Academy of PHYSICAL MEDICINE

Transcript

Gait Analysis in Clinic
With Dr. Paul Barrett

APM: Our guest speaker is a man we've had on before. He's Dr. Paul Barrett who is a PhD podiatrist. He spent 20 years in the arena of gait analysis and lower limb biomechanics, very experienced man. We're getting him back for the second time because after the last broadcast, people said they hadn't had enough of the detail behind gait analysis. So when he gets here, he will take over a large part of the evening. What I want to get from this this evening is I want to look at the common foot abnormalities that we might see in clinic. I want to see how we can identify those easily, what they might mean in terms of biomechanical problems throughout the kinetic chain and what their impact might be on patients and of course, what we can do for them either through physical therapy or through orthotic therapy. So before I start, I want to welcome my gust patient this evening. Rowen, thank you for coming to join us, already barefoot and ready to stride across our gait plate. The way we're going to do this, we're going to use The Orthotic Group technology. Now, The Orthotic Group, TOG as most people refer to them, produce a force analysis plate. They're not the only manufacturers of this sort of technology. I use them because I found them to be very useful in terms of customer support. When I need clinical advice on the scans that I'm producing, they're very quick to respond. They produce extremely good quality orthotics and they're very ready to respond with repairs and remedies and adjustments when orthotics don't go quite right. Unlike so many things in medicine, I think orthotics are no different. Sometimes what you think is going to be the perfect orthotic just doesn't work and you have to try some weird and wonderful adjustments until you get the best result for the patient. So the first thing then is to have a look at the equipment that we're going to be using this evening. There are two main parts to this and we're going to look at the first part. The first part is the force plate which you can see on the carpet of the studio here and this is an earlier generation than the current model but it still scans at 150 cycles per second. And so as the patient walks across the plate, what we'll be seeing is the ground reaction force coming up through their feet every 150th of a second and the software will analyze that

in 10 different areas of the foot as you will see when we turn to the computer itself. It also does a static analysis. You'll see that demonstrated in a moment and all that comes through the software on the computer. So if I turn to the computer now, what I've done here is I have entered Rowen as our guest patient this evening. It's asked for his date of birth, his gender, his weight and his foot size. Weight is important because it dictates the thickness of the orthotics that we might use and the orthotics produced by The Orthotic Group are what's known as semi-rigid. In other words, there's a little bit of give in them and the foot size is important not only for the size of the orthotics that are produced but also because it influences the size of the picture that's generated as the patient walks across the plate. This technology analyzes the patient's stride in pairs. So it does a left and a right and then it saves the pair along with a static stance all at once. I find that slightly odd. I'd rather it just be single feet because then you can mix up the scans so you get the ones that you think are right but what it does mean is that I would always carry out 3, 4 or maybe half a dozen scans until I'm happy that I'm getting a repeatable product. Obviously, and if you find it yourself, you're walking down the street and there's a gang of youths on the corner, it's actually sometimes quite difficult to walk because you're conscious that people are watching you. Patients find the same thing going across these plates and invariably in clinic, almost invariably, someone will be perfect when I practice them across the plate and then when we come to do the scans, they will stride up completely differently or they'll wobble. So I do several scans to make sure we get the perfect answer, as it were. There a number of ways, a number of theories in getting people to walk across the plate. The one I think is most commonly held is that they should take two steps before they actually hit the gait plate which means you have to have them starting in the same place each time and the plate, the right distance from them. We've marked out the floor with tape in here. In my own clinic, I start with them with their back against the wall and I adjust the position of the gait plate so that they're actually in the right place when they hit it. So we're going to get Rowen. Rowen, if you could stand on your first mark, please. As you can see from the screen here, it's very simple at this stage, there is a save and scan button. So we're going to save the patient's details and we're going to get him to walk across the plate. Now, you don't need to tell the plate which foot is coming first because it'll work that out from the scan. So Rowen, if I can ask you to step up with your left foot first and you can see the image of the foot as it arises on the screen there. The only reason I said, "Start with your left foot," is because that way, I know which one to tell him to start with next time. Otherwise, we could end up with dozens of left foot scans. Rowen, if you start with your right foot this time, please. All right, the screen's gone blank because the software is now expecting a static scan. So Rowen, if you could stand inside the white rectangle on the plate and what you'll now see is a crosshair effect on the screen which shows you where the center of balance for our patient is this evening. When you're happy that that is no longer moving, you can press capture and the machine will now save the scan. So Rowen, if you go back to your first mark while it's

doing that. It's an interesting scan, the static scan because it shows you whether the patient's putting more weight one side than the other. It shows you whether they're leaning forwards or backwards and you can often determine whether there's a leg length difference from increased or reduced pressure on one or other side of this. It doesn't always correlate but if we now go back to the program…OK, looking at the screen now, what you can see is…the white areas around the feet are no pressure at all, around here and then we've got a graduated pressure from blue through to yellow and to red. And so the higher pressure is the red areas. What's most useful about this is this dotted line which runs up the middle of the footprint, as it were. Each of those dots is one cents from the machine and it gives you an idea of the overall pattern of the footfall. So it can give you a good idea of whether your patient is pronating or supinating and the red spots in the footfall here can give you an idea of whether there's an overall buildup of pressure on the inside or the outside of the foot which, very often, will correlate with supination or pronation. Now like I said, I'm going to do a second scan with Rowen because I want to be able to compare the two to see whether that was a normal base for him. So I'm going to press "new scan" and Rowen, if you could start again with your left foot, please and then on your mark again and start with the right foot. OK, now I'm not going to do the static scan again. I'm just going to tell it to capture the scan and while it's saving, what we will get from this is we'll get an analysis of 10 different aspects of our patient's foot. This will be broken down into the various parts of the gait process. It will be broken out to heel strike, pre-midstance, midstance and propulsion and we'll be able to see the normal ranges, normal pressures within those phases and be able to judge whether our patient is matching those optimal criteria. Some of the other things that are possible here, of course, and one which is quite useful at this stage is this "compare scan" function because if I press the "compare scan" and then go for the previous scan by double clicking, you can now see that we've got…both of the scans have carried out on the screen and it is often useful to be able to judge whether those are similar to each other and there are quite a few differences between these, as you can tell. What we've got here is considerably less pressure around the left heel on the most recent scan and we've also got more spacing between the dots on that scan. I'm going to tell you why I'm really relieved because our guest speaker has just arrived in the studio. So while he's getting mic-ed up, I'll carry on briefing you about this and then he can come and give you the really in depth stuff about gait analysis. You'll also see that there's a different pressure buildup. There's a hotspot on the outside of the left foot here and on the inside of the right and on the big toe whereas the pressure seems more evenly spread on the second scan. What we can also do with this is, as you can see from the buttons at the top, we can have a look to see whether our patient compares well against what is described as an optimal scan. Now on the right of your screen, you now see what The Orthotic Group have decided is a more or less optimal scan. I'm not convinced that it's perfect but they assure me that they went through thousands of people and this is the best they could come up with. I think

there should be a clearer curve at the bottom and that it should curve more gently towards the big toe as it goes through the gait scan but by and large, it's not a bad analysis of an optimal scan and we can then look at Rowen's scan and we can say, well, this line on his left foot goes far more directly towards the outside of the foot and has a sharp turn inwards whereas this one has more of a curve to it, goes up through the center of the foot and on the right foot, this one appears to be more medial with less of a turning on to the big toe. So already, there are things there which might be regarded as unusual. Now, I'm not going to say that this is the perfect scan. In actual facts, I would've gone through several scans before we decided which one to use for analysis purposes but this will do for the purposes of this evening. And having done that, I'm going to go back to the normal screen here. We'll use that but let's come back into the studio for a minute. Paul, welcome, again to the Academy of Physical Medicine.

PB: Thank you.

APM: I'm delighted you made it. I was having to wing that. I'm not really prepared for briefing on gait analysis myself. What we've discussed so far is that…what we want to get from this is some information whereby our viewers this evening can analyze some of these gaits when they come into the clinic through simple eyeballing gait, if they don't have the technology, recognize some of the common abnormalities and I have in mind hallux abducto valgus and bunions, claw toe, hammer toe, mallet toe and plantar flexed first ray which I know is a particular issue that you concerned with in the past. You talked to me a lot about it in the past. There may be other things. I've got some photographs of those or some images of those that people can turn to if that's helpful. And then, of course, your process for going through case history taking, what's important, how you go about the analysis that's necessary to come to the conclusion that orthotic therapy might be useful, some other therapy might be useful and then how you would analyze the scan that we've just taken of our patient here. Does that —

PB: Yeah, absolutely. Sounds good.

APM: Can I turn to…I'm not quite sure where we're at. We're slightly thrown by the fact that we've had to do this in an odd sequence. Can I start with those foot abnormalities that I mentioned?

PB: Sure.

APM: If I just bring up these scans here, right. So on the screen at the moment, our viewers are watching slides of claw toe and hammer toe which from that screen, you'd think, "Well, it's pretty obvious." Now, I've always thought that claw toe is less obvious elevated than that but very often, down on the ground but they were more arched whereas the hammer toe, of course, it's dorsiflexed at the metatarsophalangeal joint and then flexed on to the floor

and then dorsiflexed again at the distal interphalangeal joint. What does this mean in terms of the effect on the patient? Why might they have that? How do we fix it, if we can?

PB: Well, first of all, when we're looking at these particular abnormalities, they accompany a certain foot type. So they're not an entity onto themselves. One is generally caused by flexor stabilization and one is caused by extensor substitution, one occurring during the swing phase, one occurring during the loading phase. If we think about an over pull of the flexor tendons on the sole of the foot when you've got a mobile flexible flat foot, what you get then is an over pull of the flexor tendons. Flexor tendons insert in the distal fillings and then they cause this retraction. They pull and they cause the hammering of the digit and it cause a curling of the toes also. So you can very often see curly toe on the 5th, a curly toe on the 4th.

APM: When you say curly toe, you mean what we've seen here as hammer toe?

PB: Well, a hammer toe is where this dorsiflexes. A curly toe, you'll get an abduction of it also. So it's actually pulling it, it's twisting it into this position as well as this position. Clawing of the toe is a different thing. It normally accompanies ankle equinus because what you're getting then is an over pull of the extensor tendons when the foot's in swinging phase. If you have a very tight calf muscle which is pulling the foot into plantar flexion through swing phase, we have two options. We either trail our toes or we retract our digits and that retraction…because it actually attaches on to the proximal fillings, it tends to pull the toe up in a clawed fashion and the difference really is a clawed toe will be at a much steeper angle and a hammer toe won't be at a steeper angle. It'd be much more defined with the middle digit and very often, that can even extend to what's called a mallet toe. A mallet toe then moves around just…and it really only affects the very distal joint but they're due to, you know…yeah, exactly. So that would be a mallet toe.

APM: Yeah.

PB: A mallet toe also can be evident in somebody who has a long digit. That's also very common for people that have a long second. My mother-in-law has a mallet toe, long second digit.

APM: Would you normally expect that these are going to affect 1 or 2 toes or would they normally affect all of the lesser toes?

PB: You tend to see it all the time…not all the time. You tend to see it nearly all the time in the fifth. It's called digiti minimi quinti varus and it's a big, long fancy name for curly or retracted fifth digit. That's one of the things you look for in a child. If you're looking at a curly toe, curly 5th, curly 4th, it can be a good indication of a flexible flat foot. If you're seeing it in an adult, so if the mother has it and the child has it then it's a good indicator that…then there's

no point letting this child wait until they're 20 before we start deciding that we might treat this, OK? So these particular things, you tend to see them as time moves on but the actual curly toe in the 4th and 5th, you'll see in the young children. The actual clawing of the toes becomes more progressive with a more equinus or anterior equinus foot type.

APM: So are these things fixable? Do orthotics make a difference? Can physical therapy make a difference? Should we worry about it? Are they going to give the patient mechanical, biomechanical problems, any particular pain?

PB: I think that question really relates to when they come to you. If somebody has had claw toe or a hammer toe for 50 years, I don't think it's fixable unless the surgeon gets at it. I think if someone is younger and it's flexible, what I tend to do is…my rule with the foot is if I can put it into a better position with my hands, I can do it with a device. So if I can take a hammer toe and straighten it with my fingers then there's a good chance we can help to straighten it a little bit with either a brace or taping or some other manual therapy.

APM: And do you find patients come to you complaining because they've got hammer toes or are they complaining something else and the hammer toe's merely a manifestation of that?

PB: Very few people come to me complaining of hammer toes. They come complaining of a corn on top of a hammer toe or they don't relate the corn to…they think they've got a bad corn. They don't then look underneath the corn and think, "Well, why have I got the corn?" You know, very often with a flexible foot, if you just put a metatarsal pad, move it forward and push it up underneath the metatarsals, that's enough just to help straighten the digits. And again, this is not, you know…it's not something you're going to miraculously stretch out that flexor tendon but it's certainly going to help. And it can be the difference the difference between a toe rubbing in a shoe or a toe not rubbing in a shoe. You can also use silicon which is called OrthoForm, OK? You can make a multi-digital prop which…it's like putty. I'm not sure if any of you've seen it. It's putty, add a little bit of hardening agent to it. You mix it up in your hands and then you fit it in underneath. So essentially, you take the digits, you make the device to sit underneath the digits and then you…it sits in between two toes and the patient wears it. If that works, we can add that to an insole. So we can actually put a bridging pad further forward to help lift in the case of a mallet toe.

APM: And if you see one of these problems, claw and hammer, mallet toe, would you normally associate it with problems further up the kinetic chain? Is it going to be an indication you'd expect, let's say, as in extreme lower back pain?

PB: Yeah, I mean let's take, for example, a hammer toe. Normally hammer toe's caused by a flexible flat foot. It's caused by the loading phase when you've got a flexible flat foot or an over pull of the flexor tendons at an acute angle or oblique angle. If you have somebody who has a flexible flat foot, when they load, they elevate the first metatarsal. We talked about this in our previous web discussion and that then causes the first MTP to load. So that will then cause a compensatory reaction through propulsion which causes the foot to rotate, externally rotate. IT band has to over fire but it may do it and then have…they get switched off. Piriformis gets balled up and we get an over pull of our iliacus and our soleus major muscle. So yeah, you can take a hammer toe and you can follow that all the way up the chain because the hammer toe is a result of abhorrent foot mechanics.

APM: So we can perhaps look in a little while about what we might do about these individual conditions, whether through physical therapy or through orthotic therapy. One of the slides I did, this came over a moment ago, of course, is hallux abducto valgus or, you know, commonly called bunion because the bunion is actually only the bit around the first joint, isn't it? So what's likely the cause of that? There's a common I think fallacy that it's brought about by women's footwear. It is more commonly seen in women, isn't it?

PB: It is more commonly seen in women and there's a lot of men who have it too and don't wear women's shoes very often but this is caused by hypermobility through the first ray, very often, even a short first ray, like a Morton's foot which is a slightly short first ray but it is caused by hypermobility through the first ray of the foot. Interestingly, there was a study in Africa where there was a tribe had never seen shoes and a lot of them had this deformity. So it's a genetic link. There's also a lot of I think confusion on what is a hallux abducto valgus and what is an exostosis because what you've got to look at is deviation from the midline of the big toe. So you want to take a line from the first metatarsal and the follow through and that's your deviation. If you have a large lump on the side of your toe but very little deviation in your digit, in your hallux, it's more than likely an exotosis on your first and that's something then you can refer to orthopedics but if it's not, if there's a lot of deviation then…and being honest, research doesn't show that an insole will correct this. Research shows only that it will help slow down the rate of progression of hallux abducto valgus.

APM: So ultimately then, people might be looking for surgery but it might be delayed if they're using orthotic therapy.

PB: Yeah. There's one very good operation for an exostosis or for hallux valgus which is…it's called cheilectomy which…if the joint space is intact, they can chisel all the old, extra bone away without really being invasive into the joint space and it can get you in a good range of movement back without being off your feet for a long time. There's also a lot of research and a lot of work been done at the minute on first MTP joint replacements which really are going to

be the way, you know, I think we're going to move ahead. They're looking at now coming in and sticking a joint on to the existing bone so that…it's nearly like coating it in Teflon, with a joint. So when that wears out, it's a matter of peeling it off and peeling another one back one. So we're not reducing the actual length of the bone. The first thing to remember is a mechanical problem. Unless you've been forcing your feet into shoes that are far too small for years and years and years, that's a mechanical problem. If it's a mechanical problem, what you've got to do before you even think of surgery is address the mechanics because no point…so many people have hallux abducto valgus surgery. They never ever address the reason that they have a hallus valgus to start with. So it's —

APM: And the mechanics will still be there after they've had the surgery.

PB: Absolutely.

APM: And what about arthrodesis? I mean I remember when we spoke to Professor Bill Ribbans on the subject of foot surgery a few months back and he was saying that actually, surprisingly, a lot of people have the joint immobilized, fixed and they seem to suffer no biomechanical problems. In fact, he was talking about sportsmen who have this done and still carry on a high level sport.

PB: There's an operation which will arthrodesis the joint. They tend to do it in a slightly dorsiflexed position so that it lifts it up off the ground a little bit. The problem is that most surgeons will look at that…it does straighten it, it tidies the joint up and it immobilizes it. Therefore, there's no pain. Any arthritic change, no pain. That's great. However, now with a joint which doesn't bend with no means of forward propulsion, so we have to roll the lateral 2, 3, 4, 5 and that can lead to a lot of what's called transfer metatarsalgia where we transfer the pressure, we transfer the pain, we transfer all the problems on to our lesser metatarsalgia or metatarsals. Now, that's a different pathology and therefore, it doesn't fall into the same statistic analysis as the first MTP did.

APM: So maybe there are no problem because they're not looking for the other problem —

PB: So maybe there's no problem in that joint.

APM: There's one other I wanted to look at before we moved on here. I remember you briefing me at some length about plantar flexed first rays. Now, it's quite the common finding, abnormality I understand, I mean, I wouldn't like to put a percentage on it. What's its significance? How does it happen? What might it do to our patients?

PB: Well, one of the things I have in mind to mention was the sort of…the two major foot types that you're going to see in your clinic every day are flat foot or a high arch foot. Flat feet, you've got to be weary of because flat feet, in the majority, are flexible. They look flat, they are flat and the problem is that people treat them as if you've got to tilt them out.

APM: Just to interrupt you there. Now, I asked what sounds like a stupid question last time we did this. There may be people watching who weren't on the last broadcast. When we say a flexible flat foot, does that mean that off weight bearing, there is an arch or simply that you can put an arch into it if you push it hard enough?

PB: Now, flexible means that when you're looking at a foot, normal weight bearing, you can dorsiflex the hallux, create the Windlass mechanism, create a nice arch and then when they stand, the whole thing collapses, totally compensates.

APM: And is that a test you would do in clinic then?

PB: Absolutely. To me, that's a better test than looking at the position of the foot, than measuring subtalar movement or…sorry, inversion, reversion on static measurements. I would rather look at a foot static, look at a foot weight bearing because at least you're getting movement there. At least you're finding out how much movement is happening, how much compensation and you've got to remember that a lot of the problems…when people come in with a flat foot, a lot of their problems are lateral, a lot of their problems are caused by this subtalar rotation happening to allow them to propel themselves forward. So don't be fooled by somebody coming in with a flat foot and thinking, "I've just got to wedge them up," because very often, the big problem is when they go to push off, they are rolling off. Getting back to the plantar flexed first ray, very often…your plantar flexed first ray is very simple, OK? It tends to come in as a foot that looks like a high arch foot. A lot of people will ring me and say, "I've got a patient with a cavus foot," and I'll ask them, "Is it mobile?" and they say, "Absolutely, very mobile." So it's a plantar flexed first ray and a plantar flexed first ray is when the first ray drops down below the level of the other metatarsal heads.

APM: As we can see in the slide here, yeah.

PB: As you can see on the slide, yeah.

APM: When you do this measurement…if we're looking at the slide now, when we're taking this measurement, what…this practitioner appears to be holding the foot in a particular position. Is he in subtalar neutral or is it just —

PB: He's doing what they call locking the forefoot on the rear foot, so he's pronating the forefoot on the rear foot which locks the metatarsal joint and if

you can hold it in a reasonably tight position, subtalar neutral. What you want is…when the first ray has dropped, it gives an impression of a high medial arch. Now, then you've got to say, "OK, now it's a plantar flexed first ray." The next question is very simple, is it mobile or rigid? So if it's mobile, it will move. How much it moves will depend on the next point, is it compensated, partially compensated or uncompensated?

APM: And is there a difference between an acquired or congenital plantar flexed first ray?

PB: Most are congenital. You can get some acquired over time but the vast majority of feet we're going to see will be congenital.

APM: And are there mechanical types, foot types which will contribute to this or aggravate this?

PB: Mechanical foot types in what way?

APM: Well, if I remember, had a long way back now, if we have a pronated foot then does that affect the mechanical advantage, say, your peroneus longus which is going to then pull this further into flexion which may then also aggravate the pronation and therefore effectively create a vicious circle?

PB: Well, with this, you're going to have the…it's the tibialis anterior, OK, tends to be hypertonic. It's not working very well and you get a little bit of hypertonicity of the peroneous longus and very often of the flexor hallucis. The question of whether we can work on those muscles specifically to stretch them is —

APM: But it's the pronation affecting the mechanical advantage of those muscles. So if you correct the pronation, might that reduce the worsening of the —

PB: The pronation in this foot tends to happen a lot more through the midtarsal, tends to happen subtalar through midtarsal because our heel doesn't have as much…there's not as much pronation of the heel very often. When the first metatarsal hits the ground which it does early because it is dropped, the question is how quickly will it elevate and how much will it elevate. If the it elevates all the way up then we get a very quick pronation through midtarsal joint, sometimes called a high oblique midtarsal joint axis where you get a very quick midtarsal joint pronation happening, an elevation of the first block which means then you've got to have those big abductory twist. If the first only elevates slightly so it's partially compensating, it doesn't actually come up above the level of your other metatarsals and what happens is you'll end up with a lateral motion about the axis, the longitudinal axis of the foot and if the big toe doesn't come up at all, if it don't get any dorsiflexion then we get a lot of lateral movement.

APM: What would be acceptable in compensating in gait? If they were going to compensate completely for this problem, would you expect that to dorsiflex above the level of the lesser toes or is it sufficient if it comes up to the same level?

PB: Normally, if you're going to see this foot compensate completely, you'll see it go up above. If this is a very hypermobile plantar flex first ray then what you'll get is…you'll hold 2, 3, 4, 5 and you literally waggle it about like it's a thumb and that means when you see that person stand, they get a big initial collapse of the foot and again, it's…it fools people because you see a high arch foot on your chair but what you're actually getting is a lot of initial stage internal rotation of the tib-fib. So you do get a lot of issues.

APM: Before we go on and do any sort of practical demonstrations in here, since we're sitting down, you talked about pronation, you talked about supination. Now, as I recall, different people have different interpretations of those terms and I can never remember whether it's Americans who regard them as simply equivalent to inversion and eversion or the other way around but I remember being taught possibly by you that actually pronation is a triplanar movement. It's inversion, abduction and something else.

PB: Yes, pronation. That's abduction, eversion and dorsiflexion. It becomes more complicated than that because obviously there are open and closed chain pronation and supination. The one thing I would say to simplify that is never think of a foot as pronated. Always think of pronation or supination as a motion rather than a position because it is triplanar. You can't look at a foot and…very often, they'll say, "Oh, the rear foot's pronated." The rear foot's maybe everted. So as you say, it's only one part of a pronatory force.

APM: Somebody's written in a question or sent in a question to ask what is a plantar flexed first ray and I guess we're using podiatric terminology here, aren't we?

PB: It's a big toe that sets down below the level of your lesser toes.

APM: The ray being the first —

PB: The ray being your medial cuneiform first metatarsal and your hallux.

APM: How many rays are there? Are there five or…?

PB: Well, generally, we only really speak about the 1st and 5th because the middle three digits are fixed.

APM: Which is why I asked that. I mean I wonder whether that was regarded as being a ray because it's fixed as opposed to the others.

PB: We talk about the 1st and 5th rays, probably because there's movement in it and we're differentiating between the 2nd, 3rd and 4th which are pretty much fixed in place. So yeah, everything that's applicable to the first ray very often will be applicable to…you can get a tailor's bunion on the fifth rather than…hallux abducto valgus, that's called a tailor's bunion. You can get other issues on the fifth as well.

APM: And since we're going to look at analyzing gait, perhaps you'd like to talk us through the conventions of dividing the gait cycle. I've mentioned already that we have heel strike, pre-midstance, midstance and propulsion. Are those the phases that you would use or…?

PB: Especially when I'm teaching, I tend to break gait analysis into two major phases into contact phase and propulsive phase. The reason I do that is because there are two sets of injuries or pathologies that really are caused when we're walking. One's caused when we contact the ground and one's caused by propelling ourselves forward. Contact phase, it's all about impact of the heel on the ground and rather than, again, looking at a static position like we used to do for years and years and years, we tend to now look at how fast is the foot hitting the ground. It's the speed of loading rather than the position of the foot when it hits.

APM: When you say how fast is the foot hitting the ground, you don't mean how fast is the lower limb moving and therefore hitting-? Do you mean the movement of the calcaneus —

PB: We're talking more about…everyone walks in different speeds and will impact the ground at different force because of the weight but we're talking about…everybody will hit the ground in an inverted position or nearly everybody. Some people don't but most people will hit the ground with an inverted foot, on the lateral aspect of their heel because of the width of the pelvis and everything else. It's how fast it goes from inversion to eversion because there are a lot of things that are trying to control that movement. Post tib is trying to control that movement. Our medial gastroc's trying to control that movement. When our foot's coming down then, we're trying to have a good timing pattern whereby our center of gravity moves over our foot as our foot loads from back to front. What we don't want is for our foot to load really quickly and for our center of gravity to be behind that. We want it to move over the top of the foot. So contact phase tends to cause a lot of problems, lower, you know, posterior tibial dysfunction, plantar fasciitis, gastroc problems, spring ligament, even into the knee, patellofemoral and into the ground. Propulsive phase gait, that's what we have to do…propulsive phase gait's all about compensation. It's how we're compensating for what happened in the contact phase because if we contact and load really quickly, we then have to try to get ourselves into a position whereby we can propel ourselves forward.

APM: Just to keep this clear in my mind, when you say load quickly, what is it we're loading? Loading the…?

PB: Loading the foot. If we load lateral heel and come down very quickly, it elevates your first ray and then we come into propulsive phase very quickly. So what happens now is we have to compensate because we have no movement through our first MTP joint. Our foot's mobile. It's pronated when it should be supinating. So it should be becoming more rigid. Supination makes the foot rigid. Pronation unlocks the joints, makes it a loose bag of bones which is great for adaption to the ground, for shock absorption but it's not very good for propulsion. So we want to get to propulsion in a phase when we're supinating, bending our big toe, supinating and pushing off in a sagittal plane motion but if we don't do that then we have to compensate. And so propulsive phase tends to cause a lot of compensatory problems further up the chain and those tend to be the opposite. Then we start looking lateral, look at IT band and again, we're up into our pelvic stabilizers or hip flexors.

APM: And the problems that you talked about from the contact phase, is that simply because of the absorption of shock in other soft tissues or is it the movement in those tissues that's occurring? Because as the foot inverts, it's also rotating the tibia, isn't it?

PB: Yeah.

APM: So which is the problem? Is it the force which is being generated and pushed through all these soft tissues or is that rotation, either too much, too little?

PB: Well, it's a combination. Pronation is a good thing when it happens at the right time, for the right length of time, OK? So what happens…at a controlled speed for the right length of time. It's bad when it happens very fast and for a prolonged period of time. So when it happens very fast, we lose our natural shock absorption. Our foot should land and roll. That absorbs shock. If it lands and hits, it sends the shock up the kinetic chain and yes, absolutely, the ankle's rubbish at absorbing shock. The knee's not good, tends to go up. The next best place to absorb shock is really our L4-L5 in and around your lower back. So it tends to go all the way up. The rotation's not good because as you know yourself, there's not very much rotation that can take place tib-fib. The knee's very good at absorbing a little bit but once we hit 10^{o} to 15^{o} of rotation, our knee doesn't want to move anymore. So the rotation, when it happens towards end range is when it starts to cause problems because the muscles don't like absorbing shock, rotating in the end range and then having to turn and rotate back out.

APM: Well, I know we haven't had time to run through this in rehearsal as we would have loved to have done but for Easyjet and their delayed schedule, if I were to bring in our guest patient now, would you like to run us through how

you would analyze his gait? We've done two scans on Rowen already. I haven't done any case history taking and, you know, I leave that to you, how much you want to go into that but I'm sure that we can come up with something.

PB: Well, first of all, what I would say is when I examine a patient, it doesn't start with the patient in the chair. The one thing I always do is I see the patient in the waiting room. I'll see them get up out of the chair. I'll see them walk from the chair down to the clinic, see them taking their shoes off. You look at their shoes. You always pick the shoe up. You look at it, you feel it, you see —

APM: Do you get much in trainers? I mean so many people are wearing trainers these days and I see very little in trainers that gives away any evidence.

PB: I'm not really looking, very often, at the wear pattern. I'm looking at the actual…how good the shoe is. Something else which you may find stupid but if the trainer has a smell then that also lets me know I'm not going to put a foam top cover in an insole. So there's a lot of things that I'm thinking already before I even have a patient anywhere near the chair because all of those things will affect…what sort of an insole? What sort of a device on the shoes?

APM: And you're not going to put a foam insole, foam top insole in because it's just going to absorb sweat or —

PB: If the shoe has a smell then we're going to address that but also, we can certainly put in a leather top cover because it's something we can wipe, something that's washable and it's not going to absorb the smell.

APM: Leather as opposed to vinyl?

PB: It's vinyl. Leather, shiny leather, real leather, we can put on to an insole but real leather's not great for the longevity. It tends to dry up at the corners and it will absorb more smell than a vinyl. So something that's wipeable. As a podiatrist, obviously, it's not only…not all podiatrists are on this but as a podiatrist, we also are sort of trained to look…we look at the foot. We look at the veins in the foot, vascular for a foot which is going to swell up a lot. Obviously, you got to be careful what sort of an insole…it may fit now but if a patient's wearing it for three hours, it may make the shoe too tight.

APM: Well, I'll tell you what we'll do. Before we look at our patient, what we'll do is we will look at a gentleman's shoe and a training shoe and one of my team will bring those over to us in a second and you can tell us exactly what it was you'd be looking for in both of those things. Before we do that, what are the types of training shoe that are generally issued by shoe shops and do they make a difference?

PB: The one thing I would say, I think we touched on this before, is shoe shops now will all have the treadmill and somebody with very little training to tell you what shoe you need. There's a lot of sales and marketing. Some people like New Balance. Some people like ASICS, some people like Nike. So what I would say is if you're going to have an insole, have a neutral shoe. Don't go for all the other bits and pieces. When I'm looking at a training shoe, there's three things that I really look for. OK, first thing is I bend it. So a shoe should bend at the toes, all right? It shouldn't really buck up in the middle.

APM: So that's not a good shoe.

PB: I'm not saying that —

APM: But you prefer not to see it quite so flexible in the midfoot —

PB: And again, like if this is a shoe which is going to be worn around the house at nighttime, you know, for an hour, that's OK but if you're going to run, if you're going to do a lot of training, stability wise, there's no stability there. Second thing is if there's no stability there then there's very little stability to stop the foot rotating that way.

APM: So what you just demonstrated there is not sufficient. It shouldn't twist.

PB: No. Push it, twist it. Third thing, pinch. Now this is good. That's hard. You'd want the shoe to have a nice, hard heel counter because that's what holds the heel and if that's really soft and flexible, like, say, a pair of Converse or something then the foot just collapses over straight away.

APM: And is an orthotic then wasted in an issue like that?

PB: It's not wasted but again, it's like getting glasses and wearing them at the bridge of your…down the bottom of your nose. They're not going to be as good as they may be. So that, I would say, is OK if you're just milling around the house. If you're going to start running marathons, it's certainly not what you want to be looking at.

APM: Our guest patient will be disappointed to hear that because he's intending to run a marathon in April, I understand or at least, that's what he thinks. Right, then there is a standard men's shoe.

PB: That's a standard men's shoe from about 1940.

APM: Thank you very much.

PB: Is that yours? Most men's shoes nowadays aren't like this because this is the proper —

APM: This is a gentleman's shoe.

PB: This is a gentleman's shoe. Yes, it's definitely a moneyed man shoe which…we have a very good shoe. It's very stiff at the toe, no movement, no twisting and very stiff, you know. That is, you know, a good shoe. It has a lot of stability and that's why a lot of people, when they wear that sort of a shoe, don't have as many foot problems because the shoe is giving them a lot of stability. Most of the modern shoes don't have that stability because they've got a rubber sole. They're not built to be resold or to last. They're built just to do a little bit.

APM: Would you get any evidence…yeah, you're getting some now, aren't you? From that one already but from the sole of the shoe to start with, would you expect to see any evidence of gait imperfections there?

PB: Well, the first thing you would do is you'd look at the heel and in this case, if anybody can see this, the shoe's lying at an angle of about 45^{o} here. So there's a lot of heavy impact on to the lateral aspect. The second thing that you would look at is on the sole itself. You can see a circular wear pattern here. So if a patient has a lot of what's called abductory twist, so they're actually twisting just to propel themselves forward, you can get a big circular wear pattern here which is quite a good thing. The other thing as well is for people with extensor substitution. When you look at the shoe, very often you'll get this. The toes coming up a little bit and again, someone with very tight calf muscle, very often you'll see the toes coming up just a little bit. Now apart from that…that's really all…I don't give advice on what they should wear. I say to them, "Look…" I give advice on the HOKA range of shoes if you're running large distances and you're not a good runner because HOKA will absorb a lot of the shock, you know. At the end of the day, a running shoe is designed to make you run for longer badly. That's all it's really meant to do. So if you're going to run for longer, get a HOKA. It's going to absorb loads of shock and help you propel you forward. That's what it's designed for. If you're going to run moderate distances, the likes of an ASICS GEL Nimbus is a very, very good…it's been a gold standard for years. Saucony has been good. Brooks Beast have been good but they're a slight motion control shoe and Nike Air Pegasus has been a pretty gold standard shoe for a long time.

APM: Is that a new development? Because in days gone by, I think even you have said that Nike shoes, because of their air cushioning have been quite bad for gait because they reduce the proprioception or they were thought to reduce proprioception as you use them because there's so much cushioning in them.

PB: For a long time, the idea was…Nike went 360. First of all, they had added a lot of air cushion and air pockets and they added all the air pockets into the heel part of the shoe here but what happens is that…and it's the same with any shoe, even a motion control shoe, you land heavily on the outside. So what happens is the pockets out here burst before these pockets burst and when

that happens, you get a very unstable shoe. That's OK if you change your shoes every 300 miles which we don't, so most people end up with a laterally unstable shoe. Nike then turned full circle and went to free running shoes. So they went and said, "Right, OK, we don't want to absorb so much shock. We don't want to let you run badly. We want to give you a shoe which allows your foot to function as it should do," but what they didn't realize is you have to be, technically, a very, very good midfoot, forefoot runner to wear a Nike Free.

APM: Nike Free are sort of a barefoot equivalent?

PB: They're a barefoot…it's like a Vibram FiveFinger or a Nike Free. It's a shoe with minimal amount of support or cushioning.

APM: Which we may have time to come on to later but you said you recommend Nike Air Pegasus was it?

PB: Nike Air Pegasus, ASICS GEL Nimbus.

APM: So how do they differ from the Nike you just described? They've not got the air pockets —

PB: No, no air pockets and they're very mild motion controlled and ASICS GEL, it's a gel rather than an actual air pocket but still, if you're going to run marathons, if you're going to train for a marathon, you got to change your shoes every 300 miles.

APM: Is that necessary or is that just something manufacturers tell us to make us buy more shoes?

PB: No, it's probably more necessary now because we're not as light as we could be and because manufacturers are actually making the shoes softer. This one, point and case. This is soft. I mean that's a soft…so that's a really soft sole which means you give that 200 miles, that's already, you know…it's already curling up like a slipper. So if it's already doing that now, it's not going to withstand.

APM: I don't know whether it's relevant but I think Karrimor now owned by SportsDirect, aren't they? They used to be a very reputable mountaineering shoe.

PB: That's what they were and you know what? They are still the…you'd probably still get a good Karrimor coat or a hiking good but what you tend to find is…my bugbear at the minute's Skechers. So I don't know if anybody wear Sketchers or represent Skechers but they have a range of Go Walk and Go Run and it's really just a soft plimsoll with a layer of memory foam in it but the memory foam flattens. You hit the ground again in less than a second

when you're running and it hasn't come back up when you hit it again. So what you've got is an unstable shoe with no cushioning and most people who go into a shop are dubed because it says on it "Go Run". Don't get me wrong, it's fantastic marketing but it's not good for your feet.

APM: So Skechers again. I have a number of patients who swear by Skechers or I presume they're just using them effectively as slippers around the house rather than for serious walking or running.

PB: Most of my patients say that but every time one of them comes in to me, they're wearing a Skechers. They always say, "I only put them on to come out the door."

APM: There's a resource, isn't it? On The Orthotic Group's website, there's a sheet of recommended running shoe or there used to be. Is that still there? And you divided them into motion control, stability and neutral shoes.

PB: There's a guy who works with The Orthotic Group in Canada called Dr. Alvin Lustig and he has done a lot of work with the different manufacturing companies. That's out of date now and to be fair, footwear changes so quickly. I mean ASICS GEL Nimbus changes…they change every nine months and it'll be a subtle change. I used to wear Nike Air Pegasus when I ran then I changed to Saucony then I changed back to Nike Air Pegasus then I changed to ASICS and it's just because they change very subtly.

APM: Couple of questions for you, well, actually one question, HOKA shoes?

PB: HOKA, H-O-K-A.

APM: It's a brand I haven't heard of. Have they been around for a long time?

PB: Not long. They were developed by a couple of French ultramarathon runners who were doing so many miles, like 120 miles a week and their knees were getting sore. So they have an extra thick heel or sole. They have a very slight rocking motion on them too. So it's not a gimmick like an MBT is. It's a shoe which is designed to help just propel you forward but it absorbs a lot of shock. The Clifton is just an ordinary road running shoe. It is half the width of a normal shoe and twice as absorbant. It's like walking with pillows on your foot. It's well worth the try or going into-. It's well worth looking them up and trying a pair on.

APM: And that, walking with cushions on your feet, that's not the same as wearing the air cushioning that Nike used to have —

PB: No. Absolutely, it's much better.

APM: The second thing wasn't a question. One of our viewers has apparently had to change browser and they've gone to maxilla which shows what anatomy nerds we are. I think most of us might be on Mozilla but maxilla's a good one. Do you want to carry out some gait analysis on Rowen, our guest this evening?

PB: Sure.

APM: How would you like to do it? Do you want to do it on the treatment table or do you want to start talking to him here or…your call.

PB: It doesn't matter. Do you want me just to do an examination of —

APM: Well, I think you've told us what you'd be looking for in walking. So I think it'd be useful for us to see precisely the things that you're examining and maybe even things that aren't there, how you would examine, say, for plantar flexed first ray, assuming he hasn't got one. Just take us through those things and what your interpretation of his foot abnormalities are.

PB: Sure.

APM: Let's move across to the treatment table. You do that because you don't need me for this part.

PB: Hello. Nice to meet you. OK, can you lie flat back? OK. OK, I don't do a lot of leg length work simply because of the fact that I don't feel it's very accurate. So I don't measure from ASIS to medial mal with a measuring tape. So what I do is I have a look and again, I look at the patient walking, I look at the creases in their trousers. Just have a quick look at the knee caps. Give them a shake, drag them down the bed very slightly and look at the medial mal. So I put my thumbs in the medial mal, the same place.

APM: If we get the camera in here close, we might be able to see what you're doing. I think most of our viewers will be aware of that.

PB: And at that point, all I do is I would ask the patient then to sit up. So if you could sit up for me. OK? Now, what we're looking for when the patient sits up is one leg rotating forward or down and is one leg staying the same. So if you lay back again. So again, I have a little bit of rotation of the pelvis as the patient moves up into sitting position. It's not much but it's a slight indicator of a functional sort of leg length that may be present. Other things, again, I'll look at a patient. I'll take the pathology but I'll start really at the hips and work my way down. So if there hasn't been any problem with the hip, what we'll do is we'll just do very gentle internal and external rotation. So internal rotation of the hip, external, just to see is there a block there? Is there something which is either painful for the patient or something which is stopping the movement? And again, we do the same with the leg flexed.

We're looking at the rotation of the pelvis. So we're feeling to see any grittiness, any crunching but more importantly you're looking at the patient and making sure the patient isn't wincing or isn't in pain when you're doing it. Then we bring that down. If the patient has had any problems with their knees, we'll look at the ACL, do the cruciates, do the collaterals. I always have a look at the patella. So we want to look at the patella and we want to look at the quads. So we want to look at the movement of the patella. So again, we're just looking at the movement of the patella which is feeling left, feeling right. I'm just putting my hand on top to feel is there any crunchiness, to see is there any chondromalacia patella underneath because again, that's something that is very common.

APM: How do you feel about that chondromalacia test where you fix the patella inferiorly and tell him to tense his quads?

PB: I think it's a great test —

APM: Horrible for the patient.

PB: Horrible for the patient.

APM: Should we make him do it?

PB: But it is fantastic. If you tighten your quads for me, Rowen. Again, what we're looking at is VM, VL. We're looking at the actual…how much definition we have on VMO or on the vastus lateralis. And again, if you relax again. And again, yeah, it's just a matter of that if you tighten your quads and bring in the knee cap up. There's no crunchiness, there's no pain. There was no problem with that.

APM: And when you say we're looking at VMO, we're looking at vastus lateralis, I always think that it's rather unlikely that they're going to look equal in size.

PB: No, absolutely no. VM —

APM: What are you looking for? When we talk about it, are they balanced and balanced doesn't make much sense —

PB: They're not balanced. The VL is much, much bigger than the VM. VMO is part of the VM, obviously, which is attached into the ductors but it always is…the VM's always smaller but it gets its effect because it fires first. So it fires first, VL fires second which then the equivalent motion will pull the kneecap straight up. The timing pattern gets changed around very often which means VL fires first, drags the kneecap, VM now is working with a mechanical disadvantage, can't pull the knee cap back straight but if we get a force working this way, the resulting force should be straight. That's what we're looking at with patellofemoral. After that, we look down the leg. As a

podiatrist, my background training, we'll always look at skin type. Is it normal skin type? Is it dry? Is it flaky? Are there a lot of dains present? Is there hair loss a third of the way down the shin? That could lead you to think that there could be a vascular problem or diabetes or…we'll always ask the questions. Is there anybody in the family with rheumatoid? Is there any history of inflammatory? And then we come down. I'll always just come down the inside of the shin bones, specifically a third of the way up, test post tib, test to make sure that there's no irritation to the post tib tendon.

APM: So you're testing that quite high up the tib then. I've always tested it as it goes around the malleolus. Am I doing that too low?

PB: The problem around the malleolus is you've got your tibial nerve. You feel that, Rowen? So if we want to inject this foot and freeze the whole plantar surface, little injection because the tibial nerve is just here and right beside is the blood vessel. So if we want to feel for the pulse, we'll just put our finger there and we'll feel a nice pulse and we've got the vein, the blood vessel and the tibial nerve. That has a communicating nerve that goes to the calcaneon. So if you've got someone with a swollen ankle, it can very often get referred ankle pain down here. Treatment for that can sometimes be an injection proximal.

APM: And when you get damage to the tib posterior tendon, where does it normally occur?

PB: Tib posterior tendon starts to fray in and around here but you'll feel it here.

APM: He will feel pain or you'll feel the difference —

PB: I will feel lumpy. It'll just be like bump, bump, bump, bump all the way up and notty because what's happening is the lining of the tibia here is getting…you're getting little bits of bleeding here

APM: And when you do that, is he going to feel pain? Can you elicit pain —

PB: He will pain if he has post tib dysfunction or acute tendonitis. He'll feel pain when I put my thumb in there. The other thing I'll do is I'll…you just give it a tap, a third of the way. That's the most common site of a stress fracture and then we look at the…again, this muscle bulk here, tibialis anterior. This will very often tell you that there's something wrong because the hair will be either…there'll be less hair on it or there'll be no hair on it. So that can be an indicator of anterior compartment syndrome.

APM: Now, hopefully everybody knows what you mean by anterior compartment syndrome but just talk us through the significance of that because that can be quite serious, can't it?

PB: Anterior compartment syndrome is quite debilitating. The anterior compartment, you've got your extensor tendons coming to your digits. You've got your extensor hallucis and you've got your tibialis anterior which, if you put your feet towards you, is this tendon here. The three of those muscles come up. It's nearly like they're in a sausage skin and they come up the front of the leg here. Some people have a very tight compartment and whenever you exercise a lot, it fills up with blood and it doesn't empty. Once it fills up to a point where the pressure's too high, it won't empty and you get ischemic pain. And it's very simple to tell because people will say like, "I was able to run for three miles. The pain went away after 10 minutes but that reverses. I was able to run for, you know, 100 yards and the pain stayed for three hours."

APM: So that is a —

PB: That's the progression, yeah. That's the progression of…treatment, ice it after a run, compression bandages, compression socks. You got the compression sock or sleeve now that Paula Radcliffe's been wearing for years but it's caused generally by the forefoot loading too quickly. So again, we're looking at that but that just doesn't happen. It's caused by forefoot slapping down. So it's an over pull on your tibialis anterior.

APM: And that overloading, that rapid overloading is happening because of what generally? What's the most common cause?

PB: Well, it's actually…your tibialis anterior is used whenever you move into midfoot. It's used as a controlled pronator. So it works by lengthening rather than concentrically, so the action of the tib ant is to load the foot, is to bring the foot down gently. You'll see people on a treadmill, you'll hear them in the gym and they run and you'll hear the slap because the forefoot's not loading in a controlled manner which means that every time the foot loads, it's tugging, tugging, tugging. These muscles are getting massively overworked. They're getting tugged. They're getting little bleeds into them which…microtrauma and that causes all these symptoms, inflammation.

APM: And is that likely to become a surgical emergency?

PB: Not likely but surgery for it is not great. We used to do a thing called a wick catheter test where we pass down a catheter down through here and then they made you go on a treadmill but surgery, open fasciotomy where they open the thing, they let the air, you know…the chances of getting infection are high. The chances of wanting to do it are not good. The best thing is, you know, obviously, control the foot mechanics, control the activity and work through a rehab program with a good therapist.

APM: Do you get athletes who try to run through this?

PB: You always get athletes who try to run through everything. Runners particularly will try to run through everything because…they always say that a runner will have three injuries at any one time. So those are normal and anything over that, they go to physio or an osteopath or a chiropractor. So that's really, again…we're looking at alignment, looking at knees. We're looking down the shins. Once we get to the ankle, really looking at…we're looking at the ankle. We're looking for swelling. We're looking for lumps, bumps. We're looking at discoloration of the skin then we —

APM: What are you going to infer from all those things? I mean if you've got some swelling, what's the first thought that goes through your mind?

PB: Well, if you've got swelling then we're looking to see why we've got swelling. Is it just because of joint effusion? Is it because we've got an unstable ankle? Have we rolled an ankle at a time? Have we sprained the ankle? Generally, swelling is due to either venous insufficiency or even a little bit of joint instability where we've got leakage of synovial fluid but there'll be a history behind it and at this point, we'll look at ankle dorsiflexion. Again, we just slightly put the foot into slight neutral position and if we put the foot into a slightly neutral position and try to dorsiflex, what we've got here…if we can take —

APM: ---.

PB: I hope everybody can see that. The lateral border of the foot, the foot and the leg, that should form a 90^{o} angle which then should also move another maybe 15^{o}, maybe 20^{o}. Now in this case, I would classify that as like -20^{o}, -15^{o} because we're not even at 90 and that's it, in neutral. And what happens at this point is we get subtalar joint pronation. So again, if we do that again without putting the foot into neutral, see how much dorsiflexion we get at the ankle? So most people will say, "You know what? Yeah, no problem. We've got good range of movement at the ankle." If we put down into neutral, no and again, if you put this foot into an insole to prevent that pronation then that's what's going to happen. They're going to stress this.

APM: When you do that…I mean when I do this particular analysis, I'm looking to see that the bottom of the calcaneus is roughly 90^{o} to the tibia and then I also look to see where the forefoot's going and you're looking for a forefoot equinus, whether flexible or otherwise and in Rowen, it looks, from where I'm standing, as though there's a very, very slight plantar flexion of the forefoot. Is that a significant problem? Because obviously, that's going to push him into dorsiflexion before he's even started to move.

PB: You can see there are two giveaways for Rowen's foot. One, he's got a thing here called dorsal humping of the foot which is the dorsal aspect of the foot through the cuneiform metatarsal area and you can feel the ridge across here because —

APM: Is that an exostosis or is that simply a —

PB: We've got a little bit of exostosis here because we've got an impaction of the joint. We've got lower position of the forefoot with regards to the rear foot. So we have got an anterior equinus. Absolutely right and an anterior equinus, if you imagine a foot on a high heel shoe, that's the shape it's going to be which then shortens the calf muscle.

APM: You've met Rowen before.

PB: The calf muscle ends up in a shortened position and, you know, over time, if it's in a shortened position, it will take that position. So it makes it harder. So we talk about expectations and managing expectations. If I was your practitioner, I would be saying we need to stretch your calf muscles. Now, everybody else might be wanting to try to get them to 20°. I might be happy to get you to, you know, maybe 10° above 90. So simply because the nature of your foot's dictating that you are going to have tight calf muscles and sometimes you can just put a little bit of a heel lift in bilaterally and that will offload a lot of the stress because it's going to bring these two more level. OK, make it more plantigrade.

APM: Would you expect that there are patients around, there are people around who could have that very same foot type with exactly the same characteristics you've identified there and no symptoms at all?

PB: Yeah, absolutely. Symptoms are caused whenever our body gets to a point where it can't compensate any further and now, if we just lead a fairly normal sedentary life, we don't do too much, generally, we'll be OK. If all of a sudden we then ask our body to do something it's not happy with…say, you want to run three miles a week or 3 miles 4 times a week, that might be OK. Five miles four times a week, very often is the tipping point and then it becomes a problem. Looking at the ankle, we, you know…after that, we look at range of movement. Now, in this case, there's very little eversion and a lot —

APM: How much would you expect from neutral?

PB: Well, you should be looking at a 2 to 1 rough sort of…and again, how much…well, that's the piece of string. Some are hypermobile. Some aren't. Rowen's very stiff. His ankles are very stiff. So there's very little movement, inversion and there's absolutely none eversion at all, all right? So he's got a very stiff foot type and again, what we're looking at here is a plantar flexed first ray —

APM: Fantastic.

PB: So we've got a plantar flexed first ray. The question where —

APM: Can we try and get the camera in a position where we can see what you're doing which means coming around to Paul's shoulder there if you can please Ryan?

PB: So if we look at that, this is down, below the level of these metatarsals. Now, what we…first question is, "Is it mobile?" So it is mobile but is it fully compensated? Well, again, if we push it up, it doesn't go up above the level of these digits. It goes up a bit and see the arch? The arch doesn't collapse. What's stopping it is more than likely this joint. As we push this up, this joint is impacting.

APM: So we could try freeing that joint off or is that a —

PB: Absolutely. There are a lot of foot manipulations. I don't do it. You would do it but I would do a navicular cuboid here fibular and I think it will be well worthwhile in this case because the foot is very, very stiff. There's very little movement. So we would look at that foot. We'd look at the midtarsal. There's not a lot of movement. We're looking at the first…we've got a little bit of movement but not a huge one. So we've got a partially compensated plantar flexed first ray. That means that when the foot hits the ground, it's going to elevate a little bit but when it gets to that level, it's going to roll. So it's not going to go up any further. So we'll get a lateral roll. Not a huge amount but a little bit. First MTP joint, we've got really good range of movement, really nice arch but again, we see how tight the plantar fascia is when I do that. The whole foot's very tight.

APM: That's a good range of movement but on the first ray, on sort of the hallux there but that's off weight bearing. Does it matter that that's off weight bearing or…?

PB: You can't do it weight bearing to actually plantar flex that. That is a good question because a lot of people will have you standing, will try to dorsiflex your hallux and if I have you standing as you are now, barefoot and I try to dorsiflex your hallux, all I would be doing is pressing your sesamoids into the ground. The only way you can physically bend your toes to roll off your 1st onto the 3rd, 4th, 5th —

APM: But isn't this the counterargument that as you're walking, you are weight bearing and you need to bend your hallux, you need to dorsiflex it.

PB: Well, yes but you're not static. As you walk, you should be loading and rolling forward which is completely different from somebody just pushing your sesamoids down into the ground. If I look at that, I'm looking at the foot in a static position. I'm saying, "OK, I can bend the big toe." Therefore, Rowen can walk in a sagittal plane. There's nothing physically here that will stop him

walking normally in a sagittal plate. He's got a pivot point. He has this…the beauty of the gait scan is we can now have a look at the scans next and we can actually see is he doing it.

APM: And if that were hallux limitus, how far would you expect…what would you expect to feel? Would it be obvious?

PB: Hallux limitus, you'll see a lot more sort of joint sort of degeneration here. You'll feel the crepitus and you might get about 20°, less than 40°, certainly and I would say anything under 10°, I would say they're rigidus.

APM: What about his other toes? I mean we have some really deformed here by the look of it. I mean would you read anything into those?

PB: Well, what we've got here is our extensor substitution. We've got a lot of retraction of the digits here and again, it's essentially a tight calf muscle pulling the foot down and if the foot's like that, when you go into swing phase, you're going to trail your toes. So what happens over the years is we pull our toes back, so a bit like a…try to pull a horse's head up, you pull hard on the reins and that's all that's happening here. We're trying to pull the horse's head up. We're trying not to trail our toes on the ground.

APM: So those toes are dorsiflexed at the distal joint, at least two of them are by the looks of where I'm standing. Does that make him hammer toed?

PB: These are more claw toe because we're not getting such a big issue here and the other thing with a claw toe is a claw toe will force the metatarsal heads downwards because when you pull the whole toe back, you end up with a real forcing the metatarsal heads into the ground. So it can cause irritation through the metatarsals here, a thing called metatarsalgia. One of the last things I do is I look for Morton's neuroma. So I look at the metatarsal parabola. So what we do is we look at the metatarsals. I was wondering, is there a pen that I could possibly borrow?

APM: There will be in a second.

PB: The magic of television.

APM: So we talked about the metatarsal parabola. Obviously, there's a perfect arch for the toes-.

PB: Again, this looks a wee bit barbaric but if we grab the toes and bend them in the wrong direction, you can actually mark…you can mark the metatarsal parabola. So what we're wanting to see here is a nice curve, OK? All right. Well, what we want to see is a nice curve and we want to see all the metatarsal heads really prominent. The second metatarsal in this case is a bit short. The fourth metatarsal isn't as prominent. So what we want to look at

then is if we've got a fourth metatarsal which isn't as prominent, we want to look and check on the bottom of the foot is there any swelling? And again, the fourth metatarsal does feel a little bit swollen. One of the things then we would do is we would check for Morton's neuroma or check for a Mulder's click. So we hold the foot around the top and we push up on the fourth while we squeeze. We push and squeeze. We do that with the third. We do that with the fourth and we'll work our way along. In this case, there's no evident clicking or popping. We do it in the other feet as well. We've got one on that foot. So on this side, we've got a really big click whenever we push up and pinch, push up and pinch. You can actually hear it pop and that's because the nerve that's coming up…that's actually a really…that's a better picture there, if you can —

APM: It would be, wouldn't it?

PB: That one. It's all right. It's just been very awkward but this fourth metatarsal's nearly gone. You can see the first. You can see the second. You see the third. You can see the fifth. You can't see the fourth. The fourth one's sort of missing. So as soon as you see that, you think to yourself, "OK, it must've dropped. It must've fallen down through the transverse ligament," and when we push up and pinch, click. OK? So we actually feel it clicking.

APM: We should've mic-ed his foot up, shouldn't we? But sadly…OK. Is it worth having to look at him standing or are there tests you would do standing? The last time I think you did a squat test with our —

PB: We did a squat test. We did a single leg squat. So if you want to stand up, OK. So one of the tests that we'll do is…it's the double leg squat. So feet pointing the same direction, OK and you'll just go down into a squat, all the way down and back up again and when we're doing this, we're looking at two things. We're looking at the foot. We're looking at the knee and we're looking at the heel, those three things. So if you do that again, all the way down. So what we want to see is can the patient go all the way down? Is the knee buckling in or is the foot rolling in or is the heel popping up off the ground? The next one is the single leg squat. So what you're going to do is you're going to stand on your right foot and you're going to bring your knee cap along the line of that pen. OK and back up and we'll try that again but try to keep your upper body not coming over. So you're going down. Now what we're looking at here is hip stability, so we're looking at the the glutes essentially and again, if someone has very weak glutes, as they're coming down, you'll get an internal rotation through the femur.

APM: So the knee cap will drift into the medial —

PB: You'll get an internal drift and that's very important as well because you may turn around to somebody and say, "We need to stretch your calves because I will put an insole in," and the patient could say to you, "Insole still feels very

hard," but, you know, if they haven't addressed the issue of the hip stability in the glutes, it's because every time the foot hits the ground, we're getting an internal rotation.

APM: It seems to me that Rowen has very flat feet standing. Flat feet aren't always symptomatic, of course, are they?

PB: Not always symptomatic. I would say they're not completely flat but they're on their way there. I'd say it's partially compensated. If that was a fully compensated foot type then he'd be completely collapsed and again, there are different ways of measuring. I measure a couple of different things. If you want to lie up, I'll do one thing very quickly. When I'm measuring a foot, I don't take a Plaster of Paris cast. I actually measure and I take a number of measurements. So I will measure once from here to here, that side of the foot to that side of the foot. Outside equal with the medial malleolus. OK, so when I'm looking at a foot, I measure this width and I measure center of the 5^{th} to the center of the 1^{st} and I measure the heel from here to here and then measure from the outside of the first or just behind the first down to just in front of the heel, that side and this side, OK? The last measurement is very simple. The last measurement just goes from midpoint here straight to the back of the heel. Sorry, that's not the last one. The next measurement is the measurement of the arch-wheel. Put the foot into neutral, bend the big toe and when you've done this for as long as me, you can feel with your fourth finger just in the side of the ankle, to the head of the talus and you can push up with the inside of the body or hand like that and then dorsiflex the big toe all at once.

APM: What are you feeling with your fingers? You're just waiting until you feel the…just until you feel it. You don't want to feel too much —

PB: When I wobble and I can feel the head of the talus coming in, coming out, coming in so I go 'oh', there it is, halfway between in and out. Now, I will measure the height of the arch and the height of the arch is what we take is the point of the skin just below the navicular and the height of it from there to there, so I'll measure that. So that's telling me my starting point, OK? Now, if you jump up, Rowen. The last measurement I'll take is a patient standing. We have a mark here and we measure now, OK? Some people call it navicular height, navicular drift but what that gives me is exact dimensions of the foot. It gives me exact dimensions inside, outside and it also gives me an idea of how much the foot's compensating between high arch…between me being able to manipulate it to the patient standing and how much it actually collapse when they stand in a normal position.

APM: If we cut back to the computer now and look at the gait analysis, perhaps you would talk us through what you're seeing on that dynamic analysis of Rowen's feet. I'll let you have the computer chair and you can just talk us

through on that. Now, this is…the audience are now seeing what's on the screen there.

PB: Are they seeing me or are they —

APM: No, they're seeing the screen.

PB: That's good. OK, so when we look at this scan, we looked at Rowen's feet and the one thing that you can see here is asymmetry. So that will be the first thing that would jump out of this, you know, screen at me straight away, is that there's asymmetric sort of pattern. When I see that, it always…straight away, the first thing I say is I wonder is there a functional leg length because one foot's supinating, one foot's pronating.

APM: And you just brought up a screen with some measurements on it. What screen is that?

PB: That's just your total pressure screen and that then allows you to mark on, you know…you can mark on that the propulsive phase, toe off. You can actually then…if we got back to the previous screen, you can actually add pain callus. So if I wanted to say there's pain and it's on the heel and you can turn around and say, "OK, well, the pain's 10 or 9." So it just marks things on to…allows you the next time you see the patient to be able to tell. OK, so if we start with a…first thing I would do to my patient, I refer this on for a really good pelvic assessment. Left foot, what we're looking at here is…when I look at the foot, the first MTP joint could bend normally. There was no problem with the big toe joint. When we're looking at the scan, the first MTP joint is gone. It's not on this at all. So this patient is rolling off the outside of their foot. It's all peak pressures on the fifth metatarsal head but there's nothing between the rear foot and the forefoot. So it's really just heal, bang, straight on to the forefoot and it's all supination. So this person, in this case, I know I can use the big toe so I would be wanting to put an insole here with the first metatarsal cut-out and probably a reverse Morton's extension which is a pad which will go underneath 5, 4, 3, 2 which will actively rotate the foot at the forefoot. The medial arch will actually initiate some pressure through the midfoot and what it'll do is it'll take it from the rear foot to the forefoot in a more controlled manner. So that's part of the treatment process here. The other part of the treatment process is stretching of the calf muscles. It's working on the hip stabilizers, you know, and a bit of manipulation of the foot, try and get a bit more movement through it. The other thing here, again, there's no, you know, toes, no digits, really. So right foot, completely different. The right foot is all medial. So left's all lateral, right's all medial and when you get one foot really internally rotated and one foot externally rotated, the big problem with this is it actually generates torsion of the pelvis. Two flat feet will rotate the pelvis in one plane. One flat foot, one supinated, one pronated foot type will cause a rotation in two planes and that's what causes the problem here. This will cause a lot of torsion right up

in through SIJ. So you're looking here, we've got a lot of problems through the heel, a lot of pressure, straight up onto the first MTP and then on to the IPJ. So the foot moves into a pronated position and pretty much stays there. This gait line shows there's a bit of a wobble just at the knee where the knee's starting to load. If we follow this gait line out, that would move us up the outside of the foot and roll us over as we should be doing but what happens here is the foot loads and then we get an internal rotation happen. So again, if that was my patient, I would look at that and I would think, "Well, OK, I must test that right knee. I must check and see is there anything there that may cause problems down the line."

APM: Well, I'm conscious that we've only got three minutes left and I can't believe it's gone so quickly. Could you just very, very quickly go to the force diagram, the analysis, the report on this and just illustrate what we're getting from that in terms of analyzing our patient's mechanics? Again, it will have to be quick but…

PB: Sure.

APM: We haven't really got time to do that but the machine will produce a report which is analyzing 10 different areas of the foot, showing us the assumed optimal ranges of timing and pressure and then will tell you whether our particular patient is meeting those optimal ranges. Is that useful in clinic? Does that help you in prescribing orthotics or otherwise?

PB: Well, it certainly helps if you're looking at somebody who's got a sesamoiditis or a very heavy corn underneath the 2nd or 4th or 3rd met head. I can show them the scan and say, "That is why you're getting that problem. We can offload that. We can move the pressure to other parts of your foot." So yeah, it is very good and it's nice to know. We can also look and say, "OK, look, your medial heel is loading very early, staying loaded too long." We can change how the foot actions when it hits the ground and that's what important. We can't change the shape of the foot but we can change the action of the foot when it hits the ground.

APM: So we have two very quick things then. One, what use is this technology in clinic? Since you diagnose most of the problems of this patient by eye and by hand, does it help?

PB: Definitely helps. Beforehand, I would look at that, it's all static. I'm looking at a foot in a static position and assuming dynamic function. What I need to be able to see is how…as what I've just seen, how does that relate into gait? I couldn't have told from looking at that patient that it's so asymmetrical. So yeah, that's a good marketing tool and the patient understands that. The patient doesn't understand that they've got hallux abducto valgus or —

APM: Marketing tool's the wrong term, isn't it? I mean it's an illustration. It's explanation rather than…we're not going to sell them something on the basis —

PB: Well, I suppose marketing's probably the wrong word but if a patient doesn't understand, they won't buy into the treatment. So it's a treatment tool but the patients, when they understand what they need to fix, they're more likely to to become a part of the treatment.

APM: Paul, it's been great, as always.

PB: Thank you.

APM: We might go on for a little bit after this so we've got some more information to put up on the website for people on the basis of that scan but that's it for this evening.