Fundamental movement skills - Part 2

Right, so let's look at what are, now that we've looked at how you can bifurcate this simple skill of vertical jump. We looked at two different skills. We also looked how do we phase them into, you know, their sub-phases. Now let's look at what do we analyze. What biomechanical considerations should we be careful about? So during the flight phase, right, so flight phase as in from descent to ascent, right, so that is your flight phase. So when the body is in flight, there is no contact. So flight phase also has no contact on ground, which means your body in air, right, so that is your flight phase.

So once you have gone from descent into the ascent, your proper body positioning or coordination is quite important, right, because you are in the air. So to maintain the body position and to maintain the coordination is quite important because the way you maintain the body position will impact your landing. So landing is from your ascent when you're again going for the contact on the ground to finish the jump, so your foot contact, right, that is when you're landing. The landing mechanics are quite important, right?

So why these landing mechanics are quite important? Because the way you land, if for example you land only on your heel and stay there, there are a lot of ground reaction forces that go up, right, which can have injury implications. Hence, it's quite important to have good body positioning so that your landing mechanics are efficient. Right, so we are at it. So landing mechanics, that's why for proper absorption of these forces when you're landing, your hips again go into flexion, knees, and ankles along with it, right? So it aids us in absorption of these impact forces as we spoke about.

And all of that then helps us to prevent injuries or they're quite key for preventive care. Right, so for this, let's just look at. So these ground reaction forces, so how are they important or what's the biomechanical characteristics of that, sorry, consideration of that. So GRFs is basically the push off the ground with the legs, so that generates your ground reaction forces. So right, that's going back to your third law of motion, there's equal and opposite force.

Hence, if you're using or producing force to push off from the ground, you're generating equal and opposite force, which is to the acceleration of gravity, which is your ground reaction forces. So they act against gravity. So gravity is acting downwards and that's your body, for example, oops. So your GRF acts in the opposite direction, right? So they are quite crucial for propelling the body upwards.

So GRFs are quite crucial, generating as much force. So that leads us into force production. So for force production, your important muscles are of the lower body as we looked at, cords, hamstrings, gluteus maximus, these muscles around the pelvic region, because there's a lot of rapid extension happening at the hip and the knee, and they contract generating upward propulsion. So you see how we can finally bifurcate with all the

knowledge that we have collected in all of these previous modules, you can use that bit-by-bit information and put it into the context of a vertical jump, which is a fundamental skill, right? Once we get the knack of understanding how we can do it on these skills, we can then go on to bifurcate your sporting skills, right, because a vertical jump, for example, could be an underlying movement pattern.

So where else would you see a vertical jump being executed? For example, volleyball. So your volleyball would have a vertical jump, right, your basketball would have a vertical jump. So you see how of all of these sport would have these fundamental blocks or these fundamental movement patterns and understanding these or perfecting these will help you understand the sport quicker or be good at the sport quicker, right? And in case we want to go back to sport analysis, you will often see that we again come back to the foundational movements, we again come back to these skills, try to perfect them, and then try to maximize or have efficient performance. Right, so the last bit here is the center of mass.

So we know that the definition of center of mass is where the body's mass is concentrated, right? So to have a controlled center of mass or to have a balanced posture to coordinate the movements specifically of the trunk, right, and the limbs, it's quite important to, let's just get rid of this, so you can see what's written here. So it's quite important to ensure efficient force transmission, right? So to transmit the force, right, it's quite important for a balanced posture and coordinating. So your center of mass is moving from a down position to the top, right.

So now that we have looked at the vertical jump, let's try to understand the horizontal jump. So as opposed to the vertical jump and then as the name suggests, the movement analysis, let's start with the aim again. So the aim is again to achieve maximum horizontal distance, right? So this will again test different capacities and let's understand what do we test. So again depending on your biomechanical characteristics and it depends what you're testing.

So the horizontal jump is another important performance test. So again with the horizontal jump, they can be broadly categorized into standing broad jump with hands and standing broad jump without hands, right? Now why would they say broad? Because your feet are shoulder-width apart. So that's why. So it's not a narrow, you know, characterized jump, it's a broad jump.

So shoulder width apart, right? And then that's with hands and without hands. So the performance outcome here again is to look at lower body strength but in different direction, right? This is more, you know, in the forward or the upward propelling direction and this is in the forward propelling direction. So it's lower body strength and also explosive power.

So you see every time when we look at with hands and without hands and the role of hands, right, to create or to categorize a jump as explosive, right, because it's quite dynamic

as we've looked at it. Whereas without hands you're purely testing majorly lower body strength. It's quite important to know the difference. Right, so let's get into the phase analysis. Before that, let's look at functional anatomy.

So again the plane of motion is sagittal, right? So you're looking at the sagittal plane of motion. Best view to analyze this. So if you're looking at analysis, then lateral view and frontal view, right? So looking at the jump from the front or the lateral view and the tools that you can use again for this are your force plates because it helps you to look at landing mechanics and also your video cameras that help you do qualitative analysis.

Right. So what are some of the major muscles that we use in the horizontal jump? Now because we know that it's concentrated in the lower body, it would be again your big muscles. So you have knee extension during take-off, right? So if we just quickly draw. So that's your body and that's without hands and then you have some kind of, the way you're landing would be from that position as well or in the air you might have, so you definitely have that phase. Sorry, let's do that again.

So you definitely have that phase, right? Something like that. Right. So you have knee extension during take-off. So once you're about to go from this phase to that phase, that's your take-off, and as the name suggests you're basically taking off.

So you have your quadriceps, right? And then what's also happening is with your knee extending, your hip is extending as well. So that would be more of like a, that would be more like a, that we looked at. Right. So you would have your hip extension during take-off as well.

Right. So, and your hamstrings and gluteus maximus, the major muscles are quite key in that. You'll also have ankle plantar flexion. So your ankles is quite important as well. And for your ankle plantar flexion during take-off, again, your calf muscles of gastrocnemius and soleus are quite important. Along with all of this, you have your core muscles.

Now, remember that core muscles are also important in your vertical jump. So I know we didn't have it in that slide, but yes, they are quite important and for horizontal jump, you have your core muscles that help you stabilize the spine. So the spine that you're looking at that goes through different, you know, transitions. So it helps you stabilize the time during take-off and landing. So that would be your, some of that would be your landing.

And of course the arm swing. So in case of the broad jump with hand, you would be using your deltoids and your pectoralis major, which is your anterior chest muscle. Right. And your deltoids and your pectoralis major are quite important in helping you with the arm swing. So now that we've broken these down into what functional anatomy and what muscles are quite important and at what phase, let's look at the different phases. So you have the take-off phase where you're actually taking off, right? So you have rapid hip and

knee extension happening as we've looked at, and which is coordinated activation of these muscles.

Right. Then the next phase would be the mid-air phase. Right. So you've taken off, now you're in mid-air or as we looked at in the previous, that's the flight time. Right.

So that's the body is in flight. Right. So during the mid-air phase, there's a slight difference of course between both the jumps. What happens in the jump without the hands is there's minimal muscle activation as the body is in flight. So you're just traveling through the flight.

Right. So you're maintaining or controlling your balance and coordination. However, in the jump with hands, there is arm swing contribution. Right. So because your arms are being used in the flight, there is additional forward momentum that's gained. So apart from when you've taken off, the arms then have helped you to add to that momentum.

Right. And during the landing phase, which is your last phase, so we've broken this down into take-off, mid-air, and landing. Your hips and knees again go back into flexion, that's to absorb the impact. Right. And there's eccentric control. So that's a control landing mechanism where your lower body muscles are quite important.

We know which ones those are by now. And if not, let's just link them back here. And your core muscles again help you stabilize. So you see how every time we do this movement analysis, it gives you a bit of a blueprint of how to approach a skill and how to bifurcate it into the important interaction of functional anatomy, the mechanics, breaking it down into phases, trying understanding the underlying action. Right. So as a coach now, all of these when you're looking or evaluating, so for example, if you're testing, right, if you're testing horizontal jump, and we will be looking at what variables to look at.

So you would be performing it the same way. Right. So once you get your video data, right, you would be breaking it down into phases. You could also then break down into sub-phases for certain movements. And once you've broken it down into phases, we've looked at what are the important events.

So events of interest. So you will follow through the same pathway. Right. And in the events of interest, what is my anatomy? So if I'm looking at functional anatomy, I'm looking at what's the plane of motion. Right. So what's the plane? What's the axis? Right. And through these, what are the major muscles? So major muscles.

And why would this be important? So that you can develop strength accordingly, right, in your major muscles that are important. And from functional anatomy, then you would look at movement characteristics. Right. So when you're looking at movement, you would look

at the biomechanics. So you see the procedure for analyzing or looking at every skill is the same.

Right. So if we follow this blueprint of having to go down these steps, you're literally breaking down a complex scale into trying to understand the nuances and becomes easier for you to study it. Now that we've looked at horizontal jump and vertical jump, let's try and understand some of the important biomechanical characteristics. Right. So for key biomechanical considerations in the flight phase, which we've also looked at previously defined as mid-air, right, you need to have proper body positioning and coordination as we've looked at for the vertical jump and it impacts your landing position. Just let's quickly briefly go through these because we've already looked at these during the vertical jump.

It's just to reiterate and give you that both the jumps would have similar biomechanical consideration, it's just the direction of both of them. The propulsion of the body is in different directions. Right. So landing mechanics, again, your hips and knees and ankles upon landing get into flexion. So this aids us to absorb high forces, impact forces, key for preventive care.

You also have your ground reaction forces, again, there's a push-off from the ground to generate ground reaction force, it's just the direction is towards that. Right. It's propelling the body.

That should be forwards. Right. And your force production is again by the lower body muscles, we know those big fours by now, and they contract generating forward propulsion. Right. And then again, it's important for your center of mass that's traveling through space and that's covering a horizontal distance. So that's covering the horizontal distance to maintain good balance and posture.

So there's efficient transfer of force. Right. So now that we've looked at the horizontal and the vertical jump, let's try and understand the key performance variables. Right. So what are we looking at as coaches, as sports scientists, when you're trying to analyze, what do we calculate? So the key biomechanical variables would be the jump height and the distance. So in both the case scenarios, either if it's the vertical jump height or the horizontal jump height, you would look at height and distance. So basically it's maximum height reached by the center of mass during the jump or maximum distance that's reached by the center of mass during the jump.

Right. So this is a key biomechanical variable to look at. You'll also be analyzing your ground reaction forces. So the force is exerted on the ground so that you can get a fair bit of an idea of what you're using from the ground and how you can propel your body upward or forward. You'll also be looking at the velocity profiles. So velocity, which is defined by speed of movement during the jump. So your vertical velocity in the case of the vertical jump and your horizontal velocity component in the case of the horizontal jump.

Right. You can also look at acceleration. So rate of change of velocity during the jump. So how are you accelerating? Right. So GRF is part of acceleration as well. So are you taking off, for example, using this GRF. Joint kinematics are quite important, of course, because we go into flexion and extension at these major important joints of the lower body.

It's key or it's crucial if you could know what is the depth that you're achieving. What is the angle that you're achieving during landing, during takeoff? Right. And of course, even during mid-air for us to understand that during the mid-air, what's the body positioning? Right. So important joint angles would be hip, knee, and ankle. During the takeoff and the landing time, it's also crucial for us to understand the duration of the phases.

Right. So from your takeoff to your mid-air to your landing, if we can understand the time durations, it can help us give an explanation of what's happening faster or quicker and what's happening slower. Right. To put it in very layman terms. So time duration gives us a good understanding of how the movement is being performed.

Right. And how are we accelerating? How is the velocity changing? Right. Also, when you look at the counter movement, because you're starting from a standing position, we also looked at the depth that is achieved. So what depth are you achieving? So that you can then look at the ground reaction forces as opposed to the depth that you're achieving.

So have a comparison of that. Right. So we've looked at, you know, the biomechanical characteristics of the key performance variable. So all of these variables are quite important. As we've mentioned earlier, let me just quickly mention that the tools that you could do this with, of course, for a qualitative reference would be. For a qualitative reference, it would be the video camera.

So you can look at the overall quality of the movement. Right. Whereas for your, sorry, for your quantitative analysis, and you do have quantitative numbers in this, that is for your kinematics and kinetics, because you have ground reaction forces as well, you can use force plates and you can also use 3D motion analysis, right? Where you can put markers and you can understand precise joint kinematics. Force plates would give you GRFs. Right. So all of these variables can be looked at with these tools that we've looked at in the, in module five.

Right. So we've looked at vertical and horizontal jump. Let's quickly get into running. Now we do have a module following this on gait analysis, gait forms, and fundamental base for running and walking patterns. So you will be learning more into that module. However, for the purpose, and of course, running is quite complex.

Running as a sport is quite complex. It depends on if you're a sprinter or 200 meter runner or a 400 meter runner, or even for marathon, right? Or running casually for fun. So all of these require different set of biomechanical characteristics underlying that help us

understand the technique, the output, and what's important. Right. So for running, let's look at running as purely a recreational thing here. So what are some of the major muscles in running? So you of course have your quadriceps because it's heavily dominant again on the lower body.

So there's, quadriceps help you in eccentric contraction. So there's initial contact and then concentric contraction happens when your loading, right? So your load, there's a loading response to extend the knee. Right? So that's what we're getting into. Quick brief of functional anatomy for running. Whereas your hamstrings, right? So your hamstrings eccentrically contract during the loading response. So of course there's equals, so it's an antagonist and one's a prime mover, right? So when quadriceps is your prime mover, your hamstrings are the antagonist, and vice versa.

Right? So the hamstrings eccentrically contract during your loading response for controlled knee flexion. So there is knee flexion happening. Whereas your gastrocnemius and your soleus, which is your calf muscles, these are your calf muscles. Where would you, I know we've not discussed this so far, but let's get into where would you find them. Yes, they would be located posterior.

Right? So on the posterior side. Also, if you're looking at anatomical reference, it'll be distal to the hips or the knee. Right? Quick recap. Right? So gastrocnemius and soleus, they undergo concentric contraction for plantar flexion, which is happening as you take off and you get into the flight phase. And that happens repeatedly over and over again as you run. There's also gluteus maximus, which is, so these are majorly one, two, three, four, whenever there's a lower body dominant activity, quite active muscles, you know, for your flexion and extension that's happening at the hip, knee, and ankle.

So gluteus maximus again along with the hamstrings, it's on the posterior side, so goes in for a concentric contraction, mid-stance. Right? So there's a mid-stance phase as you will look at in the gait module that's responsible wherein hip extension happens. Right? So for hip extension, you have your gluteus maximus that go in for a concentric contraction. Right? And your hip flexors, as the name suggests, they flex the hip.

You have a concentric contraction, so you're getting into flexion. Hence the concentric contraction happens during pre-swing and initial swings. Swing is your leg movement here, not your arm. Pre-swing and your initial swing for hip flexion. So that's what the hip flexors go into the concentric contraction for. I know this could be a little daunting because you have a lot of muscle actions happening at the same time and different enduring phases of running, but if you could break it down again and try and understand, right, what the quadriceps do, what's the plane of action, right, what's the contraction happening, what's the mechanism that's happening, it's quite easier to remember.

Then you have another muscle which we haven't looked at. So as opposed to the calf muscle, this is in your anterior compartment. Right? So that sits on your tibia. Oops. On your tibia.

And as the name suggests, its tibialis anterior, so anterior part of the tibia. So that goes under eccentric contraction during the initial contract for the foot to dorsiflex. So if you see your gastrocnemius and your soleus muscle responsible for ankle plantar flexion, tibialis anterior, that's on your anterior part, is for your foot dorsiflexion. Right? And then you have your upper body muscles. So these are all your lower body, your upper body muscles, combination of a lot of them, your shoulder muscles, your rotator cuffs, you know, your anterior muscles of the chest that contribute to the arm swing. Right? And then last but not the least, you have your abdominal muscles that provide core stability and also maintain body posture during running.

Again, quite important. Right? So for that control of center of mass, the transmission of forces. Right. So let's look at the key phases and the mechanics during running.

Quick brief through. We have first phase, which is the stance phase. We have stance phase is known as your weight-bearing phase because that's exactly where your foot is in contact with the ground. So one or two feet are in contact with the ground. It happens. There's a lot of weight bearing happening, push-off from the ground, ground reaction forces happening during the stance phase. So what's the mechanics over there? Of course, because as weight bearing happening, there is load absorption.

So there is impact forces that are being absorbed. Post the absorption. when you go into the takeoff, there's propulsion happening. And of course, there's maintenance of balance as you land and you move into propulsion, absorption to moving into propulsion. There is maintenance of balance. Right? Second phase would be the swing phase. So as the phase name suggests, this is where it is non-weight-bearing phase where the foot is lifted and you go into the forward action.

Right? So you lift the foot, move into the forward action. That's the swing phase, no weight bearing at all. And the mechanics here would be the limb advancement. Right? So the limb is advancing from the weight from the weight-bearing phase into the preparation for the next stance phase. Right? So in between two stance phases and when you would have your swing phase.

Right? And then you have transition phases. So between your swing and stance is transition phase. As the name suggests, that is where you are in transition. So transition occurs between the two phases, which is stance and swing. So between the weight-bearing and the non-weight-bearing phase. And we do know from now that the mechanics there would be to have a good transfer of body weight and controlled movements that it's a preparation time for your limbs.

Right? So if you look at it, of course, these phases can be then subdivided into sub-phases. Right? Which is a detailed analysis of running. But for the purpose of this module, we'll be just looking into these three major phases, which is your stance, swing, and transition phase. Right?