

## Supplementary file 10 Barriers, facilitators, adjunctive interventions, injury prevention and performance

### 10.1 Barriers and facilitators

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#### Principles

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Number of cues and amount to change at a time

“Definitely, one. So, one, using one or two cues. So I’ll try one or two cues and I’ll really hammer those cues until I know they’re gonna work or they’re not gonna work and that’s it.” (5)

“So things like increase in cadence can be tough enough by itself and often they find that really, really hard and then sometimes you can throw a couple of other things in but it just depends on the person.” (6)

they’re initially allowed across a 30-minute window to run for one minute and walk for four and in that one minute, they’re thinking of one cue at one time. So the first cycle of five minutes, they’re thinking of one cue, the second cycle is second cue, et cetera. With only ever three cues, probably four cues maximum are ever delivered. So they gradually fill that up as pain allows ..... We learnt early on that actually if you try to overload these people with three or four cues, they’re thinking of them all the time, that doesn’t work from an educational theory point of view or actually just effecting change.” (7)

“I try to focus on general cues, not a bunch of very small specific items ..... I guess I consider one thing just changing the movement and not – ‘and this time I’m going to work on the hip and this time I’m going to work on step length’. I think I’d probably just be okay trying to do it all at once. (8)

“(I) deliver as few coaching points as I can, sometimes just one or two. Three, if I think it’s absolutely necessary. When we first started, we tried to change too much.” (9)

“I would never change more than two in most cases. I think that again, it depends on the individual, particularly the links between the variables that you’re changing.” (11)

“I will tend to do one thing at a time. I think it’s actually its quite hard changing the gait styles, so I tend to do one cue at a time. But within a session, I might do a maximum of three, but always working one thing at a time

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.... "I think sometimes it's probably an easy intervention to get wrong. It's probably quite easy to move things too much and to end up overloading other tissues." (12)

"I'll go through a whole heap of different cues and choose one." (13)

"I never give my patients more than five things to walk away from my clinic with on a particular day. So that means if I gave them two things to think about with gait, then they're gonna get let's say, two stretches and one strengthening exercise and that's what they work on for that week. It's never more than two on the gait retraining. It's just too much to think about. I would say probably 75 percent of the time, it's one thing." (14)

"Usually, I would just give them one. Run wider. Run shorter. Run softer. Watch the horizon." (15)

"I try not to add more than probably two cues within a session if I can." (16)

"I just find the one that I think that seems to resonate with them, and then that's all that they work on." (17)

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Types of cues to use

"I would often use verbal cues or feedback, just mirror feedback." (15)

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Individual response to cues and importance of communication

"Some people respond really, really well to watching the video and they're very in tune with their body and they'll just do it. Other people, you've got to use ten different cues and different ways of phrasing things and then eventually they get it. So just finding what works for that person and then at the end of the session, you write those cues or catch phrases down for them to think about their running and they'll usually be able to do it quite well." (6)

"you might find they come with quite set ideas about – they might have been told that forefoot running is best and they must forefoot run. And then, you'll kind of have to educate and work within that too. So, I think as much as there's a physical side, there's also the importance of good communication." (12)

"everyone's very different and some people will respond very well to one cue and totally not respond to others. So you really have to try a whole range and just to see what works with that individual." (13)

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“it seems like some modifications is are really easy for some people and some are really hard and it’s not the same for each person.” (15)

“it’s finding the right cue that seems to work for them.” (17)

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Using changes to pain and symptoms as a guide to choice of retraining

“I use pain a lot, pain and symptoms.” (1)

“If they’re saying that they can subjectively just feel less impact, you know, that they don’t feel it in their knees as much, their back doesn’t hurt as much, their X Y Z you know, the kind of outcomes in that respect, fantastic as well.” (3)

“If we’ve got somebody who runs with their foot – their leg or the foot toe down or their leg externally rotated and they end up with, let’s say, medial foot pain ‘cause that really exposes the medial foot and puts a greater load on it. And if we have them run with their foot pointing straight and that sort of reduces their pain, reduces their – And that to me is indication that that’s a good direction to go in terms of the retraining.” (4)

“I’ll ask them what felt better, “What was the cue that you felt you could do?” And then we go from there.” (5)

“So probably just get them to rate their pain out of ten is often what I do and then get them to rate it again after. So case example is they might have five or six out of ten pain. You make a change and they say, “Oh, my pain’s four out of ten.” You make a different change, they say it’s two out of ten so maybe that’s what you focus on instead.” (6)

“What I also find is quite useful whether it is to do like a half and half so let’s say you’re getting to run a half the tennis court with this new, slightly wider stance you’ve suggested. And then at the half way point, drop back in their old style, and they can actually feel that difference between the newer style and the old style. I think that’s quite a useful thing to do, because you can show them the video the difference between old and new, and they can feel, ah, okay, this is what it feels like to be a bit more diverse and a bit narrow.” (12)

“for things like patellofemoral syndrome. When you change their body mechanics into theoretically a different pattern of movement which should be improving the issue, you’ll often get more pain ..... So I don’t know if pain

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is necessarily a great cue in that sort of context ..... really, the ultimate measure is whether is they're continuing to have recurrences over the next two years. So I don't know if pain in – Right then and there is a great indicator.” (13)

“I'd give them something new to do, and they'd say, “I feel no pain.” I guarantee they're gonna keep doing that ..... I think a lot of people who have success in changing their gait pattern are hurt, and so, that pain is an incredible motivator for them to change away from something.” (14)

“you're looking to change their pain ..... pain's the primary one (outcome measure).” (16)

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#### Visual facilitators

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##### Importance of using video to facilitate

“I use video ..... visual analysis but for most of them I use my camera to show the person what happened with the changes.” (1)

“I mean, video's a good one because it's an opportunity to at least compare visually for the athletes what they'll do versus what they're doing now.” (3)

“go to anyone, doesn't matter who it is, doesn't even have to be a physio but the person you're going to go to should look at your running if it's a running injury.” (5)

“it's more of a qualitative assessment rather than quantifying anything, which a lot of people say it's not valid, but then, that's what a lot of physio and sports science is, it's more an art, which is guided by science ..... you can measure angles and different things. I don't really ever do that. It's more just to slow it down frame by frame to show the patients what they're doing.” (6)

“every session that we see them is based pretty much more or less exclusively around that video feedback.” (7)

“I think that's pretty helpful honestly, showing somebody a video of their running mechanics, slowing and pausing and rewinding it, to show them what we see. It's - a lot of time it's real time, the mirror is a little bit fast for people to really appreciate ..... I would show or I demonstrate a video, say “this is what we are trying to change”. And you know what? Honestly a lot of times people may – can really – some people were

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coordinated, I'm not sure what the medical reading is but some people really just need to see it, and they see it and they go "Oh golly." They can make that change really easily." (8)

"I mean, video feedback, I think it's vital. It's been the best – I found it the best way, and sometimes the only way to effect change. It's one thing to tell people what to do but until you see yourself doing something, people – most of my clients just don't realise what they're doing." (9)

"And I often give them some feedback with regard to that, with the videos, and look, this is what you felt like, but this is what you look like. So we'll give them some video cues that way as well." (11)

"real-time video feedback. I think that can be useful for people who are really quite competent runners or feel comfortable on treadmills or feel comfortable changing movement in real time, but there's a certain percentage of runners that you'll see that just can't do that. They don't have the movement awareness. They're not comfortable on the treadmill so I think it's got to be adapted for the client." (11)

"I do think they need as much feedback as possible from that, so that because it is quite hard to adjust it and they will often overshoot and say with stride width, they'll end up widening up their stance too much and you have to show them the video so that they can find that happy medium that you're aiming for." (12)

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#### Camera set up and video protocol

"Sometimes I'll have two cameras set up so or sometimes I want about three cameras that's got the video and I just work the cameras around. So you got rear on, front on, side on view ..... I use a combination of high speed video cameras. So I've got a video camera that films at 250 frames/sec and I use these – use a – just use the SD card that comes out of that, stick it in a MacBook Pro" (3)

"I'll do a little bit of video from behind, from the side. So I'll tend to do – I'll do a few seconds from the side and a few seconds from the back. And generally just go back and put it on the split screen and they can have a look and they tend to love it." (5)

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“With every one of our patients, we spent at an initial sort of 45 minute to an hour session on a video treadmill with a sagittal and posterior camera ..... there’s also two TV screens in front so they can actually have realtime feedback because they’re running, although it’s not a very effective way of doing it.” (7)

“I do 240 (frames per second) but I think 60 we find – I think 30 would probably be okay if you are recording a lot of strides ..... “sometimes I just bring it into Windows Media Player and just slow it down.” (8)

“Sixty (frames per second) is enough but with the cameras on the iPads and the Android devices at the moment, the exposure is not good enough because of such a small lens even with a high frame rate, you tend to get a blur particularly in clinic situation in low light situations, it’s a problem ..... I’ve used Templo software a lot in the past, Contemplas Templo. I’m like just investigating other software at the moment so I’m looking at Dartfish, I’m looking at Pro Analyst, I’m looking at some of the app-based software as well, you know, Coach’s Eye, V1, there’s a few others out there.” (9)

“I’ve used a two-camera system, you know, one from a sagittal point of view and one from a posterior point of view and then we have that linked into a computer. Video someone then slow it down, point – you know, try to figure out what parameters of the gait are perhaps leading, either causing or preventing their conditions from getting better. And then pointing out those parameters straight back on the treadmill as quickly as possible getting them to change those parameters, reviewing, and playing video side by side so they can see the before and after and then they can feel what it’s like to be running in this new way.” (9)

“I don’t think that people as a reference necessarily need the high definition of a multi-camera system ..... “I use Ubersense currently. And that’s – Using those app has got a good – feedback through – I play it around with a few different systems and for ease of use and I think that if you use a high definition camera, it’s great, but actually in terms of running re-education, I don’t think it makes a massive difference.” (11)

“I do video analysis. I tend to use the iPhone 5 because it’s got high frame rate. You can get 120 frames per second with that ..... I really like Ubersense. I think it’s really useful. It’s the main one I use. ” (12)

“In the clinic, primarily what I’m doing is using an iPad and some pre-software ..... look at them from the side and from back and from the front and then slow them down and then sit down and show them what we’re looking at

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and we look at some very basic things. I tend to look at symmetry quite a bit 'cause I think symmetry is important ..... I use Kinovia and then we use – We also use the Dart Fish” (14)

“I used 2D video and I would take a front view the posterior view the lateral view, and I would find, and honestly, the video was very informative. So, and if I told somebody had lousy form, they really wouldn't believe me until they saw it or was shocked how they looked, picture is worth a thousand words.” (15)

“I will typically video them. I will then show them and break down and talk and draw lines and do those sorts of things. I will give them a cue. We'll go back on the treadmill at the same speed. We'll let them run with that new cue. I'll video that, then I'll show them again.” (16)

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#### Using mirrors

“And the mirrors are accessible, but I don't think that's the best option.” (1)

“What I'll do is use a mirror and that mirror in a 45 degree angle in the treadmill so that they can see their anterior trunk lean.” (2)

“So we use a mirror for any alignment issues that we're trying to change ..... We tried using a mirror 45 degrees to the angle of the treadmill and facing our mirror in front. So you can actually see the foot. The person could look at the mirror in the front using that 45 degree-angled mirror next to them but it's happening so quickly it's hard for them to see.” (4)

“I think, imagery - opening the knees. Can be useful to have a mirror sometimes in front so they've got something that they can see.” (6)

“Mirror. I don't like that and I don't believe really aligning segments in front of the mirror, like when you do with iron there. I have a hard time with that. I think we screwed up all the biomechanics with that type of intervention.” (10)

“I use mirrors. There's a mirror in front of the treadmill. And that could be useful for some. Again, it depends on the movement contents. If you get people – The same would be for video feedback.” (11)

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“I’ve never done mirrors. Well, I’ve tried, but never seems to work.” (17)

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## Protocols

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Completing assessment and retraining over-ground or on a treadmill

“We have a treadmill at the clinic that was a specifically rigid applied to make sure that there is no absorption in it. So we have people running on the treadmill, and we want them to – to hear themselves when they run, and that’s a very good – very good feedback for them to try to lower the impact forces ..... For people who are not used to running on the treadmill, I go outside, but usually I mostly use the treadmill because it’s easier.” (1)

“I don't do any analysis work on the treadmill ..... If they only run on the treadmill then let’s see that 'cause that's what injured them. But if in any other case, if a runner is running outside, I want to see them running outside ..... There is room for treadmill analysis in clinic and I get the constraints.” (3)

“we haven’t had a problem with people getting off the treadmill ..... Looking at over ground and treadmill data and they are remarkably similar in the kinematics and ground reaction forces. I don’t know whether, you know, muscle activity is maybe different ‘cause it certainly feels.” (4)

“Yeah, treadmill. For me, it’s just convenient. I think, obviously, outside is ideal and I’d love to be able to do it outside and have a look at how they run outside, but it’s just a difficult thing to do.” (5)

“I do pretty much all of my stuff on the treadmill just for practicality reasons. If they’re familiar with running on a treadmill usually a minute warming up and I’m happy to look at them and start playing around with their technique. If they’re unfamiliar with running on a treadmill, usually I’ll get them to run for at least three, four or maybe five minutes just to get used to running on a treadmill - assuming that they’re not gonna get lots of pain during that period.” (6)

“particularly in the better runners, the treadmill doesn’t allow you to replicate that hip extension propulsion that allows an increased piece of ground to be covered on a normal over ground run ..... if you put someone on a treadmill and ask them to run a way, you ask them to run, most people can do a pretty good job of it whereas

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you send someone off to get a run 5K in the park - it would be very interesting to see how much of a crossover of these changes is mirrored in an assessment session versus actually their day-to-day running.” (7)

“I think that initially, the gait education work is easy to do on the treadmill definitely, but we do need to end up at the point where people are primarily track or road running or trail running. We need to get those changes back out onto the road ..... most of all, the treadmill is just for accessibility reasons.” (11)

“I often start on the treadmill ..... So we do a bit on treadmill, a bit out in the tennis courts. And if I'm at a local running club, I'll tend to work with them on the track there. So, yes, I kind of mix up a little bit depending on what's available.” (12)

“It's usually a visual analysis. They need to be on treadmill and then I'd take them out onto the oval to see whether or not it's the same.” (13)

“Most of the time, I work with them in the clinic. So, I was on the treadmill. I did have some athletes who've I've worked with on the field in which case we used the video over ground and looked at it ..... it didn't matter for me where they, whether it was on a track or on a treadmill but I wanted it stable environment at first. And I wanted it to not be in a competition or anything where there can be a lot of additional motivational or intentional demands to them. ” (15)

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Running protocols and guidance

“We try the changes for just a few minutes, 'cause we don't want to injure that person when changing loads from one structure to another.” (1)

“just to run for a minute, walk for a minute six or seven times, go home, that's your first session.” Because they've got this engine they're not like a runner who hasn't run and therefore hasn't done anything. They got this engine from the bike. That's mind-blowing to them to say, “That's the session and they end up doing far too much, far too quickly because they haven't got the limiter of the aerobic endurance for the matter that a runner who has not run for six months would have.” (3)

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“when they leave us they’re running 30 minutes without any feedback. So that’s like 30 minutes and then we instruct them to increase ten percent per week so that they can give themselves the time to adapt the change in the loads ‘cause it does change the load of the lower extremity.” (4)

“I always do run and walk programs with them and that could be as short as a two-minute run, one-minute walk, two-minute run and that’s it the first time. To some people I say alright you can go up for an hour and run but every time you feel like you can’t sustain the changes in your motion you have to stop and have a rest and leave it more up to them - so it depends on the individual.” (6)

“The reason we use 30 minutes is really it’s actually quite a challenge for a lot of people if they haven’t been running at all ..... If they have to stay for two weeks at running one minute, walking 4, that’s fine because we’re using those one-minute runs to reinforce the cues ..... we’d aim for no more than alternate days in that walk to run program.” (7)

“using a walk/run programme not expecting people to go out and run for 30-40 minutes with a new style. We’ll get them doing a minute or a couple of minutes at a time then having a bit of a rest again.” (9)

“if they’ve got a recent injury and we’ve got no time pressures in terms of event preparation, then I put them on a graduated loading program where we might start walk, jog with them and that would be nine minutes of walk, four minutes of jog, three cycles of that for a 30-minute cycle ..... and as we’re dropping down the minutes of walking and ramping up the minutes of running, that actual minute of running becomes the new technique.” (11)

“in terms their running re-education, what we tend to do is say – to spend short sections of a each run, maybe a minute in every five or a minute in every mile, just really trying to focus on one of the cues at a time.” (12)

“it’s something that I want them to think about for a minute, maybe once every 15 minutes during a run and just spend one minute focusing on it and then go back to just running. So I try to get to them to integrate it very gently.” (13)

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“Get on the treadmill or go out and run in the street or whatever with that and then on for a minute, off for a minute, on for a minute, off for a minute, on for a minute, off for a minute, and then see if they can maintain it. Once they do that, then see if they can maintain it for five minutes or so and then they’re just supposed to increase the amount of time.” (14)

“I would use the traditional running progression, sort of a run-walk progression as they return back from injury and during the run portion that’s where they would focus on the new cue that I was giving them and then when I give that and I would make them have a day of rest in between runs ..... if they weren’t sore the next day, then they could progress a little bit more on the second run.” (15)

“I would ask what they cared more about, their intensity of running or how long they wanted to run and I did not want to vary both of them at the same time. I wanted to vary only thing.” (15)

“I would give them a side point of advice that initially I only want them to run one minute out of five being conscious of their new gait. And I don’t then progressively increase ..... I think there’s that self-organisation that goes on with that.” (16)

“For every five minutes that they run, I have them run for one minute or like five, like focusing on it, and then ease that up over time.” (17)

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Number of clinical consultations and time frame to make changes

“average is four times – three to four times (sessions to implement changes).” (1)

“we’ll spend a good couple of hours, a few hours in the first session working together, getting them almost the tools for job and the understanding ..... From there I’ll send them an email, we’ll do a follow up session, probably about three or four weeks in, set you on the straight and narrow and usually coming six weeks after, they’re in a place where they’ve been – they can feel that its – it’s not hard to do something about it.” (3)

“So we take four sessions, we go from ten to 20 minutes over those four sessions and get them sort of used getting off their heels and then we bring them back to ten minutes again and we’d go from ten to 30 minutes over eight additional sessions in the alignment retraining.” (4)

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“I think I probably need a lot more than what I do. I take a minimalist approach. I’d probably see them once and then again about a week or two later and then again about a week or two after that. And if it hasn’t changed a lot or if they’re struggling, then I’ll tend to think about other options and that could be a referral to someone else for another opinion.” (5)

“maybe three times a week with some time in between sessions just to help with my findings, helps with more learning, to slow it down. So that’s why I said three to four weeks. I think probably eight to ten sessions for most people is enough.” (8)

“My average number of sessions would be between three and four ..... Sometimes it can be four sessions over eight weeks or four sessions over four months.” (9)

“My average number of treatments per runner is less than four ..... when we do biomechanical assessment of one hour 30 with the camera and everything, we always see the person another time to conclude about all this thing and it’s like two weeks after and sometimes we don’t see them again.” (10)

“My average would be anywhere between two to six sessions, of anywhere between four weeks to three months. I think again, it comes back to how competent a person is from a physical literacy perspective, how committed they are in enduring to their runner re-education cues and exercise programs that are associated with their runner re-education program.” (11)

“I would say probably looking at a roundabout four to six weeks of working at it. You can get, I would expect to see some change by the second or third session in their running gait, hoping to see that they’re improving at least one cue. But whether, I don’t know whether if you reviewed them a year down the line, you’d see that change maintained, I think probably you end up with a kind of halfway house between where they were and where you want them to be.” (12)

“I only see people once. And I give them the cues and as long as they’ve – As long as we’ve come up with a cue which you’d say, “Follow the cues so you can make the change.” I don’t necessarily see them again so you can

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obviously achieve the change in a session and then they need to go off and integrate that into their training.” (13)

“it needs to be more than just I got them off on the treadmill and I showed them. ‘Cause I guarantee you bring them back in six months, I think the chances – It takes time to change a motor pattern and you’ve got a pattern that is so habituated, you’ve got to change it.” (4)

“they can change it relatively quickly. They can change the way they run within one session, like, within a few minutes. And the stuff that I’m doing right now, and we were giving them 45 second escalation to a new cue and the feedback and they’re actually getting it faster than 45 seconds ..... how long can they sustain it when they’re first learning it is a different question? And then how long can they sustain it over time, you know, it’s hard.” (15)

“I don’t look for permanent plastic changes in kinematics. It’s more of a pain thing ‘cause I believe the system has to desensitise. So I try to do just like the majority of people like one to three is enough.” (17)

“I think it’s the hardest thing to change is how you run. So lots – So like once a week with somebody, and then they have to be practicing on their own the other times.” (17)

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Need for coaching versus independence “when people are in the retraining, the eight sessions or 12 sessions, whatever, if they’re getting off their heels as well, we do not allow them to run outside of the lab because we want every foot strike to be right and they’re doing it under our guidance.” (4)

“You have to educate them on the signs that they need to look at and what they need to be aware of or when they should stop and when they can keep going ..... And patients like that and they usually respond quite well to that.” (6)

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“I don’t think this is something that you can go on a course, be taught three or four key factors and then try and apply them yourself. I think you need that visual feedback in order to be able to see and be coached change and I think it needs one-on-one coaching ..... Now, who delivers that, I don’t think it matters.” (7)

“we’re using some of these mobile monitoring devices to kind of give people feedback on their cadence at a given speed, so they can see their speed, they can see their cadence and you can calculate step length from that ..... those are just those personal running computers like Garmin or Polar ..... They can see it on their watch, so they have that real time ..... I think that that’s nice but it’s expensive you know, they’re about \$150 to \$200 US dollars for one and not everybody is willing to do that.” (8)

“People can look on their watch when they're running for 10 seconds, count how many steps they take and increase that by one to two.” (9)

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Possibility of and length of time for habituation to occur

“We can take an athlete out and I can get them running differently in two hours. That’s fine, but it’s the case of better allowing the new - the structures which are loading quite differently and then obviously then we count the neuro pathway frames, try and catch up with what we’ve got the athletes to cognitively constantly think about during the session ..... We usually see that someone had a significant effect in around six weeks ..... the body takes time to catch up with the brain ..... I think that once you’ve learnt it, you will always recognise the pattern. ” (3)

“(Running retraining) takes a lot of reinforcement and based on the motor control literature takes a removal of the feedbacks, the extrinsic feedback such that people develop their own intrinsic feedback ..... I tell people that this retraining whether it’s alignment or impact is something that’s not gonna really solidify in weeks, it’s gonna be months.” (4)

“When I bring people back and I ask them to go back to their old pattern they have a hard time doing it. It tells me they really have learned a new motor pattern ..... we should be bringing our patients back in as physical therapist every six months for a tune-up ..... bring the people back. Make sure they’re okay.” (4)

“The patients I’ve seen, it’s taken six months or more to really feel like they have changed.” (5)

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“For some people, they make the change the first time you see them. They can work at it for a week or so, and after that then they’ve pretty much made the change permanent. Other people can take three or four months to make the changes required. So it depends on the significance of the change you need to make and it also depends on the ability of that individual. So what they’re underlying muscle endurance is to be able to do it, soft tissue issues which might restrict them or allow them to do it.” (6)

“I think six weeks realistically is the minimum amount of time if someone’s been running in pain, or not being able to run more than two minutes or so, six weeks is a reasonable intervention time to get that to work.” (7)

“I don’t really think that I’ve actually changed or trained their usual gait pattern. I think I’ve helped them to learn a new one, and as long as they think about it, they can use it.” (8)

“we can make changes in people pretty quickly, but that movement change has got to be based on the quality of movement before we look at quantity of movement.” (11)

“in the case of someone who has pain it’s pretty quick, it happens pretty quickly that they make that change within a couple of sessions and my sessions are 30 to 45 minutes apiece. So very quickly, it could be within a week. The – And it’s in those people, it’s likely to last, in my opinion. They’ll maintain that. They’ll report to me that they maintained it. But in the individuals that I have worked with that have come to me and requested a change or made a change on their own, those people are the ones who don’t typically maintain that change because they’ve changed this for the sake of changing, so I find that that’s less successful.” (14)

“I think that’s really variable. I’ve undoubtedly had people who I think I’ve probably had an intervention with and I’ve changed their gait and it’s sustained some sense of change. I absolutely have no doubt that I have other people who I’ve changed their gait, their pain’s gone away and when I’ve seen them running incidentally, three months later, they’re running exactly how they used to run, but without pain.” (16)

“I definitely bump into people at fun runs and things that we sponsor as well and they all talk about, “That really changed me. I’ve been running really well since then.” And that might be 12 months later. And they feel different and they feel happier and they think they’re running better.” (16)

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Importance of considering fatigue

“See what happens as people start to get tired. What’s really one of the big areas for me, especially back on working on one of marathon athletes or marathon runners” (3)

“especially with people who have pain problems following fatigue I’d probably get them all running to fatigue and checking them. Practically, you don’t often get the time to do that clinically. So you just need to take that into account that perhaps the pattern you’re seeing, if it’s a slight difference when they’re not fatigued it’s probably gonna be far more pronounced when they are fatigued.” (6)

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Running in pain or not

“I tend to look at their irritability at the time. So say, they present to me and they’re getting flared up and they look like based on subjective they’re more irritable than the next person. Then I would slow them down a bit.” (5)

“We would allow them to run off to about four out of ten on a visual analogue scale.” (7)

“Technically, it’s usually not up to me but they run - Most of these people run with pain anyway. So I advise them to stop if the pain is – if I’m imposing a change and their pain is getting worse from my advice to them, then I tell them to go back to their usual routine or whatever they are doing or they have been doing.” (8)

“We don’t mind mild discomfort when someone is running so people are concerned that a little bit of pain might be, “Oh, should I run through it? Shouldn’t I?” So we use a 3 out of 10 rule ..... or more than 24 hours after the run we get them not to stop running but to rest for a day or two, by then go back in again.” (9)

“tendinopathy ..... If people’s got a five out of ten, as long as that settles quite quickly and it doesn’t hang around in terms of latency.” (11)

“Ten being the worst pain. For me, zero to three is acceptable, providing that it settles quickly afterwards, provided there’s no reaction the next day. Anything above a three, I would say, is a cue for them to modify something ..... if they’re getting more than a three out of ten, I want them to try and find a way of modifying their running to reduce the pain. If they can do that, then I’m happy for them to continue running a bit, but if they can’t and stay sore, then for me that’s okay. That’s the point where I get them to stop.” (12)

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“it does depend a lot as well on a whole host of things, the pathology, what stage the pathology might be in, what part of their training season they’re in – if they’ve got competition on the horizon. So there’s lots of other things. If they’re in their off season, they’re not training for anything, maybe we’d be a little bit more cautious.” (12)

“The tricky thing, of course, is we want to see how it is for twenty-four to forty-eight hours afterwards as well .... they might have been able to get on top of it when they’re running, but not if they’re waking up the next day, it’s much more sore, they’ve done too much and they know that they gotta kind of go a little bit easier next time.” (12)

“My philosophy is very much, you need to get yourself pain-free and then you need to maintain yourself running pain-free .... If anyone’s getting anything more than niggling discomfort, they need to slow down or they need to stop” (13)

“I tell them to keep that pain scale below a level of five and I define to them once they get to my patients, I try to tell them once they get to a five that usually means that they notice it with every step and they’re feeling like they’re not running normally.” (14)

“I usually tell them to run up to but not into pain .... for the most part, I would prefer them to be, no pain, right? And if they had some pain, even if it was just a little bit of mild one, mild zero one two, that, maybe that’s okay. But when we start getting up in the three, four, fives, I wouldn’t go above that though. I wouldn’t go and give them three four five. I’d probably tell them to stop after about a two.” (15)

“In terms of how much pain I’d tolerate, that’ll be condition specific. If this is somebody with an acute something, then I’m not gonna tolerate much pain at all .... I’ll give them a threshold of two out ten. And I probably tend to sit around the threshold of two out of ten.” (16)

“They can’t be flared the next day. That’s the biggest one to me. They’re allowed to persist, but they can’t be hobbling and ruined the next day.” (17)

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“Tendons. I think they’re allowed to hurt a little bit. Bones – No.” (17)

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## Barriers

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Baseline muscle function and flexibility, and structure

“both how difficult it is for the patient change due to maybe underlying soft tissue tightness or weakness or whatever it might be” (6)

“I think the common feature in here is a weakness in posterior chain and I think that’s important. So that is a critical component of our retraining process alongside kinematic changes because clearly the metabolic load of these patients goes up because of the increased cadence step rate and hip extension.” (7)

“recognised kind of stiffness through the posterior chain isn’t gonna happen until we’ve done some work with them, from a strength and conditioning perspective, for example. So there’s certain things that went in physical literacy.” (11)

“I do think that strength is important. If you are – if you have particularly weak glutes, for example, I do think it’s quite hard if you’ve not got enough glute strength to control pelvic position or hip position to ask someone to then – during running.” (12)

“If you’ve got someone, for example, with quite bowed legs, they’re not gonna be able to run with a wide stride ..... So, we have to kind of make sure we’ve got a reasonable idea of what is going on with their posture, so that we’re not asking them to do the impossible when they trained in their running style.” (12)

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Cognition and dedication

“They need to have a fair bit of just dedication to it, really. And they need to be – They need to take it onboard, so they need to understand it.” (5)

“their ability to cognitively be able to make those changes. So, some people cope really well, other people don’t cope so well ..... some people are very in tune with their body ..... that definitely makes a big difference.” (6)

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“I think it’s very much on an individual’s aptitude and the coach’s ability to alter the cues.” (7)

“if you’re running for five minutes with good form and then five minutes with bad form then it’s the repetition of bad form which becomes ingrained so you’re going two steps forward, two steps back. I’d rather you walked rather than ran while you catch your breath and then gradually build that up with good technique.” (9)

“Can people – If I ask people to do something or ask them change their movement, have they got the movement and vocabulary to be able to do that or not? ..... You have to initially buy them into the process of what you’re gonna do that’s different with them and get some changes that are tangible for them pretty quickly to get them on board. So I think that that can affect their desire to make changes. You’ve got to get involved into the process, what you’re gonna do.” (11)

“There are some people who are really brilliantly bodily aware and they can make changes really quickly within a session and there are others who perhaps aren’t so bodily aware. And so, it’s gonna take them longer and more practise.” (12)

“Whether gait retraining will work for that person, depends on motivation, their compliance.” (15)

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## 10.2 Adjunctive interventions

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### Importance of adjunctive interventions

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Running retraining is part of the solution, adjunctive rehab exercise importance

“I think gait retraining itself is not the standalone answer to any of these things ..... For me the whole gait retraining side of things, it needs to come hand in hand with a solid rehab program ..... it’s not just telling people about the key cues, it’s actually getting them to physically subscribe to the right – you also subscribe to a program – in terms of practice and exercise program, non-running practice and exercise program which is right for them.” (3)

“(You need to) assess what pattern faults you think they’ve got and then from there, you can work out how best to change, if some can be changed straight away. Others will require a lot of manual therapy or strengthening exercise, endurance-based exercise to be able to facilitate that change, sometimes footwear, sometimes orthotics, sometimes taping as well.” (6)

“changing someone’s running has its place but it’s not the be all and end all.” (9)

“I think in tendinopathy, runner education is very much a part of the other interventions that we’re gonna be using. It’s not a standalone treatment, but it’s certainly part of the jigsaw puzzle that we can use with people. It’s not about all just exercises.” (11)

“it’s (running retraining) probably just gonna be one piece in the puzzle, not the whole thing.” (12)

“nearly always have a strength and conditioning program to go along side it because I think that’s quite important. Then we’ll have a good discussion of how they should modify training volume, frequency and intensity.” (12)

“gait retraining in and of itself is not the answer.” (14)

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“I would never just put them on a treadmill and tell them to change the way they run without doing a full assessment first. It’s usually the full physical therapy screening, flexibility, range of motion, strength and all of the key musculature, as well as some of the functional tests.” (15)

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## Muscle function

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### Importance of muscle function

“It’s less of strength I’d say ..... You know, to show me how your body chooses to perform this exercise, a lot of the time. Same with the squat, I won’t initially coach him into it. I” say, “Show me your movement pattern.” (3)

“In the clinic, we believe in developing a good foundation just for the durability of that muscular output and the endurance of that muscular output so we do do strengthening ..... you can run and perform really well at high levels and for long distances with very weak hip core musculature. I mean it’s kind of actually catch up with you but you can do it. It’s not like you need it to be able to run but you need it from good alignment and for not overloading your tissues.” (4)

“you need to identify any strength or endurance issues and if they have them, then you’ll do exercise rehab to facilitate changes there ..... If they’ve got difficulty with endurance or strength, they’re gonna have a lot more trouble. Not so much making a very short term change but making a sustained change over a period of time - running and controlling hip motion.” (6)

“Virtually all of our patients will work with a strength and conditioning coach to deliver a posterior chain strengthening program which is sort of a deadlift, double leg and single leg based to try to improve the strength of our runners ‘cause clearly they’re not used to using the extension mechanism and we’re trying to stiffen the movement and actually that becomes very tiring very quickly and so in addition to the kinematic change I think that’s an important component.” (7)

“in terms of activating the extensors or particularly the hip extensors, if we get an earlier foot lift of the contra-lateral side, then when we’ll be getting that earlier glut activation. So I think it’s more about activation while you’re running rather than just strengthening.” (9)

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“we have flimsy evidence that weakness ..... We cross-sectional study that there is something that will serve weakness and problem and pain. But in the same time, when you – We do prospective study. We cannot show clearly that there is a causality effect so it’s more correlation ..... My opinion is probably more a problem of inhibition ..... There is evidence that exercise works, but we have no idea why.” (10)

“Tight hamstrings and tight weak hamstrings can lead to overuse of the gastroc and then strain on the Achilles.” (14)

“more on control and activation and strength because most of the runners that we test, I would say most, are strong ..... it’s more coordination and timing of the strength than it is just the strength by itself.” (14)

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Tests for muscle function

“with the bridge I’ll be interested to see through constant interrogation what they’re feeling. Some of it, it’s all hammies, lower back ..... It’s the same guys who are saying that these are the areas that are still – that do the work, those hamstrings, their bent lower back and, “I can feel the tightness down anterior thigh ..... you know, it all sits hand in hand so often with these things, you try to push hip extension, knee flexion. No wonder they can’t get those loops working ‘cause that’s – that anterior chain is just screaming. ” (3)

“get up onto their toes and just going through a set of 300 toe taps. So left to right, left to right from a position where both heels are on the floor, so up from tip toes just pulling. So dorsal are actively [dorsal-flexing through one foot hold it up towards chest, down, other foot down. Right foot down. Left foot down. That kind of tempo through to 300 reps ..... if they’re failing that 300 test they’re sent – they’re put into a pre-season, you know, remedial calf strengthening kind of program.” (3)

“certainly we do hip strengthening but they have to be able to do as I said, ten single leg hops well-aligned so the knees can’t come in. So obviously it’s a visual subjective assessment but we’ve looking for good alignment so that requires them to have a certain amount of strength and more importantly, motor control” (4)

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“I use things like resistance static contraction in the clam position to test for lateral rotators. I’ve used stuff like side lies leg raises repeated, but looking more at motor patterns in control rather than how many they can do. Then I do stuff like leg extension, and leg curls.” (5)

“Repeated side lie, straight leg raise, I look for three things. One is a give or hyperextension of lumbar spine, QL dominance, TFL dominance and that usually manifests as leg external rotation or hip flexion. So I look for those patterns and if they’re displaying those patterns, it’s either tightness in the hip flexors, which you then have to tease out a bit or it’s gonna be a lack of ability to activate or strength in their inner glutes.” (5)

“With the calf, I’m looking for quite a bit of strength endurance. So the main thing I’m looking for in calf is, if they’re an athlete, I want them to be able to do 40 to 50 calf raises. And my main thing with the calf is soleus. Soleus is the most important thing. When it comes to Achilles injuries, soleus is the key thing.” (5)

“Tib post, resistance static contraction as well as calf raises over a step full range. So looking for that supination-pronation type effect of tib post, you’re getting that resupination in the foot.” (5)

“Also, looking for strength and also balance of strength. So, obviously, patellofemoral pain, looking at hip abduction, hip extension strength is really important particularly terminal extension, looking at joint flexibility, range of motion. So there’s a lot of different things that can contribute and some of these things will prevent you being able to change someone’s pattern.” (6)

“looking distally - so getting them to hop for 30 to 60 seconds, something like that. So you’ll find some people - 15 seconds and that’s it they can’t hop anymore, they’re just really tired or painful so we try to increase that tolerance as well – is important. It’s probably more functional than just doing a heel rate for running.” (6)

“I like to have a good look at general conditioning, things like repeated single knee dips, repeated calf raises, repeated single leg bridges. I might also look at that and I objective measure, like 10 reps max on the leg press, something like that, just to give myself – give me an idea of like what their strength and conditioning’s like.” (12)

“we have six performances on a test that decides whether our patients are ready to return to run or begin a running program ..... So one minute wall hops, a one minute ball or wall sit with the knees at 90-90, a one-

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minute of step ups, quick step ups on to a six or eight-inch step, one-minute plank and then 50 double leg squats fast and 25 on each leg, single leg squats fast. If they can complete those without any major compensations then they're ready to return to their return to run program." (14)

"we look at the interaction again between – As I mentioned earlier, between the hamstrings and the calf muscles, the relationship between the hamstrings and the gluts, whether they're glute dominant or hamstring dominant. I'm sure you've heard quite a bit about that and then – And I think that we have started look at – We're doing some preliminary studies in our lab now, is looking at the posterior sling, so you looking at how the latissimus muscles attach actually to the thoracolumbar fascia and how the thoracolumbar fascia then places tension on the gluts so potentially strengthening of the latissimus muscles or even an arm sling augmentation might have some effect on the activation on the gluts." (14)

"We love the glutes and we forget that the hamstrings are maybe five times the muscle volume ..... for some reason we want the glutes to be the big hip extenders. So I do like a glute bridge where you walk your hamstrings out. And I think runners should go and have their knees straight to be able to load up that position there and without cramping up." (17)

"I like the hip flex flexor strength, you know, like knee above. You should be able to pump it up and down three inches ..... I like the bent knee sort of calf raise where you're like leaning way forward into the wall. Your knee is way over your toe like it is in running and you're just kind of pumping your heel up and off the ground and pushing off your big toe. And its needs – sometimes people are like one foot, they'll do 20 fine and the other one, they can do eight and it starts to cramp and feel sore. And crazy enough, I even do a clamshell. I know it's not functional or whatever but I used to hate it, and then I started testing runners in one side with – I think you should be able to do 50 and you feel fine and the other side, they do eight and their leg gets all ratchety and they're really tired. I'm like, "Well, that's odd." So now I test that on everybody. Boring old clamshell." (17)

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Relative importance of strength compared to motor pattern

"I think muscle activation is more important ..... I mean, if I want to have somebody have strong abductors, great. But if they never use it while they're running, that's not so great." (15)

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Other functional assessment

“So I have a look at people squat, have a look at people single leg squat, have a look at people in their lunge and just see kind of how they’re able to achieve the control approximate and, you know what a lot the time I will be sending people exercises to work on, with knees and various other kind of key areas to try and improve their hip control.” (3)

“I take them through a protocol of – I sort of plyometrics stretch shortened cycle type activities starting with double leg, down to single leg, down to forward hopping, going to maximal vertical hopping, going to box hopping, and landing.” (5)

“We’re looking for movement patterns during tasks such as single leg squat, hopping ..... “you’re looking at how heavy their landing is ..... making sure the heel’s not slamming on the ground - so it’s that nice, controlled landing pattern. Looking for the height - you’re not asking them to hop really high but some people who have a lot of trouble they will barely get off the floor ..... then also you’re looking more proximally so it gives you a really good indication of pelvic control. So looking to see how much contralateral pelvic drop you’re getting, potentially hip adduction as well, although you tend to pick that up a lot more on a single leg squat rather than a hop - whereas probably the pelvis is a bit more on the actual hopping task you tend to pick that up a little easier.” (6)

“I use Kelvin Giles with movement dynamics, physical competency screen within my runners. So obviously, Kelvin’s work, I think, probably will be - It’s looking much more towards movement efficiency, then controlled endurance, and then strength and speed. So that’s the kind of principles that I follow, really. And that will adapt depending on, like I said, needs of the runner, whether they’re a multidirectional runner, a team sport runner, or whether it’s a more of an endurance-based athlete.” (11)

“I would start runners doing some static movement control, simple single leg balance, single leg squats, things like that to try and make sure they’ve got adequate movement control ..... I think single leg balance is a good place to start looking at how well they can maintain the hip position; the pelvic position. Looking at – if they’re getting lots of excess movement around the foot and the ankle or the knee to try and adjust for that.” (12)

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“I have a look at their one leg stand stability, straight leg and bent knee. So really, I only look at, as they’re sort of non-gait parameters. I really only look at their stability and try and get them to improve their stability when obviously correcting their hallux valgus has been the key complainant.” (13)

“Calf race endurance test. I will use hopping and I will tend to – I have no way of validating this, but it’s what I do so I will tend to get people to hop at a self-selected for 30 seconds on one leg and 30 seconds on the other leg. And then I’ll get them to do maximum continuously hopping for 15 seconds on one leg and 15 seconds on the other leg. And I’m only interested in a left right comparison based on frequency.” (16)

“I will look at a single leg stance, a single leg squat as a global motor control issue. I will use a Thomas test I will look at hip internal, external rotation ranges and I’ll measure that. I will usually, not always, but I will use handheld dynamometry to look at hip abduction, adduction and internal, external rotation ratios. I will look at their capacity to do a long lever, single leg bridge, just to get indication of willingness to load through posterior chain, particularly high hamstring tendon ..... and I use 15 as a benchmark. I may, but I won’t always do it, particularly if I’m just using this as a screening tool, look at a side plank to fatigue, purely as a gross measure of trunk endurance.” (16)”

“I think a runner should be able to do a squat. I think they should be able to do one-legged dead lift. I think it’s interesting if they can’t do one leg squat, if their knee corkscrew and everything. I – like a – some simple test like that often don’t correlate what’s going on kinematically during running. But I still think it’s worthwhile to see maybe it’s a habit that they have.” (17)

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Exercise prescription

“I’m worrying about the (anterior pelvic) tilt ‘cause that’s stuff that we’re gonna address in terms of trying to put the correct exercises in to deal the whatever muscle issues there are ..... there are a number of leg exercises and drills with the mini-bands that I get people doing just to – again, mainly work around the hips, sometimes around the shoulder girdle as well but mainly work around the hip to get them exercise the right areas.” (3)

“before we ever start retraining folks, we work on a lot of foot strengthening. We do a lot of doming. We do towel curls. We do up and adduction of the toes. We do doming and hopping. We do box jumps. We do – We

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get them prepared before we start two and a half times their body weight on that foot when they're running." (4)

"So for the hip, a lot of stuff like the split squats into range for hip extension. A lot of glute retraining and strengthening, in functional positions as well as non-functional ..... I do two bridges like a short lever bridge for hamstrings and glutes combination and a long lever bridge that I use for more hamstrings, and that's, can be on a chair or something like that, but you still can't get around the fact that you often get a lot of glute activation with both of them, and therefore it can mask a real weakness of their hamstrings." (5)

"They might lack gluteal strength and endurance so you'll get them doing a lot of strengthening there using Thera-Band or whatever else you feel like is gonna be necessary." (6)

"I don't recommend just general strengthening for the sake of strengthening for everyone, and I try to keep their home program manageable and directed towards their impairment ..... any more than three or four exercises and I find anyway, maybe I'm not a good motivator – I felt – adherence starts to go down and I lose – they stop doing the exercises because there's too much time or effort." (8)

"we can start gently bringing in plyometric probably a little bit earlier but not so for the purpose of building power and speed. It's just for changing activation and increasing stiffness." (9)

"But it's a chronic one and my best treatment for plantar fasciopathy, chronic one, is loading the tissue, eccentric exercise and my biomechanical thing will be – will go in the same way ..... I think that strengthening is always good. It's exercise." (10)

"In terms of new things like ABCD skip routines for people, we use drills to create stiffness in the posterior chain and particularly for, I think, tight calf, Achilles, plantar fasciopathy, depends on the subgroup that I'm working with. I'm treating a few – Quite a few sprinters at the moment so we use lots of high hip lock type of work with them and forget that – And a range of glutes muscle activity." (11)

"I think, classically, their strength and conditioning stuff might have more influence on the forces and how well the body can absorb these forces. But it doesn't necessarily change the joint angles in the way that we might

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hoped it would, whereas running re-education if the patient can do it, I think it probably will change both of these parameters.” (12)

“That dynamic strength again, I tend to do parts of the whole so I’ll actually get people doing drills and exercises, and then try to see if some of that transfers over to their running.” (14)

“I tend to think about stiffness and softening people’s knees when it comes to patellofemoral type pain. So I tend to do a lot of hopping, jumping, step up, step down, sort of activities to see if they can transfer that over.” (14)

“a lot of times, lack of stiffness in the knee has to do with weak hamstrings, which gets right back to what I was talking about with weak hamstrings and leading to calf strains. So I tend to work more on hamstring strength than hamstring stiffness or stiffness for increasing stiffness in the knee than I do trying to increase the quadriceps.” (14)

“I usually would have them, I want to make my patients go through sort of functional progression before they return to running and part of that functional progression was sort of strengthening if you will, those components that were weak and stretching out those things that were tight before they would return to run.” (15)

“I historically see more problems with hip adductor, hip extensors in runners. So, I tend to focus there. So when it doesn’t work on the posterior change. I usually don’t see a whole lot of calf weakness issues, I haven’t seen a lot of quads.” (15)

“I don’t use a lot of stretching. I use a lot more strengthening.” (16)

“That tissue is gonna adapt. But I think exercises also do something as a desensitisation where we’re treating the patient’s beliefs and his pain is so much more than just the tissue. So – And I just call it increasing capacity.” (17)”

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“The most complicated biomechanical model is not complicated enough. So we can be even simpler in our interventions and just treat almost everything with exercise and make that whole system a better athlete, so that they’re better able to tolerate everything.” (17)

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Distal strengthening

“skipping because it’s on the forefoot, I think that it’s another type of training to promote more forefoot or mid-foot strike.” (1)

“you’d be surprised at how weak the calves are in people who are heel strikers ..... in order to get people off their heels, you’ve gotta get them out of highly cushioned elevated heeled shoes because that encourages a reference strike pattern and in order to do that you’ve gotta strengthen the foot and prepare the foot.” (4)

“If they’ve got poor endurance in their calf, they’re gonna have difficulty trying to change to a forefoot or midfoot strike pattern ..... someone might lack the calf endurance to be able to do a forefoot strike or midfoot strike. So you get them doing like heel raises on a step” (6)

“use a lot of pretty high load isometric stuff. Yeah. So I will go for pretty high load rather than through purely endurance-strength leading to a lot of more plyometric dynamic stuff and I tend to work with people getting towards 60 seconds bounce or skipping as a starting point to go into running.” (16)

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Exercise focuses and progressions

“To some people, there’s some dissociation work to be done ..... People just need to learn how to move different bits of their body.” (3)

“you need to get the strength, hamstring, quads, going down the chain just looking at calf and calf strengthening. Plyometric exercises, stretch shorten cycle, hopping, tib post, basically everything ..... I do things with therabands, with machines, isolated one joint, progressing to multi-joint compound exercises that are functional. And then progressing to power exercise then progressing to function.” (5)

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“I try to get them off the bed and standing up as quickly as we possibly can so their exercise progressions are functional. They’re sports-specific, and usually, they’re weight-bearing pretty quickly, rather than doing 3,000 clams on the bed.” (11)

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Assessing and addressing flexibility

(Triathletes are tight) “your serious tri-athletes. They’re spending so much time on the bike that they’re just usually so tight through the whole – the whole entire training to be honest.” (3)

“If you’re let’s say, so restricted in certain key areas that you can’t get into the desired position comfortably without everybody working against this whole path of least resistance, then either you can be working ineffectively to get in that position ..... So we look at the hips. So yes, Thomas test, some test, we look at hamstring length. Again really less so to gets a kind of pass fail with that one. So I’m not saying, you know, I want you to be able to show me 90 degrees at the hip with an extended knee.” (3)

“the two areas that are tight the most in these runners, it’s their calves and their hip flexors. So we have to – We definitely it’s one of the areas that we focus on it’s the hip – gaining that hip extension and increase in the compliance in their hip flexors.” (4)

“If someone’s overstriding and they’ve got really tight hip flexors or really tight rectus femoris, they’re gonna have a lot of trouble preventing themselves from overstriding so that’s often something you need to change as well ..... I like doing lunges for that - works really well if you get them to concentrate on their pelvic position. You actually get a nice eccentric loading on TFL and on rec fem and that can help improve extensibility.” (6)

“I think that if you’re stiff and if you’re naturally stiff and it’s not a new stiffness, you are adapted to that. And this stiffness can be – can help you to become more efficient, more economical and you’re used to this specific stiffness. So I don’t teach of a lot of stretching exercises, except for specific pathology.” (10)

“I’m not mostly fond of stretching. I tend to use dynamic mobility and I use lots of stuff that’s multidirectional, three-dimensional” (11)

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“There’s no good asking them to run with a more extended hip, if they’ve got no hip extension at all.” (12)

“I think most runners have always enough mobility to run. I don’t think any joint comes near its – I don’t – Yeah – I don’t think any joint comes near its end range during running, even dorsiflexion.” (17)

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#### Running drills

“I tend to do as well some drills away from off the treadmill, just actually looking at trying to isolate different components of the gait cycle. So I might get them to work at the swing phase and actually trying to get them to sort of stand they’re doing things where they’re practicing combining a bit of hip extension with a little bit a knee flexion sometimes.” (12)

“Running up inclines can be a great way to teach technique if you do it well because it does give you – It does demand a more active gait. So it demands a more compulsive gait.” (16)

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#### Manual therapy

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##### Use of adjunctive manual therapy

“If someone’s foot is very stiff, it’s not gonna attenuate loads really well. So, you know, we would definitely work manually on trying to increase the flexibility of the foot.” (4)

“They might lack flexibility. There might be tightness, hip flexors, rectus femoris, so you do a lot of soft tissue works. So looking at massage, trigger point releases, dry needling sometimes and then exercise again to facilitate that.” (6)

“I tend to think, what can I do within this half hour that is going to have the most impact and so I’ve moved away from doing a lot of manual therapy for a lot of conditions I see. If I think someone does need some manual therapy then yes, I will bring that in, but typically not in the first session.” (9)

“Very, very rare. I must state more spine, cervical spine, thoracic spine, post traumatic with ankle strain and manipulate the palette and different bone, but I do some specific things for the pathology itself.” (10)

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“I will use things like massage, acupuncture, various different hands-on treatments, but then my main hope with those, it's going to be regulating pain before we can do much in the way of gait retraining and things ..... Reduce the symptoms and then look at the S & C and gait retraining and training error and everything else like that. But I wouldn't generally be doing like lots of long-term hands-on stuff session after session.” (12)

“if someone's got a really, really, tight gastroc and they're limited in dorsiflexion or for whatever reason, and we absolutely utilise that.” (14)

“I would consider manual therapy and taking things that I would do just to get people over the hump if you will.” (15)

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## Footwear

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### Importance of footwear choice

“If they just spent a little bit of time thinking proximally, sorting out some of the key areas there without worrying too much about, you know, always throwing themselves in zero drop shoes. Then they probably would have been all right.” (3)

“the ideal pattern is one where you're landing on the ball of your foot with the lower effective mass that allows you to then use the foot 'cause you've got 26 bones, 33 articulations, each with six degrees of freedom, four layers of arched muscles. All of that is there for a reason and I don't think we utilise them when we use a heel strike pattern with an arch support and cushion shoes.” (4)

“I'm a big believer in the concept of form before footwear.” (6)

“My mantra is really you can run in anything. I wouldn't mind if you run Wellington boots. I think it's how you run and how you are coached to run that makes the difference ..... in our bulk of the recreational market, we probably let them run pretty much in what they like.” (7)

“We're a long way from any type of evidence-based prescription for running shoes, but I do cautiously make some recommendations with people.” (12)

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“Go for the subconscious changes first by shoes ..... only do use conscious cueing if I have to ‘cause I don't think it's effective ..... really, you're just having a bit of a crack at change in the way they load because you can't work out what else to do with them ..... Hopefully, changing the shoe alone is enough.” (13)

“Sometimes you get some unpredictable stuff coming out of that where you get the change to what you expect. So it'd be like orthotics and quite know what's gonna happen.” (13)

“The evidence isn't too strong for making changes to the footwear unless the ones that are in – Absolutely in the wrong footwear. So usually, I would say most of the time, I leave it alone.” (14)

“most people, 80 percent of the people, are gonna do fine in a stability shoe or a standard neutral shoe.” (14)

“Most people do not need a motion control shoe. I think that's way over the top. So I don't make that recommendation very often.” (14)

“I find patients to be not very compliant of their footwear prescription over time. That's hard, to keep up with the footwear industry.” (15)

“I would rarely use footwear changes to change that strike.” (16)

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Potential of minimalist footwear

“(For a 30 minute run) I would start with two or three minutes, of minimalist footwear, and proper gait pattern (and) twenty-seven other minutes with the traditional shoes with the good technique as much as they can ..... we add one or two minutes per training (session) of minimalist shoes, and I usually don't go back to traditional shoes when the change is done.” (1)

“Footwear can be quite important ..... if you've got an individual that's heavily heel striking, they've got a big, big profile in their shoe in terms of high heel versus the forefoot so that the pitch is large, then that's something you often need to change.” (6)

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“I think the higher the standard the athlete where they’re more likely to recommend as a minimal foot drop shoe only because it often is in those guys who have much better proprioceptive feedback because of their higher level of running to affect the kinematic changes.” (7)

“The more durable intervention in the time is the shoes. You change the shoe, you have the minimalist shoes, then he will keep his minimal shoes forever. If we teach cadence, you don’t change the shoes, I think he’s not durable.” (10)

“If I have something in the foot, I don’t change the shoes before the person is cured. So what we have now is metatarsal stress fracture because people move to minimalism ..... I never change the shoes for someone who is not injured, used to it, big bulky shoes and don’t want perform. Don’t change your shoes. If you start the running program or if you are a kid, you need to start in minimalist shoes for, I will say 95% of people.” (10)

“We can use shoes positively in certain people. For example, with things like cadence change, it can be useful to get people into a more minimal style of shoe ..... I want to try and get people in the least amount of footwear that they can get away with, not only for the biomechanical perspective, but from a matter on the foot perspective from an oxygen cost. If we can reduce their shoe weight by a hundred grams, then we’ve saved them some oxygen consumption.” (11)

“I’m quite cautious about changing long-term footwear decisions. So if they do forefoot running in a minimalist shoe for a long time, I’d be very, very cautious about shifting them back to a more supportive shoe, but likewise, I don’t tend to go the other way either. I don’t tend to push people into minimalist shoes from supportive-structured shoes.” (12)

“Achilles tendinopathy, I might be looking at recommending someone to be running in a shoe with slightly larger heel stack on it to reduce weight-bearing dorsiflexion. If you’ve got someone who’s just switched from a shoe with a decent heel on it to something minimalist and they’ve developed a calf or Achilles or plantar fascial problem, I might be asking them to shift back to their normal shoe.” (12)

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“I’ll run all through a five millimetre, a standard sort of ten millimetre drop shoe, a five millimetre drop shoe, a flat cushion shoe and bare feet. So I haven’t – Have a look at how the shoe changes things ..... I think changing cushioning and changing heel raise is primary around those vertical forces.” (13)

“I prescribe them (minimalist shoes) now, and I would say it depends because with footwear, not everybody makes the modification you expect them to make with this. So, I think you’re gonna have adapters and non-adaptors. You’re gonna have individual responses to footwear ..... minimalist footwear has a place for certain runners, people who adapt, who are very adaptable, I think, it might be a reasonable modality to try to change an appearance.” (15)

“I have had patients who would be very resistant, they’re so used to their shoes, there’s no way they ever go to a minimalistic shoe. So, I take patients’ choice strongly into what they would like to do.” (15)

“If someone is like pretty injury-free, I don’t change anything. So I do like minimal. Personally, I like them, too, but I don’t think they’re for everyone. I just don’t think we have good enough clinical reasoning yet to see who gets them.” (17)

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Barefoot running

“Make that person realise that the foot strike pattern with shoes on and barefoot is different ..... Someone having a huge impact force and not able to increase the cadence ..... I think that the barefoot and minimalist shoe is a really good tool to work on the retraining of this person because it helps naturally increase cadence ..... So, that’s the tool I use the most.” (1)

“So again, if you get them barefoot they can feel it. So that’s why we like to do it barefoot but once you get them into shoes, even the minimal shoes you start putting some of that sensory input.” (4)

“Taking your shoes off, try running without shoes on. That’s fine. That I find is okay and that’s not a bad thing to try as a last resort. So if you’re really struggling with them to try and get them to change (cadence), then get them to take their shoes off.” (5)

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“We take off the shoes. They run on the treadmill again and they run with better impact where they’re using behaviour or maybe 70, 80% of the patient. But there is some that don’t – doesn’t change. So, we need other intervention.” (10)

“just taking their shoes off right away, you know that – just so that they can feel how they run with their – in bare feet. It’s such a nice, easy way.” (17)

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## Foot orthoses

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### Whether to use foot orthoses

“I’ll give people orthotics that I think would be helpful, maybe that I can manipulate a little bit with some posting or a wedge, and I’ll have them do an exercise. Something that I know is provocative, whether it’s walking, running, step downs. And if it helps them, if it reduces their pain, then it reduces their pain. I don’t need to know why, but it does. So, I will use them in that situation where a patient finds it effective, but from a kinematic perspective, I really don’t have – I’ve no idea what this thing is going to do.” (12)

“I’d have to be pretty desperate before I went to orthotics.” (13)

“I cast people for orthotics and work pretty closely with fabricating and modifying orthotics ..... but that’s not one of the things that I want to use for patients. I want to avoid that, but if they’ve got a super, super flat foot and no matter what type of exercise or strengthening or anything I do with that person, they’re still going to collapse in the pronation, then we absolutely are gonna use foot orthotic devices.” (14)

“very rarely that I do through somebody on orthotics at the very beginning. I’ve usually tried a few other things before I do it, but I would say probably ten percent of the time, one in ten patients, and they’re usually those really, really hyper pronated people, I end up saying orthotics is what we need to do.” (14)

“I rarely jump to orthotics first ‘cause I found so many people benefited better once they understood the nuances of footwear.” (15)

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“I probably tend to use orthosis more with people with foot pain and I probably – If I had to categorise that, so I’ll probably use orthosis more with people with foot pain where I just want to try and change loading parameters within that foot. I probably would rarely use them for things that are further up the kinetic chain.” (16)

“I think that’s a very good tool for probably more foot and ankle problems. I don’t use it for knee problems and higher because I think that we can have better outcome with just strengthening and other approaches.” (1)

“We’ve gotten everyone out of their orthotics ..... what we do is we wean them slowly out of their orthotics and strengthen their feet. Our feeling is that we want to build up the system that they were born with and the system that was designed to run with so that they can use those muscles as opposed to depending on something to support those muscles.” (4)

“So I think something like tib post, yes definitely, 100percent (orthoses have a roll) ..... “It doesn’t need to be used for foot problem. Often we’re using orthotics to change how the hip is working.” (5)

“I often take orthotics out with patellar tendinopathy ‘cause one of the issues with patellar tendon is a lack of absorption of load in the distal kinetic chain. And when people have got orthotics, that is impeded even further” (5)

“Not a great deal of the orthosis. If I find someone’s got a very unusual foot posture and maybe they’ve got a pathology that links to it like say to tib post tendinopathy, then I would tend to refer to one of my podiatrist colleagues, personally, because I think they’re superb at that ..... Generally, I don’t do that very often though I’d have to say. I think that’s partly because there’s been some fairly recent research showing us a not particularly strong link between foot posture in terms of pronation and injury rates.” (12)

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Foot orthoses as a short term solution

“Most of the time, it’s more on the short term, just to help relieve the symptoms. And after that, I just gradually take them away.” (1)

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“sometimes they’ll have a lot of trouble trying to transition to, say, a midfoot strike because their calves are getting really tight and sore and it might be because of tib post weakness. So some foot orthoses may help with that in the short term and/or taping.” (6)

“in a small portion of our patients, we use temporary inserts or disks within an insole in order to act as similar to a trigger to provide some physical feedback rather than just the verbal cueing, which I think can be very effective in some people. The difficulty of course is they become reliant on that physical cue and so clearly the visual or verbal cues are much more effective.” (7)

“there’s plenty of evidence that says that they reduce pain, particularly in the short term.” (8)

“I’ve probably had told people to remove their orthotics more often than I’ve advised people to get orthotics. They certainly do have their place in certain conditions. And we – I suppose I’ve tended to use more, like, - I certainly believe they’re more of a temporary fix for most people.” (9)

“I think that with orthotics, I do use them. I tend to use them primarily in an offload than load back up kind of passing, so if somebody’s presented with acute reactive tissue like a plantar fasciopathy, I would use them for a short space of time to withstand likely symptoms, often for a reactive state. Then I find weaning and waiting the orthotics that they never needed before the injury.” (11)

“maybe you have some foot problems that you think could be fixed with orthotics or prosthetic, sorry, or proper footwear. If you’re crashing down from above because they’ve got poor hip and trunk control, whatever you do with the foot may just end up feeling like a rock when you use them.” (14)

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## Taping

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Taping may facilitate desired changes

“They might have difficulty changing their hip mechanics because of that endurance issue. So sometimes doing some hip taping can help facilitate things as well. So, all those adjunctive things can help - so it just depends on the individual and what they’re lacking.” (6)

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“I’ll do it. If it helps with their pain ..... I really have to be careful that patients don’t see that as the treatment. To me that’s an adjunct to their treatment.” (8)

“I use a lot of taping and I use especially kinesio taping, neuro taping. I think this is a very good tool.” (10)

“I use a fair amount of ROCKTAPE. I was a user of ROCKTAPE before I was an instructor for them and I teach them for a reason. I just think it – They can be valuable. And I use that along different lines and on injuries, so we might use that from a symptom reduction perspective to reduce pain and support movement and then a deeper control perspective in certain people if they’ve got swelling or bruising.” (11)

“I like taping quite a bit. I think you can use it for a number of things, really. Probably, its mechanical effects are fairly short-lived, but it just seems to help modulate pain and sometimes you can use it as a way of helping to encourage certain movement patterns.” (12)

“I like taping particularly for patellofemoral.” (13)

“a lot of times, I’ll use taping from temporary measures to just relieve tissue tension and get them out of pain and then if they don’t need anything long term, then great, or I might use taping on one of their initial visits to see if potentially some sort of support is gonna be beneficial.” (14)

“I use taping. I probably try to tend to use taping for shorter periods. I’ll certainly use taping around anterior knees ..... I probably don’t use it a lot else for people running. I’ll tape I guess – Look, in a – I might in a reloading phase for somebody who’s had a plantar fasciopathy. I’ll tape around something like that. That’s probably it.” (16)

“I try to unload or desensitise – So some taping, sometimes gentle manual therapy. These are all band-aids to me though.” (17)

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### 10.3 Prevention, ideal running patterns and performance

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#### Consideration other than treating injury

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Possibility of injury prevention through running retraining

“I think that if you have less impact on your bony and joint structures, you’ll transfer that load to more muscle and tendons, which are more able to adapt to the load, and it will help you to be able to increase more in training without getting injured.” (1)

“A prospective paper that showed that people who had increased hip adduction, adduction had a greater chance of developing a patellar-femoral pain syndrome. So you can imagine that if you can reduce that hip adduction it is an indicator and a predictor of patellar-femoral pain than by reducing that – You would think that you could prevent injuries.” (4)

“if we can reduce that loading through some simple changes and techniques then that’s likely to have a preventive effect, but obviously something we need to look at in the future.” (6)

“That’s an impossible question to answer ..... I think it’s so multi-factorial. Injury and risk reduction of – Prognosis of injury risk is a huge topic that’s based on lots of different things, unfortunately. Therefore running re-education is gonna be part of that overall process of how we reduce injury prevalence.” (11)

“we still don’t know whether or not gait retraining is something that proactively is something we should be doing. Because if we’re doing it as a result of an injury, then I can see it, but if you’re doing it, just proactively to try to prevent injury, I don’t think we really have good evidence as to why or how we would do that.” (14)

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Varying beliefs regarding the presence of an ideal running pattern

“I’d say that’s more of a range than an ideal running pattern ..... I think the two main things would be impact force, so low impact forces and high cadence, or cadence between that range of 170 to more 190.” (1)

“I would say there’s isn’t” (2)

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“I really think that mild forefoot strike pattern with a very well-aligned lower limb where the hip, knee and angular foot are aligned is an ideal pattern with the cadence set somewhere between 170 and 180. And just a slight forward lean.” (4)

“Each individual probably has a different running pattern that would be more efficient for them.” (6)

“I don’t think there is ..... I think no one is really taught to run and it’s a skill that needs teaching similar to a tennis serve or swimming stroke ..... I think a shorter stride length and a more midfoot strike, with hip extension is probably the way to go, but it clearly doesn’t suit everybody.” (7)

“An ideal running pattern, I will say no. If you say an ideal personal, individual running pattern, I will say probably.” (10)

“I think variability is actually a very, very good thing. It indicates lots of positive aspects of what we do as human beings so to try and put one style of running onto everybody is a bit ridiculous, really.” (11)

“I think there’s probably an ideal running position for each individual, but I don’t think necessarily there is one overall ideal position we should all aim for ..... We shouldn’t all aim for the same style.” (12)

“There is not. There is absolutely not.” (14)

“My version of ideal running pattern is pretty generic it’s gotta be based, it’s gotta be efficient and it’s gotta be flexible ..... I mean I see some people run pretty lousy but they’ve been running that way their whole life and they’ve never been injured and the tissues adapted to it so I’m not sure that I would want it removed.” (15)

“I don’t front load this as – “This is how you must run”, and I – My experience would be that based on this notion of self-selecting, people self-selecting their own gait based on their own attributes then it probably ends up somewhere between what they’ve originally done and the modified gait that we’ve gone through.” (16)

“the notion that everybody runs with the same gait seems a little bit odd to me because people have fundamentally different tissue capacities, different tissue properties. And that will, in a large part, determine how they choose to run ..... Somebody who has a very stiff tendon doesn’t wanna spend long on the ground.”

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They wanna be able to bounce off the ground quickly. Somebody who doesn't have ground stiffness, but has a lot of strength, will wanna spend longer on the ground so they can access that strength to be able to be more propulsive. So the notion that everybody runs in the same way doesn't fit because of those fundamental differences in tissue characteristics." (16)

"I don't know what (ideals it is. Probably for an individual, I – that's such a cop out answer, but it's true. Yeah. For an individual, I'm sure that there is." (17)

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Performance considerations

"If the change is usually dramatic, then we're probably doing something which is negatively impacting efficiency, and trying to make the change." (3)

"you can see benefit, definitely performance-wise through just making a few little adjustments. Sometimes that does come down to a couple of simple little cues from the run and then making sure you're doing the right work in the gym. You know, promoting the right areas of mobility, the right strength, the right areas and activating the right areas." (3)

"we have not looked at performance but if you can run injury-free you're gonna obviously be able train better and, you know, you might hypothesise that your performance would be better." (4)

"logically, especially things like overstriding, makes sense that if you stop doing that, you're not gonna be getting a braking force and getting them working on hip extension, it's theoretically a far more efficient running pattern. If they're losing a lot of power through excessive hip adduction, etcetera, obviously if you can control that, you're gonna get a lot more generation in the sagittal plane and in my eyes, that's also gonna make you more efficient." (6)

"with all of the changes that you make very rarely do they not feel more fatigued when they first start. But usually, depending on how much muscle endurance and strength they've got will vary how long it takes them before they feel comfortable with it .... Within a couple of months, they just feel like that's their running pattern, they don't have to focus on it anymore and it's no longer fatiguing for them to do it." (6)

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“they noticed, initially, things were very hard and from a cardio point of view, but then seemed to get a lot better around 6 or 7 weeks. So, you know, from a performance point of view, there may be some benefits as well and again another good research area.” (9)

“performance variables can take a little bit of a downturn when people start to change things with movement because I think lots of reasons for that, the way in which we apply new movement and skill – I use the analogy, if there’s lots of runners come back and say that, “It feels so much harder with this new technique ..... So I think there are positive benefits to be gained probably needing for long-term and probably performance detriments potentially when you first made the changes and you have to be a bit patient with them.” (11)

“you change your running gait and actually, it feels hard, especially initially. So, that might suggest to us that metabolically, at least it’s a little bit more challenging to run in the way we’ve asked them to. So, in the short term, it might even be a little bit negative for performance.” (12)

“if you’re making someone’s running style a bit more efficient, if you’re reducing unnecessary movement, particularly side to side movements, you don’t necessarily need – yeah, I think it can make them a bit more efficient.” (12)

“If you look at the average runner who runs a half marathon in the US, you probably would find that they’re a 40-year-old female and you probably find that they’ve been running for, on average, less than five years. So these are not elite runners. They’re not experienced runners. And I think that to some extent, that group of individuals could benefit from some – Potentially could benefit from some level of gait retraining for performance, but there’s no data to suggest that that’s true ..... The data set that we’re looking at right now suggests it has more to do with just fitness than it does anything else, and that strike pattern and strikes per minute and body type and all these other things really don’t seem to matter as much as just fitness and these are not fit people so we’re talking about a range of fitness here.” (14)

“I think you’d see minimal changes in that group. I think in really, really unfit people, potentially, you’d have more success and then in really, really fit people ..... if you had to pin me down, I would say that I don’t think

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there's a role for it, mainly because I haven't seen anything out there that shows that just by changing someone's gait, does it increase their performance" (14)

"I've seen certain things when it comes to performance perspective, if you're running forward, you wanna make sure that things are going that way. You don't want a lot of excessive rotation." (15)

"I think there's an energetic component to that as well, that if you're changing too much, then there is a change of RPE, etcetera, so they'd be going to pull back from a little bit." (16)

"Quite often, they will come back and I'd never take credit for this or big it up, but sometimes they'll come back and they'll say, "I'm running a lot faster. I'm doing all sorts of things." But I think you've got to be really careful as a physio, I think as a coach, you can take credit for it, but as a physio saying, If you do this, you will run faster ..... I don't think there's enough evidence to make that link at the moment." (16)

"I don't know about performance. I think there's a better argument for injury." (17)

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