

Exercise & Sports Biomechanics
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Lecture 49
Practical application of force plates (Continued)

[Hi, everyone]!

Application of Force Plate in Weight Lifting:

Again, one more domain which is an important one where most explosive activities are happening at the same time it is more injury prone and unless it is technically sound this will lead to severe injuries. So, one of such beautiful sport is Weight lifting.

[So, we have Mr. Kurbaswamy, the third year B.Sc sports biomechanics student is with us],

In weightlifting, we have two events, one is snatch, another one is clean and jerk. So, during these movements, the weightlifters, they perform with utmost speed, strength, power and coordination and which will load all the joints, right from ankle, knee, hip, spine, including shoulder.

[And you see here]

The beauty of this place is that underneath we have force plates. So, these force plates will help us to identify them. So, the place where I am standing here is embedded with two force plates underneath. And I just keep both of my feet on each force plate. And the moment you just apply the force, the ground reaction force can be calculated from the computer and in the software, it is recorded.

The peak force, the average force, and the impulse and the moment, the center of pressure, all these will be measured. And one of the finest information what we come to know is that what is the peak force in each leg we produce? So, what is the contribution of each leg in lifting the weight? So, that is the major factor which will be helpful to the coaches as well as the weightlifters in optimizing the performance and enhancing the performance and reducing the risk of injury.

And most of the weightlifters may not know, they are very much oriented or concerned with only the amount of weight lifted, not how much amount of weight is borne on each leg. So, almost both the legs should have equal distribution of weight while lifting and till the final movement is there. So, when this is equally distributed and the technique is said to be perfect, ideal and the athlete or the weight lifter can perform the technique and the event without any injury with utmost best performance.

[Now we are going to see Kurbaswamy performing the movement].

I just started interacting with you and now the force plate is ready and force plate has to be unweighted. Before Kurbaswamy comes here, in the force plate, right, he was made to stand on the force plate and his body weight was measured. Now, once the body weight is measured, yes, it is already measured now, and when the operator says yes, he will come and perform the action. Now he is standing on the force plate and he is going to perform the action.

We perform the activity and we can identify him, right, when he lifts away the peak force on each foot as well as the seam of the center of pressure. Movement of center of pressure can be easily identified. And when we come to understand about the asymmetry, so then obviously we have to work on the technique. So, maybe because of the load on one joint or maybe the weakness on one side of the muscles, maybe the reason for loading on the contralateral zone.

Application of Force Plate during Squat:

We can also measure the squat, okay. So, now the subject is going to perform the squat position. So, he is going to perform squats continuously, and we will be able to identify Okay, so the moment he takes more time in the upward phase, that means he is under fatigue. So, we can make the subject perform more repetitions at the desired rate.

For example, 40% of his 1 RM, then 60% of 1 RM, and 70% of 1 RM. So, he can perform. So, now he is going to perform 5 repetitions, and in these 5 repetitions, we will record the data and show it to you. So, he is performing the front squat, keeping the barbell in the front. So, I did not inform him well in advance. So, he does it quite naturally again, and this is a front squat. After the five repetitions, the data is recorded. So, that data will be shown in the subsequent slides.

Here we have come to basketball. Basketball is a game of explosiveness because it requires speed, agility, and explosive power. Most of the time, the players are jumping, as they have to take off for a jump shot or to retrieve the ball while it is airborne.

When the players are airborne during takeoff, they apply the force and go into the air, but more force falls on the legs when they land. So, it is four to five times the body weight, depending on the height they jump and the mass of the body. So, when they go for a jump shot or when they go for rebound collection, they sometimes land asynchronously. That means sometimes they land on one side, and most of the time, force plates are used to measure the landing force in three dimensions. That is the vertical force and medial-lateral force. So, the medial-lateral force is the one which loads the joints medially and is prone to injury. And we can identify the medial-lateral force through the force plate. At the same time, the vertical force and these are the two major forces when a player lands from an airborne position or phase.

There are so many types of skills in basketball. But when it comes to shooting, they go for a set shot and then a jump shot. A jump shot is the one most often used by basketball players to score. So, they do jumping movements not only to shoot but also to get the ball when it is near the opponent's ring or their own ring to retrieve the ball. So, after retrieving the ball, they obviously land—sometimes on both feet, sometimes on one foot, and

sometimes they load the joints asynchronously, and the joints are loaded, most of the time medial laterally. So, the stress is on the medial side even if we see most of the basketball player they get affected with ankle and knee injury. So, to get rid of this and to identify the amount of force which is loading on the joints as a ground reaction force can be measured only through the force plate. So, a force plate in the free throw zone and so when the players are going for a jump shot or a shot from the free throw line so you can identify the takeoff force as well as the landing force.

How long the player is airborne that can be identified using the flow speed and not only here and this place. If you see here, so this is the three point zone. From the three points, we do have force plates here and these force plates help us to measure the ground reaction force, the moment and center of pressure and flight time too and take off to flight we can measure. And so, this laboratory is equipped with lot of force plate's locations where 38 places are facilitated with force plate platforms and for different sports and games.

So, this is Versatile laboratory where all the sports and games can be assessed by using the force plate and 3D motion capture system in the real time environment. So, I am going to pass the player, he is going to jump and shoot the ball. So, you can see the jumping movement as well as the landing. So, he while receiving the ball also he just see here, so the ball is they have gone and he has to jump and receive the ball and then so while he was receiving the ball also when player receives the ball he jumps and receives the ball So, we can receive the ball also he jumps and receives.

Application of force plate in volleyball:

We have an exclusive facility for volleyball and this is actual volleyball court with the standard net for male and female. So now we have fixed the net for male and we have the system where the volleyball can be measured along with the kinetic parameters. So, whenever we go for volleyball, so only it will be video, I mean the skills will be assessed with regard to motion capture system. But only a few places have the force plate along with motion capture system.

And our center of excellence in biomechanics is one of such centers having the force plates underneath for measuring the jump service right from takeoff to landing. So, we have almost six force plates for takeoff as well as landing. And you can find that place where I am standing here is the force plates for landing, and the place where CP here is for takeoff. So, these plates are fixed to assess takeoff force as well as the landing force during the jump service and whether it is school boy or girl or national athlete or university level athlete all the metrics can be measured between these, I mean fixed force plates.

And you can see here and now we have a volleyball player, and he will be performing the jump service. and we can see the take-off and landing of a veteran and in volleyball when it comes to volleyball service is the predominant skill along with the spike and block. and with regard to defense yes obviously they go for under arm pass and over arm pass and when it comes to explosive activity yes obviously its jump service and jump on spike and jump and block so it is completely explosive nature but when these explosive skills are assessed obviously we need the force plates to measure So, one has to assess the takeoff force, the second one is the height that means how much height they have to go for and

what is the flight time, the flight time can be assessed from the force plate at the same time the landing force. So, when they land how many times the body weight is acting on the joints. So, in terms of times the body weight or in terms of Newton we can assess it.

We have not having this and this facility is equipped with not only for jump service also for spike and landing so the front row player can go for spike and landing where the force matrix can be measured at the same time the back row player when they go for, I mean spiking and landing yes obviously we can measure those forces. At the same time the blocking force also can be measured. Now we are going to see Pavitrans performing jump service and yes now again as usual the force plate operator has to be ready.

[Operator. Ready sir. Operator has to be ready. Yes. Now he is so].

This is the line, so he will take the jump from here and landing on the front side force plate. So, now you can see him performing and the force plates are recording the forces, the takeoff force as well as the landing force.

[Yes. Ready to perform]?

Application of the Force Plate in Gait Cycle:

We are here for another assessment, which is gait. So, gait is the pattern of walking, and here, So, in gait, we have different phases: one is the stance phase, and the other is the swing phase.

We have a subject, Pavitrans, who is a basketball player, but he is going to act as a subject for gait assessment. This lane is fixed with about 4 to 5 force plates of 1200 mm by 600 mm dimensions. And these force plates will help us identify the contact force at the heel strike and the propulsion force.

The braking impulse and propulsion impulse can be measured, and the COP, the moment, ground reaction force, and foot contact time—all these measurements can be assessed. At the same time, we can measure the step length and stride length when we integrate the force plate with the motion capture system. Now, the subject is going to perform the gait movement on the force plate.

Walking Gait:

[You can see walking, and after this video, you can see the data in the subsequent slides and the interpretation].

Now, the subject is going to walk. The operator is ready, and someone has to operate. the subject is ready, and he can perform walking. He is going to walk on the force plate. This is a normal pace of walking he performs. And we can identify the different loading patterns when the subject goes for slow walking, medium-paced walking, fast walking, jogging, running, and then sprinting. So, these different sequences of movement can be easily identified based on the metrics or the data from the force plate.

Fast Walking Gait:

Now he is going to go for fast walking. So, he increases the pace. So, he increases the pace, and then he is going to come back. So, the data is going to be measured in three dimensions. So, that is vertical force, medial-lateral force, and anteroposterior force. So, the force is measured in three dimensions. So, all the force plates what we have in our lab is three dimension piezoelectric sensors.

Jogging Gait:

And now he is going to jog. So, when he jogs, how the force vectors, right, being recorded comparing to the walking. At the same time, apart from jogging, he is going to perform running.

Running Gait:

You can run by increasing the pace. So, he runs. And post running, we can see how he is going to perform the maximal sprinting. So, he can go back and he can start sprinting. Okay, now he is going to perform sprinting with the maximum speed.

This is how we can measure the kinetic variables with regard to gait. So, right from slow walking, medium pace walking, fast walking, jogging, running and then sprinting, we can have all the graph. So, how the force is acting on when the leg or when the feet hits the ground. So, the mechanics of walking is totally different from mechanics of running and mechanics of sprinting.

When the sprinter runs, he sprints on his toes. But when a person walks, they have different mechanics like heel strike, feet flat, heel off, and toe off. So, these are all the sequences of movement when the foot is in contact with the ground, and the force vectors will also differ.

Application of Force Plate in Long Jump:

Now we have come to a track and field event—it is a jump event. So, in jump events, Tamil Nadu has very good long jumpers who have crossed more than 8 meters. We have a couple of long jumpers who have also represented India, and now we are going to see the long jump.

When it comes to the biomechanics of long jump, it can only be measured by the application of force plates. So, let us discuss the phases of the long jump. So, the long jump approach run itself is about 40 to 45 meters, and long jumpers have a pre-calculated number of strides. Any sprinter can obviously be a long jumper because long jump requires speed, strength, power, and coordination.

There are different phases in long jump: the approach run, the penultimate stride, the takeoff, then after the takeoff there is a flight phase. In flight, there are two different techniques: one is the hang style, and another is the hitch kick, then landing. So, these are all the different phases of long jump. But when it comes to data, for example, what is the reaction force when a long jumper goes for takeoff? It is nowhere. As far as Indian athletes are concerned, that facility is not much available. But now we have a facility—the actual track is here. We have more than six or seven force plates, almost 8 to 9 meters in length. We do have force plates underneath the track, which will tell us.

What is the contact time, foot contact time? And what is the reaction force in x, y, z directions? And particularly, what is the amount of force he applies during the penultimate stride and during the take off? and how many times the body weight is the reaction force can be assessed by using this force plate? And in this force plate we have already measured, so many athletes and also here we are going to assess with the long jumper. And so, we have seen 6 to 8 times the body weight is the reaction force when the athlete goes for, I mean the takeoff. Not only that, how much amount of time he is on the board. So, the force, time parameters is a great information or big information to the coaches, athletes and sports science professionals as well as the strength and conditioning coaches especially to design a specific program for them.

[Now, we are going to see Poovarsan performing the long jump].

So, he will be taking some approach run and followed by the penultimate straight takeoff and flight and landing. So, poovarsan is with hang style, he used hang style and he could see the data and here you can see. So, this is the data block and so, this is completely here.

Here we have the force plate. We can now very good data what we have to do or I mean the contact force and the reaction force in three dimension and one more information is that as well we can integrate with motion capture system as well as EMG. So, that will give you a beautiful data for optimizing the performance of any jumpers. So, that is the beauty of this technology.

Application of Force Plate in Pole Vault:

Now, we have come out with one more force information regarding an event, which is a beautiful event. So, it needs more coordination and rhythm. So, that event is assessed with a force sensor.

We are the fourth university in the world to have that facility, which is an instrumented vaulting box for pole vault. So, where I am standing, you can find the vaulting box, which is closed, and yes. So, this is the instrumented vaulting box. So, it is completely covered with sensor paste, yes. And the approach run, all the facilities we have fixed with the force plate, are on par with international competition standards.

So, the pole vaulter will have the approach run from the other end, and the moment he walks with the pole, the contact force when he hits the board will be measured in the xyz direction along with the foot contact because the place where I am standing is fixed with force plates along with the instrumented vaulting pole vault box. So, that is major information for coaches and athletes to improve performance and identify strengths and weaknesses, and to measure how much force the pole vaulter applies at the time of takeoff or planting. So, this equipment, or these force plates and instrumented vaulting box, can be integrated with a motion capture system. And this is how the force plates and force sensors help athletes quantify all the kinetic key performance indicators in any sport.

Application of Force Plate in Cricket:

[Hi, everyone! And again, one more game we are with, and I need not tell you about the game because by the appearance of the batsman itself, yes, it is cricket. So, now we are going to see about cricket].

In cricket there are different strokes, drives. And obviously, the moment the spectators, when they see the cricketer, the batsman, they see only how high the ball goes, how fast and how longer it goes. And so, cover drive, front foot defense and back foot defense and pull shot. So, but when it comes to biomechanics, yes, obviously, in this aspect, we are using force plates to measure the cricketer's, batsman's different strokes. And we have an exclusive setup in Tamil Nadu Physical Education and Sports University in our Centre of Excellence in Biomechanics High Performance Centre.

We could see the real cricket pitch. And in the batting zone, we have four force plates fixed underneath the ground to measure the footwork of the batsman. For an example, how quickly he generates the force. The moment he plays any front foot drive or cover drive or pull shot because the force has to be generated only from footwork.

And what is the vertical reaction force and how fast the force is being produced that is rate of force development and the moment at the same time the explosive power can be measured from the force plate what we use here. And this helps them, helps the batsman to identify how much amount of force he applies whether it is 1.5 times the body weight or 2 times or 3 times the body weight. It depends upon how and the ball selection and the technique which he uses. And here we are going to see about the batsman's different stroke based on the ball. So, he will be playing different shots where the footwork will be assessed and measured through the force plate.

[And one more thing is that I am with Mr. Kripakaran and he is a final student of exercise physiology and sports nutrition in our university and he is a batsman and he is going to act as a subject now].

Now, we are going to see and he will be playing different shots. based on the ball selection because we have a bowler on the other end and we do have force plates in the bowling end. So, we are the university, we are the lab, we are having about 6 force plates almost more than 3.6 meters in length where the force plates are mounted, where the bowler's pre-delivery stride and delivery stride can be measured with regard to kinetic parameters are concerned. So, and now we are going to witness the movement of Mr. Kripakaran and he will be playing different strokes based on the ball selection.

And post this movement, we will be explaining about the force plate graph. It is force time data. So, force is always measured in Newton. And for layman perspective, it is converted into, I mean, person's body, I mean, body, times the body weight and our percentage of body weight.

So, in the ideal context I would say what is the reaction force in terms of percentage of body weight of a person and how fast or how quickly he generates the force that is rate of force development. So, force time parameters can be measured all rest of the all components are derivatives. Now, we are going to see Mr. Kripakaran performing different strokes in the pitch. [Yes, now over to the operator. So, operator is there in front of me and

they are getting ready and switching on the force plates and now kripakaran can act according to the commands of the operators].

We have a bowler there, and now you would have seen different strokes by him from the place where I am standing with the force plate. So, we can find out how much force he applies, and the reaction force can be found out, as well as how fast the force is being applied.

So, that is the metric we can assess from the force plate. And one more thing is that, as I usually say, not only the force plate, but it can also be integrated with a motion capture system to assess the different kinematic parameters, like ball velocity, bat velocity, and joint angle velocity. So, all types of kinematic parameters can be assessed by using the motion capture system and integrating it with the force plate.

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