difficult. We never had anything like video analysis or anything of that sort was very difficult.

Only, you know, the guys there had nothing, not even DSLR-type cameras that could click very fast. After every shot, there is a gap of 3 to 5 seconds for the next shot to be taken. It was actually disturbing for athletes and also for the scientists who were working with the athletes.

Sir, from the visuals you showed—the hand-picked drawing by an artist—it shows the commitment and how involved your generation was towards sports science, particularly biomechanics. From that perspective, this generation has motion capture systems, both marker-based and markerless, force plates, EMG, and wearable sensors like inertial measurement units. **How do you see this evolution of technology in enhancing the performance of athletes and how this is helpful for the present generation compared to the previous generation of athletes?**

Now, every movement is recorded. In the early days, when we used to look into even the videos, the frame rate was relatively low—25 frames per second or maybe 30 frames per second. And what happened was that when you look in between two frames.

Let us say the arm position is here for one frame and the next one is here between these two points, we do not know what was happening, because there was no relationship showing between the two moments. But when you see it as a video, then it actually shows a continuous movement, and that was actually a drawback in earlier days.

But nowadays, with all this latest technology like motion capture and inertial sensors, the feedback which comes is for almost every frame counted for looking into the technical analysis. And there is also good in-depth information which comes from motion analysis in terms of graphical representation, showing the movement of the athlete in terms of a range, for example, running the range of motion that is actually taking place around the knee joint, the hip joint, or the ankle joint during the run. And that information is very critical in preventing injuries and enabling better efficiency in running. Certain things like EMG, muscle activation.

Normally, when athletes perform, they perform at angles which may be comfortable for them, but then we need to make them realize that, in particular, some of the angles the muscles may not be activating to their potential level, so how to make those muscles work to help in contributing greater force generation. This way, if you see, the present generation has benefited to a great extent, and as such, we see that in Olympics and International Championships, because of the scientific support, the marginal gain from one person shows that many records are being broken, and the performance difference between the gold

medal and the silver medal is relatively narrowed. that is the advantage you get from the technologies you are using.

Excellent, sir. Coming to our Indian sports ecosystem, compared to the past decade, we have a good number of biomechanics labs in different parts of the country. **How do you see the implementation of biomechanics in our Indian sports training system, and what are the major challenges in implementing or taking biomechanics to the coaching and athlete communities?**

In earlier days, way back before 2010, even video analysis was not possible with national teams. Many teams never had any video analysis or performance analysts, and it was quite difficult for most teams to either look into technical aspects or strategies for a particular game. so analyzing strengths and weaknesses was quite difficult back then, as people were not using technology in India to a great extent. But after 2010, things have changed, and a lot of biomechanics labs have mushroomed across India. That is actually a good sign, showing how much importance has been given to biomechanics. Most people working in biomechanics initially were from physiotherapy or medical backgrounds, and very few were focused on sports mechanics. But now, with various universities and institutions catering to performance, they have established biomechanics labs and expertise.

It is being given in terms of what knowledge they have about the sport. But still, we are lacking specific expertise because most people who have come into biomechanics are from the technology side and not from the sports side. the biggest problem is that there is a big gap between technology and sports-related services. If that gap has to be bridged, then we probably need universities that offer courses in both sports and biomechanics to train and produce new technical experts in biomechanics, which would go a long way for Indian athletes. some universities have introduced programs, which is a good sign. In the long run, I am sure we will have many technical experts in biomechanics, specifically oriented toward particular sports. it is going to be a big challenge, but soon we will find that we are also excelling in biomechanics. The only thing is that we do not have our own conferences, workshops, or clinics. If we could organize these, the interest generated among people specializing in sports science and biomechanics would be greater, and we could also get them involved with either state teams or national teams, allowing them to observe, analyze techniques, and assess performance, which would enhance their expertise.

Excellent! Sir, we see you as a versatile personality because you are involved in sports science, strength and conditioning, biomechanics, and high-performance direction, and you have served in Malaysia as well as in administrative roles in various capacities you had rich experience and still we could see you traveling with the present generation. I could see the picture which what you showed with the art depicted by an artist, and then followed by VHS and VCR system. Hope present generation may not know that is video cassette recorder. So big cassette they used to play even to showcase I mean show some of the matches to the players how they played and how the opponent teams play.

But over the years this technology has evolved and we are in advanced technology. But the acceptance of this technology and sports science among the coaching community, is it robust or still it needs to be further, I mean, awareness should be created among the coaches as far as Indian context is concerned. **What is your view, sir?**

Yeah, to a great extent, actually, see, the coaching community has to be involved in sports science services, that means, what i mean is that they need to be educated, okay and probably if the biomechanics are in a position to exhibit their talents or their skill in analyzing and giving a feedback on a particular technique then automatically they will also start looking into the subject more deeply.

Now, in the education system, what we have, we do not have much practical oriented works, It is only theoretical oriented. what is actually happening is that only the base of biomechanics are taught to these coaches and people in and around the sports science courses which are being run, and there is no practical aspect. that is actually one of the biggest drawback that people are not in a position to, you know, jump into the wagon of biomechanics or sports science.

So I am sure that, if the coaches are being given specific training on how to analyze a particular technique, and **what are the drawbacks in an athlete?**

Because each individual varies. So the technical analysis should vary from one person to another. And it should be described individually rather than in terms of a group-generated result. That means you are just taking a mean and standard deviation and exhibiting means. they may not be in a position to grasp so much of things, but when you tell in terms of individualization, that is individual athletes' technical issues, as I showed you in this diagram, where the position of the foot, you know, you are actually telling the athlete, if you want to rotate faster, then you need to plant your foot closer to the line of center gravity. Then you will have you will find that you will be in a position to pivot much faster, and that will add to the generation of force onto the discus. these kinds of things, if we are in a position to project them to the athlete as well as to the coaches, then there will be a lot of acceptance.

Secondly, from an Indian perspective, we do not have many technical books on sports-specific analysis. If we can come up with books on sports-specific analysis, looking into various stages of the technique, starting from approach, execution, and follow-through. If those things are explained minutely, for each individual, that would enable the athletes to perform better, and it will also give a sense of understanding for the coaches who are involved in technical training and enhancing the performance of the athlete from that perspective. Sir, we know that you have implemented a biomechanics laboratory in Malaysia and in India, specifically in the Sports Authority of India. The implementation part you have initiated well.

Now we need to understand what the difficulties were among the coaches. **Is there any big myth or misconception when we are using sports science or biomechanics, especially in a coaching scenario?**

Actually, there are a lot of myths and misconceptions from the coaches' side. Earlier, these technologies were not available. the coaches would say that they have an eagle eye, so from their perspective, what they can see, they do not have to look into any of these things. When they are observing, they are in a position to analyze things. But I am just giving an example: in hockey, a penalty corner defense or an attack 90% of people look at the ball, the traveling of the ball, from the injection, stopping, and to the. But then you do not know

the position of the attackers or the position of the defenders during that. And for this, probably you may have to get video feedback in order to see where the players were at the time when the ball was dragged, and the spaces that are available. All that information consists of very minute details which need to be visualized in terms of video only or by identifying the pattern of running of the athletes, whether the defenders or the attacking players. one is from that point of view. When you look into the performance analysis part, they were thinking that they could visualize. But that was actually a false concept.

And I am sure that none of them could actually pinpoint where the opponents' players were at the time when the drag flick was done. Now, another concept in terms of technical aspects is that many coaches believe that once a technique is developed, it cannot be changed. actually, they are cutting off the inner services of biomechanics. And if people have developed the technique wrongly, then that leads to injury.

Probably, if you can, if you analyze that particular technique in terms of people who complain about knee pain or low back pain, then you will find that these are all maybe due to the technical aspects that was automatized during the training. There was no proper feedback that was given to the athlete that is why you tend to have wrong techniques. The concept of the coaches saying that, very difficult to change the technique.

Second thing is, changing of technique when it is to be done, either in the general preparatory phase or specific preparatory phase, and it is not that you go and change it closer to the competition. That means, you know, the process of learning and relearning of a technique that may delay the free flow of the technique. And that can reduce the coordination part and perhaps that may be the reason that people do not perform closer to the competitions. But then if it can be analyzed early and if proper corrections can be made, then the athletes will surely perform. Now, I am just giving an example of if you look into Bobby George, athlete who was injured, ACL, PCL and MCL was injured in 1996. And the systematic training and strength training helped him to regain back and with better efficiency, he was in a position to create a national record within a short span of eight and a half months. that is actually where we change the takeoff leg.

Instead of his injured leg, we use the non-injured leg to take off where we encounter higher forces at the takeoff. the ability to change, the interest of the athlete, and the acceptance of that change and the coach's belief in biomechanics all play an important role in enabling the myths and concepts to be assessed from their perspective. Another myth and **misconception in training** is that coaches or strength and conditioning experts train both male and female athletes the same way, as they do not categorize based on structural aspects.

Now, if you look at men and women, if you look at the forearm, men have the right shoulder, elbow, and wrist almost in one alignment. Whereas women have a carrying angle of 15 to 25 degrees, from the elbow. When they are executing any stroke movements, whether in badminton, tennis, or anything related to a smash in volleyball or releasing a basketball, the muscles recruited by men and women are totally different. that is one of the reasons why when you copy men's structural training for women, you find that women are not able to generate enough force during the force application phase. And they may not be able to execute the movements perfectly.

There may be a bit of slack in the coordination aspect of technical execution. You need to see how to recruit those groups of muscles that are not activated, and if the technique is modified according to the structure, that would enable them—the women athletes—to perform better.

Great! Sir, it would be great if you could share some examples where biomechanical analysis significantly improved sports performance. Now, this is actually an athlete who is a 400-meter runner. I am just presenting the actual movement during a 400-meter run. And if you look from the technical side, you find his right arm is moving outside,

That means he is propelling the hand backward and laterally. Now, see, after the push-off, the knee is traveling from the medial aspect in relation to the hip joint. Now, once he is going for the high knee action, the knee is going across the midline of the body. And in another picture, you can see when his right foot is landing, you find that, the foot is landing on the lateral aspect.

And this actually means you look into it in terms of the pelvis and the shoulder rotation. There will be a lot of changes you can actually identify. But I am just giving you some of the simple aspects, which are in terms of the video here. And this is all because of something like a counterforce—that is the reason you find the arm is going outside because the knee is coming inward. if this is actually continuous in nature, probably he would be taking a spin over here, okay? During the run on this right foot, he will be actually pivoting. Now, the femur bone, that is the left femur,

is going from the medial aspect to the lateral aspect, so there's actually a counter-rotation force taking place there. And in order to compensate for that, you find that, the person is landing on the lateral aspect. Now, these are all actually counterforces, and this is mainly because you do not have a good core area. The core strength has to be, if it is bilaterally looked after from the pelvic area to the core—that is, almost to the abdomen or to the mid-thigh area—if it is synchronized and if it is developed, then probably all these problems could be solved. And this athlete, if you look at during the foot contact time on the ground, from when it is first touched till the toe-off. If you look into it, let us say the person is running—I mean, having a foot contact time of 0.0333 seconds, okay? In terms of one one-thousandth of a second, if you look into it, let us say the foot contact time is 0.333 seconds. Now, a 400-meter runner, if he is actually running with a stride length of two meters, so he will be roughly having around 200 steps.

And in each of the foot contact times, if he can reduce 0.003 seconds into 200 steps, then relatively his running speed would have been much higher. That means he would have performed much better. small corrections in terms of strength training. Now here, we need to incorporate strength training, how to work on the core area, which muscles to work out, how to stabilize his core strength, and how to introduce various movements of lunging where the lower extremity moves like a pendulum. Rather than in a curve formation, which reduces the time or increases the contact time on the ground. In this way, if you can actually cut short or dissect the technical aspects, then in the long run, you find that all these 0.001 seconds, if you add in terms of the 200 steps or 0.003 in terms of 200 steps that would add to the performance of the athlete.

Now, I will show you another issue on the technical aspects and injury aspects. Now here, you find that the athlete is running and he is landing on the heel, and relatively the knee is flexed. Here, in this picture, you find that the athlete is running with the knee almost straight. In this case, the heel is going to land on the heel, but probably transferring it into the midfoot would be a little faster because his foot is almost plantar flexed. Here it is dorsiflexed, so the time for him to land and then convert that into a dorsiflexed movement is going to be relatively higher. But then, landing on the heel with the knee straight could cause a lot of problems, from ankle joint, calf stress, knee joint issues, or hamstring pull, quadriceps pull, lower back or the glute tissue or the pelvis is going to be strained. the mechanical aspects of running are actually affected, and the efficiency part gradually reduces. And again, you can see here, the knee is straight and leaning back, whereas in this, a slight lean forward is present. the transfer of body weight during the mid-stance will be relatively better, though he is landing on the heel, but better efficiency can be achieved if those things are corrected by asking the athlete to land on the forefoot. That will help the performance of the athlete, as well as it will also help in the action of toeing in during the push-off phase. Those are the corrections which can be done and enable the athlete to perform and prevent injury.

[Thank you, and meet you in the next video].