

## EXERCISE AND SPORTS BIOMECHANICS

Week 12

Lecture 60

Expert Discussion with Dr. R. Natarajan

Hi, everyone! Today, we have an eminent personality in the field of Indian track and field. Not only in Indian track and field, but he is also internationally famous. It is none other than our superstar sprinter, who is known to everyone. He is **Dr. R. Natarajan**, IRS, an international athlete—a 100 and 200-meter sprinter who ran for India and earned many laurels.

Currently, he is the Deputy Commissioner of Customs and GST. Other than this, he still runs as a coach. He is a World Athletics Level 2 coach and a World Athletics Level 1 course director. Al he is the Honorary Director of the Indian Sports Promotion Academy. With this introduction, I welcome Dr. R. Natarajan for today's interaction.

Sir, welcome! [Thank you, thank you]. Very best wishes and cheerful enthusiasm to one and all who are watching this interview. Yes, sir. Just to start with, let us begin with your journey.

**What are the key moments that shaped your career initially? How did you get into track and field? Could you share your experience?**

**Yeah!** The journey has been very adventurous, very challenging. Very interesting. Lots of bumps here and there. Ultimately, destiny was very kind, and perhaps a deprivation of tapping the maximum potential I possessed.

Probably that one secret, one lacuna, was the biomechanics. I should start definitely praising the people who were there in my journey. But for them, my journey would not have accomplished to this stage for the last 35 years. From 1987 onwards, it was my coach, my mentor, Dr. Vaidyanathan, the former Vice Chancellor of Sports University and former Professor, Head of the Department of Annamalai University and my mentor and my PhD guide, who is no more today. I remember his reminiscences and his contribution to the field of physical education today in India.

But for him, I would not have come into athletics this far. I should say that. And of course, the university authorities, the Annamalai University authorities played a major role in my career. To make it short and sweet, but for university, I would not have completed my **bachelor in pharmacy**, because the university examinations were conducted at my convenient date.

It is a wonder. Nobody could expect a university examination to be conducted at my convenient date. That was a great assistance and support for accomplishing myself as an academician being a world class sprinter. Hats off to the Annamalai University authorities, from the Pro-Chancellor to Vice-Chancellor to my head of the department, Dr. R. Manavalan, everybody, and of course - the infrastructure.

Over a period of 30 years, or one generation, I witnessed tremendous changes in the total infrastructure. From the running track to the equipment I used, including spikes and weight

training equipment—from Cybex machines to ordinary wheel multiple weights, to isometric machines—biomechanical changes occurred from 1987-1988 onwards until 1997. And that does not end there. I am thankful to World Athletics, in fact. They gave me the opportunity not only to coach but also a license to teach coaches.

I observed a phenomenal transformation in training aspects from the days I trained to the latest training technology used by athletes up to Usain Bolt. No wonder my journey has been—people know Usain Bolt today. But **how many of you know Carl Lewis?** Thirty years ago, it was Carl Lewis in the place of Usain Bolt. **Eight-time Olympic champion.**

In 1984, King Carl was called the legendary sprinter of the world. World champion, world record holder, and Olympic record holder. Instead of saying that I ran with him—no, he competed with me. He ran with me. That was a splendid opportunity. That was a mind-boggling experience. I learned what power is, what explosiveness is, what biomechanics is, and what running action is. Yes, so many changes. From the start, from the relay baton exchange, to the finish—everything. Before and after training. The total transformation.

Each and every moment has been a challenging and adventurous journey. These are the key moments that shaped me into and, of course, I should mention the diet transformation, the amount of technology involved—what kind of diet you should take before training, during training, after training, and during competition.

Many things changed, and today, when I look back 30 years to when I was running, there's a total, vast difference—an ocean of difference. This is the journey of these 30 years.

[It is so inspiring. Thank you for your time. Excellent. Excellent. Excellent answer].

We could visualize the journey you have gone through. Through your words, cherishing moments. And sir, with this, comparing your period to now, there are a lot of technological advancements all over the globe, and also in India, we have certain sports science facilities exclusively for biomechanics that have come up.

**As a coach as well as an athlete, how do you see these technological advancements and whether they are reaching the end users like coaches and athletes, whether the present generation of coaches is adopting and embracing the technology for optimizing the performance of the athletes, or if you still see any gap in that? What is your opinion, sir?**

I should say that the technology is reaching the coaches, but the main deficiency I find is that they are deprived of the basic infrastructure.

Once the basic infrastructure is there, implementation would be very easy for them. The updating of knowledge is being transformed in the last 30 years that is what I could see. But there are challenges for the coaches at the grassroots level to implement them due to various factors.

I should say enhanced or improved or replaced with the latest implementation with the schemes only when lot of people like these participants, like these programs comes up and people show interest on them and there comes the financial flow and there comes the

implementation and the awareness becomes more and implementation is much easier. Basically the knowledge has to be developed at different levels from the grassroots level to the elite athletes. So once that is developed, automatically people will get transformed. I feel that the technology makes a difference. Every day the technology is changing.

What I learned today is not there tomorrow. So I have to update myself. Each and every coach has to have the same feeling that you have to update yourself. Unless otherwise you update, you cannot grow, you cannot progress, you cannot develop, and you cannot show improvement. As simple as that.

What I was training and what I was running and what I was using those days is totally different when compared to these days. It is a remarkable difference in the training aspects. Forget about the infrastructure and equipments. And **how many of us know what is the synthetic track used in this Paris 2024 Olympics?** Very few.

**What is the thickness of the track?** In that thickness, how much compartments are there? What is the thickness of each compartment and what is the effect of each compartment and what kind of spikes to be used for each event? Specifically what is the size of the nail? What is the shape of the nail? Whether it is star studded or pointed or sharpened or short or long whatever it is, so which would which would yield best performance to the potential of the athlete, so once again the technology matters. so i remember 1984 Los Angeles Olympics, our sprint queen of india pt usha when she ran in the Los Angeles Olympics for the first time they introduced a synthetic track so for that 1983 india laid synthetic track for the first time in india in Patiala for pt usa alone to practice it is a three lane four meters track in Patiala. Now that track is outdated the technology is much much more much much far far superior.

That is how the optimizing of technology matters in performance. The evolution of performance also remarkably changed, improved, enhanced. From 10.3 seconds to 9.58, they say 9.58 seconds is nothing, not that faster. It is going to be much faster. That is what it is.

**Excellent, sir.** Recently, we had an opportunity to meet where you had a, I mean, deliberation with the, I mean, Indian coaches. In our ki-sprint program in Tamil Nadu Sports University, Centre of Excellence in Biomechanics. Where we happened to meet and the many coaches you interacted with, sharing your experience and biomechanics—the technology, how biomechanics helps them optimize the performance of an athlete. On that occasion, we also met one of the country's top sprinters, Animesh Kujur, in our lab. We had the instrumented starting block, the 3D motion capture system, the force plate, EMG sensors, an isokinetic dynamometer, and the lab itself. We had many orientations. **How do you see these facilities helping future coaches and athletes produce world-class sprinters and athletes in our country?**

**Yeah!** This equipment makes a lot of difference. As I said earlier, biomechanics is mainly to maximize your talent potential and perform very effectively, efficiently, and economically. I mean economically in terms of your energy. These biomechanical aspects will help the individual to correct the errors they are making while training or competing. I repeat these three words.

Effectiveness in training to reach maximum potential or performance, performing the skill or drill or race more efficiently, and with an economical use of energy. How effectively, efficiently, and economically you can perform a race. That is where the biomechanical aspects make a difference. I can quote an example from my career itself. Back in those days, when I ran a race in India at the national level, people used to come and watch, asking, 'When is Natarajan's race?'

There used to be a board lit up there. Okay, Natarajan's race is at 3.30 p.m. An exclusive crowd will come and watch my race. Graceful it would be like a cycling action front and back of the legs. Lifting of your knee, extending of your legs, touching of the foot in the ground, flipping of the leg with a cycling effect and kicking at the back and making the cycle complete. When you see from a longer distance, it would be like a cycling, so gracefully running. This was during 1988, 89, 90, 91, 92, 93 when I went abroad for training, they said that you have wasted time in India. Your running action is wrong.

It was surprising, shocking for me. They told you have to change your running style, then only you can improve your performance. Instead of making a full cycle, each leg making a full cycle, each leg may have to make only half cycle. That was the biomechanical change they made in my running action.

Where our neurological system, my neurological system has been used to a particular running style, my neuromuscular activity has to be changed. Instead of a full cycle, it has to be only half cycle, only half cycle. That was a dramatic change which made me and to run below 21 seconds after Milka Singh in India, in the 200 meters. 20.9 seconds, the second Indian to run below 21 seconds. That was a great biomechanical aspect which enhanced my performance.

And how swift it can be according to a lot of scientific technology involved in it. 1994 itself muscle biopsy was there in European countries and American countries, so i was taken for muscle biopsy, and muscle biopsy is a very important aspect to determine the workload the potential of the muscle and the talent you possess. How many of us know what muscle biopsy is? How many of the coaches can read a muscle biopsy report? So for that, they have to enhance their knowledge academically, so that the coaches can implement to the athletes. When they enhance their biomechanical aspects and the scientific knowledge, automatically the athlete is benefited.

And if the athletes understands better more the enhancement of performance. Very simple as that. Yes. Sir, you have told about the change of technique and how difficult you have faced because in recent years, the coaches are feeling that there is a myth among all the coaches that they can not change the technique among the elite athletes.

Can you share experience how long it takes and what are the difficulties you faced, so that would be a really great for all the athletes and coaches. Yeah, true it is. Very true it is. That mythology is only a myth. It will stay as a myth.

But if the athletes decide, if the athlete decides, if the individual decides to change his running action with this commitment, and if the coach can communicate and make the athlete understand what he requires to change, then it is much easier. The neurons, the

transmitters, the neuromuscular activity can be transformed immediately. And if the athlete is not committed, if the coach is not committed, and if proper techniques or drills or skills are not guided to make the change, appropriate drills are not there, then also the change will not happen. I repeat, if the appropriate drills and skills are not there to implement the change, what is required, the change will never happen.

So I should, as a coach, I should analyze what the individual, the athlete requires. See, there are examples, there are odd men and women out of the biomechanical aspects. For example, you take Carl Lewis is a perfect running action technique. Perfect running action similar to Usain Bolt.

I should say Usain Bolt running action is similar to Carl Lewis. But whereas the running action of Michael Johnson is totally different. It is totally against the biomechanics. He has disproved that biomechanics cannot be influencing an athlete's performance. But it is not for everybody.

Please understand once again. What the coaches and the athletes have to understand here is that each individual is different and each technique is different. We have to design as a coach what is good for that individual and how it can be rectified and how biomechanically it is viable for that individual to perform to his potential. That is the responsibility of the coach that is why coaching is much much very responsible job than a teacher. Biomechanics is again once again how in by switching on one switch thousand lamps burns it is the connectivity of the neurotransmitters. If the neurotransmitters are working properly and if proper drills are given to that neurotransmitters any biomechanical action can be changed easily and with the commitment of athlete the discipline of the athlete and the communication of the coach what he requires if it is understood properly any change can happen at any point of time. In world athletics, we say technical terminology the terminology is nothing but neuronal variability. I can give you an example, the triple jumper at the London Olympics who won the triple jump gold medal. He took the left leg as takeoff and he performed and won the gold medal in 2012 Olympics. The same jumper at the age of 32 in Rio Olympics 2016, he took right leg as takeoff leg and won the gold with the same performance in triple jump in Rio Olympics. We call it as neuronal variability.

Balancing by nature, one leg is powerful, one leg is weaker. So as a coach, you have to ensure that both the legs get equal training, equal strength, equal power, equal coordination, and equal skill. Then automatically, the athlete can change the performance, change the biomechanical action at any point of time. I have made it very simple.

So for me, in my case, it took three weeks time to change my complete running action. Not only the pressure I had, but the interest I had to clock sub-21. That was my target. **Yes. Excellent, sir!**

It was so inspiring. Actually sir, you have spoken about the different coaching methodologies, right? So nowadays, the coaching methodology has evolved with the different science like biomechanics, performance analysis, there are many. What is the difference coaching today and whatever then, like when you are training? **So can you explain that, sir?**

It has become more scientific, more qualitative, and more analytical. More perspective and more individualized. That is—I have put it in a very crisp way. Each and every word has its own ocean of meaning. That is the biggest difference happening in this country, in this world.

And it has become more qualitative, more specific—not quantity-wise, but quality-wise. More scientific, more analytical. Yes. That is the difference. Thank you, sir.

We just want to know, as a coach, what would be the critical biomechanical principles? For example, 100 meters or 200 meters—we will take your event. Can you explain what the requirements are for coaches to understand? For any coach, they have to know the basics of biomechanics. The basics of biomechanics are nothing but how forces act upon your neuromuscular activity, and what action can be more economical, efficient, and effective in the performance of the event at different stages.

Because in 100 meters, you have five stages. Your start, then your acceleration, your drive phase, then your maximum velocity, then your maintenance of velocity phase, then finally your deceleration phase. In different phases, the biomechanical aspect changes. For that, what angle, what line of action, alignment of legs and body and hands, and how the force can be derived—the posture and angle are very important. And what are the external forces? What are the internal forces?

That understanding a coach should have, so they can implement it in the training and make the athlete perform at that level. That plays a very significant role in coaching the athletes. The basics of biomechanics change from event to event and from individual to individual. There is a lot of difference in biomechanics for each event and for each individual. The coach has to understand this basic concept and implement what is required for the athlete.

[Explanation, sir. Thank you so much. Sir, nowadays, few coaches are so interested in applying sports science on the field].

**But there are some challenges. As a coach, what challenges are you facing, sir?**

You have addressed too many coaches. What are the challenges they are facing? Can you explain in that aspect? One of the main challenges is that the athletes want overnight performance. They want to become Usain Bolt or Michael Johnson through overnight training.

They do not understand that they have gone through 10 years, 15 years of training. They do not understand that. And most importantly, the infrastructure part. That is another big challenge. And once again, coming back to the athletes, the commitment, and the discipline of the athletes. That is lacking. Very much lacking in the athletes. For which the coach has to be more inspiring and be a role model to the athletes. Then automatically the children, the athletes will become more disciplined and committed. This makes a big difference in performance.

Automatically, they will get interested. Simply not dictating, okay—you do this, do this, do that. No. Make the training interesting, make the training enterprising,

Make the training more adventurous, more scientific, and more analytical. And so that they have that competitive mindset always. And their psychological aspects have to be set right. They have a lot of domestic problems. Your schools, your relatives, your family functions—so many things, a lot of hindrances are there.

Because the grassroots level is important, what you do in the base is going to make a big difference after the age of 20 years. The base is very important. A simple example I can give you, if you do not study your eighth standard physics properly, it will be very difficult to learn physics from a physics professor from IIT Madras. If you do not train here properly with your local coaches here, it will be difficult to train under the coach of Usain Bolt. I hope you understand—it is a very simple example. Unless the basics are strong

[You cannot further develop the performance. Yes. A very clear analogy, sir. Thank you so much. Excellent].

Sir, the mother of all sports is track and field. And if any personnel who is involved in movement science, maybe sports scientists specifically, a core biomechanist would always love track and field because it is the alphabet of any movement. Citius, Altius, Fortius—faster, higher, stronger, running, jumping, and throwing. In this analogy, we have seen the 1936 Olympics, the four-gold medalist Jesse Owens. After Jesse Owens, we could see only Carl Lewis winning four gold medals in 1984. And we had Usain Bolt, who completely focused on sprinting and created a legacy. And coming to the present champion, Noah Lyles. In the present Olympics, all the finalists

We were having timings below 10 seconds that is the beauty of these finals, the greatest finals. All the sprinters ran below 10 seconds. **What is your opinion on this? What could have been done to make this remarkable scenario better?** Maybe training, sports science, or a combination of all. **Your opinion, please, sir!**

Very interesting question. Before that, I may be allowed to say the fact that athletics is not only the mother of sports, it is the king of sports. The mother of sports, I would say, includes three sports: Gymnastics, swimming, and athletics. Below 14 years, any individual should engage in one of these mother sports to develop all motor qualities, abilities, cognitive and neuromuscular activities. That is why, without being an athlete, you cannot be a sports person or play any game. That is why athletics is called the king of sports. Coming back to sub-10, India has the potential. Very soon, Indians will be running below 10 seconds. That is one of my dreams: to see Indian athletes at the top, running below 10 seconds.

We have the potential. It is only the continuity, sequential and systematic training and finding the talent at the grassroot level. So that makes a very big difference. Coming back, it is a combination of all aspects. As I said earlier, when Jesse Owens ran, it was not 100 meters, it was 100 yards.

The evolution of sprinting, and you will not believe if I say the first man to run below 10 seconds is a flatfooter. Jim Hines is a flatfooter. And his evolution has the technology the science has developed, so those days it was cinda track then it came to synthetic track, grass track, synthetic track, mud track, synthetic track then. Now, in synthetic track you have different tracks and the spikes, the technology in spikes, the technology in diet, the

technology in training, the technology in biomechanics, the technology in equipments, and the technology in recovery methods. All aspects put together is responsible for the performance.

Every millisecond matters in 100 meters. That is going to make the difference and any one of the phase they make a lots of action. Not the required biomechanical aspect is received. Then the performance is affected.

So it should be a smooth action. Execution of the running has to be very smooth at all stages. That is biomechanics, making your body to run into that smoothness that is where all the technology works. Your video analysis, your motion capture system, your timing gauge, your Kinovea, your anatomy, your force plates, your isokinetic measure machine, your in-source electromyography, everything works there.

That makes the athlete more perfect in the running action. I have one small technical information I would like to share here. From the start in the 100 meters, the first step, the knee and the ankle has to be parallel to the ground. The shin bone has to be parallel to the ground. That is the latest biomechanical aspect.

And to get into that posture, you need to develop strength, coordination, balance and the speed. And proper drill has to be made from the grass root level. It cannot be developed at the age of 24-25. The dragging of the leg from the starting block the shin bone has to be parallel to the ground force then automatically your acceleration phase is at maximum. the coach has to understand and communicate to the athlete in such a way that he ensures that drag without creating a friction dragging on the track but back in the air parallel to the ground very simple,

I am very cautious in using the words. This is a very simple, small biomechanical aspect where so much implementation has to take place while training, in designing the drill for that, in designing the strength for that movement, and converting that strength into power and driving acceleration. So much of this mechanism and training technology is involved. For which the coach is responsible. Excellent, sir. Sir, out of context. it is a basic question.

Often this question comes to me. If any candidate who gets into the school system, he has to study for 10 years to choose his stream, whether it is arts or science, up to the 10th standard. But when it comes to sports, people expect immediate results, like, okay, maybe at the age of 10, I want my son to be a national or international champion in a particular sport. What I expect is that, okay, till the age of 15, similar to the 10th grade, all these kids should play all the sports to have fundamental coordination and motor skills. Then, they can choose their specialization. There are some sports where we need early specialization, which is accepted, but most explosive sports bring the kids in at an early stage and expect them to be champions. **What is your opinion on this?**

I remember an interview 20 years back which I gave on television in Tamil Nadu. 20 years back, I gave an interview on the same question. I remember a parent, a mother, asking me a question over the telephone in a live telecast.

**Sir! My son is 9 years old, which sport should I make him a champion in?** Our aim is to make him a national champion, make India proud, and take the Indian flag around the world, and aspiration of a mother.

My answer is of four points. The **first point** is that at the age of 9, or below 10 years, please take him to a coach—a local coach or the physical director of the school—and have his potential or talent evaluated, assessed through a battery of tests. Though it is a crude technique, an old technique, it is gold. It has its own value and provides feedback on the overall potential and talent of the individual. That is the first point.

The **second point**, find out over a period of time, till 14 years, in which game, sport, or event the individual is showing interest. How do you find the athlete is showing interest in what event? Just watch him—what sport he watches on television, what sport he reads about in newspapers, or what he enjoys more. These are all small indicators to find out which sport he is interested in.

And the **third point**, find an expert to coach him. Find a qualified expert who can scientifically, biomechanically, and beautifully coach the individual in becoming a champion.

The **fourth point**, please find out the scope of the sport in the country and in the world. That will make him a champion. The scope of the sport is very important. That is where you get recognition for your country, for yourself, and for the next generation to come. So these four points I told you 20 years back.

So choosing the athlete and choosing the sport for the athlete depends upon all these parameters. But until 14 years, until you attain maturity—your puberty— it is 13 to 15 years. The basic motor qualities, the motor abilities, and the neuromuscular activity have to be developed. Because for any sport, you require these five parameters.

Strength, flexibility, speed, coordination, and stamina. If all these parameters are developed, he can go into any sport. Depending upon his anthropometrical measurements, the event can be chosen. Depending upon the talent he possesses, the explosiveness he possesses, the event can be chosen. Depending upon the limb length, height, or whatever it is, his coordination skills, the sport can be chosen.

There are different parameters to choose a sport. Based upon the talent and potential, he can become a world champion.

[Superb, sir. Sir, with this, I would like to come to one more question. Your opinion].

When Usain Bolt and Justin Gatlin, The 2017 scenario. There are so many athletes who have the sustenance in the field. Not like in India, where we see athletes achieve at an earlier period, maybe at the age of 21, 22, or 23, and afterwards, we could not find many athletes still sustaining in the field. But if you see Justin Gatlin at the age of 35, he ran with Usain Bolt in the 2017 event last event of Usain Bolt and he won and same is the case when Jonathan Edwards the triple jumper the world record holder and he did not win the first initial Olympic games but he was able to win the world championship and create a world record at the age of 27. **How do you see the sustenance of the athletes?**

The consistency and sustenance being in the field comes only when there is commitment and when there is an urge. When there is an urge, when you compete at that level, your atmosphere, your surrounding also has to suit your urge. Automatically the sustenance will fall in line. So when you get used into a particular habit, that becomes a practice and that becomes a regular routine.

After 10 years, after 20 years, it does not become a hardship or a challenge. It becomes a routine and it becomes a habit and it becomes easier. Without which you cannot sleep, you will get addicted. So automatically the sustenance prevails. So that is how it happens.

The initial 10 years will be challenging. The second 10 years will be testing. And the third 10 years will be accomplishing.

[Simple. Sir, coming to the final question to you].

Sir! You have seen our Indian athletes and coaching system, the foreign athletes and foreign coaches, and their coaching system with the present technology. as an athlete and coach at the current level, you have been witnessing all these tremendous changes. For this program, the NPTEL Exercise and Sports Biomechanics program, there are more than 1,600 members enrolled from all over India. **What is the message you want to convey?**

Because they are from different fields. They have enrolled to enrich their knowledge in exercise and sports biomechanics. What is the message you want to convey to these aspirants of this program? First of all, I wish to congratulate all 1,600 members with full appreciation for the interest they are showing. Never get satisfied—this is only a beginning, as I said earlier. This is only a startup. And you are going to embark on a very long journey. Prepare for a long journey to accomplish the final destiny of producing an Olympic medalist. That will be the greatest accomplishment of your journey in this course.

Your contribution is going to make a big difference in the sports fraternity of India. My message is that I wish each and every one gets committed, contributes, and produces a lot of evolution and transformation in the sports performance of this country. Congratulations once again. I must appreciate the whole team, Dr. Rajini Kumar and Dr. Viswanath, for their fantastic efforts and the initiative taken by such a big team, to spread the knowledge of biomechanics, the importance of biomechanics, the significance of biomechanics, and how it can make a change in each individual's performance.

[Congratulations once again. Thank you very much, sir].

On behalf of NPTEL and our team, Dr. Viswanath, and on my own behalf, I wholeheartedly thank you for spending such a valuable information. And to all the participants, it is the truth from the horse mouth.

The rich experience and truth from the horse mouth, I mean the international sprinter and international coach, Dr. Natarajan.

[Thank you so much, sir, for your valuable time. And again, we would like to have you on some other occasion to share more and more experience to the budding sports scientists of India. Thank you so much, sir].

[We came to an end of this course].

Throughout this journey, we have covered more than 15 plus technologies, which includes both open source software and paid version. If you have any doubts, feel free to contact us through either email or through Q&A forum. I take this moment to thank Visva-Bharati University and NPTEL for giving me this opportunity. In addition, I would like to thank IIT Kharagpur NPTEL team for providing us an entire backend support. I would like to thank fellow experts, all the teaching assistants who worked for this course.

Finally, I would like to thank my colleagues, friends, and especially my family members for their constant support. Once again, thank you so much for your patient listening.

[See you in the next course. Thank you].