

Genetic Testing for Sports Performance

Perform with Dr. Andy Galpin · Episode 8 · July 31, 2024 · Transcript

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Dr. Andy Galpin

The science and practice of enhancing human performance for sport, play, and life. Welcome to Perform. Hello again, friends. I'm Dr. Andy Galpin. I'm a professor of kinesiology in the Center for Sport Performance at Cal State Fullerton. Today, we're going to be talking about the role of genetics in human performance. Now, scientifically, this is referred to as sports genomics. Now, this field can be broken up into two main areas. The first is really what we call descriptive or talent identification. This is things like can you use genetic testing to determine what sports you'll be best in. You'll have more success in soccer or baseball or football or hockey or whatever else. Another example of that would be can we separate the best from the rest here? Are there any genetic markers that can be found in people that will tell us who's going to be a world champion versus just international level or national level or maybe even not good?

Dr. Andy Galpin

Other areas within this descriptive or talent ID are things like your physical attributes. So what genetic markers are available that tell us who's going to be stronger and why, have better endurance, higher VO2 max, more lean muscle mass, and other general physical attributes. And then finally, there's other things such as recovery from injury, who's more resilient to concussions, who's going to be less likely to have soft tissue damage, and other things that'll either put us on the shelf or help us come back from these injuries faster. An excellent example of this is the classic story of a world champion Finnish cross-country skier named Eero Mäntyranta. Now, I apologize on the name pronunciation there, but nonetheless, Eero was a multiple-time world champion, I believe even won three gold medals in cross-country skiing in the early 1960s and '70s. Now, what was crazy about Eero is people were convinced he was cheating somehow.

Dr. Andy Galpin

Remember, this is back in the 1960s and '70s, and testing wasn't that available or extensive, and no one really found any evidence that he was cheating, although side note, he actually was taking amphetamines, but they were legal at the time, I think, but nonetheless. The point is why people thought he was doing something odd it was because his hematocrit and hemoglobin levels were off the chart. Now, in another episode of this podcast, we go into detail about the cardiovascular system and what those metrics are, but very briefly, you can think about your

hematocrit as how many red blood cells you have in your body, and your hemoglobin is a similar metric. And what was crazy is his hemoglobin was somewhere between 20 and 24 grams per deciliter, and the average person is more like 14 or 15. So this was off the charts. His hematocrit was over 60%. Most high-level athletes are going to be in the upper 40s, maybe low 50s.

Dr. Andy Galpin

And so they had the metrics that were standardized at that time completely off the charts, and he's out there winning race after race. And so people were convinced he was cheating or doping using EPO or something like that. Well, it turns out he wasn't doing any of those things. We didn't actually know that, though, for almost 25 years later, until 1993, where a geneticist came along, tested him, and identified he had an extremely rare mutation that made his EPO receptors incredibly sensitive. And so when people tested him for his EPO concentrations, they were normal. It just happened to be his receptors were hypersensitive to his training, and so thus, he was a mega responder to that, was able to have hematocrit and hemoglobin concentrations that would honestly probably put most of us in the hospital or dead, and it actually went to his advantage and enabled him to perform at an exceptionally high level.

Dr. Andy Galpin

There actually are somewhat reports, though I'm not sure if they are confirmed, his family had the similar mutation, and so this is why a lot of people think it was actually a very legitimate thing, and he wasn't actually using that as an excuse because it seemed to be persistent among many of his family members as well. And so the idea here is what if markers like this exist, and what if you could find them? What if you're looking for the next talented world record-breaking skier or athlete of some sort, and we could see and find markers of superhuman capability? We can make sure these individuals get the resources and training and access they need to really become something special. Or even if it's within yourself, can you identify something about you that makes you unique, that explains why you respond to exercise well, perhaps not as well, and thus maybe need different training, nutrition, or other modalities to maximize your performance?

Dr. Andy Galpin

While that sounds like a pipe dream, cases like this have existed and are clearly out there. So that would be one example of using sports genomics for talent identification. The second broad category here is what I'll call intervention, which is to say, can you actually get some sort of genetic testing done and then make some sort of change and get more progress based on the information you learn from your genetic profile? This can be done in a lot of different ways, but think about it from the perspective of precision training or precision nutrition. You get a genetic test done, and you realize you'll respond better to A type of training or B type of training, particular supplementation, nutrients, nutrition profiles, eating styles, other things that can happen that will make you respond better and get you faster to your physical and performance

goals. From the exercise perspective here, we tend to call this responsiveness.

Dr. Andy Galpin

So you want to know which style of training you're going to respond the best to. From the nutrition perspective, we often call it nutrigenomics. So what is the optimal nutrition based on your unique genetic profile? Now, the third component here is actually what's called gene doping, therapy, or editing, and that is the ability to go in, identify your genetic profile and genome, and then change it to get a certain outcome or response. Now, a lot of people have heard about things like this, but they don't really realize is that actually real? Is it happening? And I can tell you right now the answer is absolutely yes. There have been over 1,000 clinical trials on gene therapy done, and there have been multiple cases and reports of this being used in sporting context. And so this is something that absolutely exists. It's only going to continue to expand in its reach, and I think it's important then for us to understand what is exactly happening here, how is it being used, is it appropriate, and how we should be thinking about this moving forward.

Dr. Andy Galpin

The best example of this was the story of RepOxygent. Now, this was a gene therapy that came out in 2002, not gene editing, but a therapy, a drug. And this was designed actually for anemic folks, and they were trying to enhance the ability of EPO to deliver and utilize oxygen in the body for those that were struggling with red blood cells. Now, this actually was only around for about a year, and I don't think there's any evidence that it ever was put into use into human testing. However, in 2004, there's actually a case of a German track and field coach who was caught and sent into jail for using RepOxygent in his athletes and actually trying to access more of it once it went off the market. And so clearly, I believe this is an area of human performance that we all need to know more about. So if I had to simplify my goal for this entire show, it would be to answer the question about what do we really know about the current state of genetic testing for performance?

Dr. Andy Galpin

An important caveat here, I'm not talking about or will be talking about anything related to disease. The necessity and usefulness and application of genetic testing for various disease states is an entirely different topic. I am a PhD, not an MD. The conclusions and summaries and data that we bring about in this particular episode are going to be strictly regarding sports genomics, sport performance, and enhancing our human performance, not necessarily treating of debilitating and serious diseases. Now, one of the main reasons why I wanted to do this episode is because not only how interesting the field is, but because of how much it's growing and transferring over into the general population. Genetic testing used to be incredibly expensive and therefore basically inaccessible for most people, and that's no longer the case. The first

human genome sequence cost around \$3 billion for one person, and now there are thousands of different companies that offer these testing for anywhere between a couple of hundred dollars to up to a thousand.

Dr. Andy Galpin

In addition to that, our knowledge is expanding greatly. Just in February of 2024, one of the major projects here in the US called the All of Us project, which I'll discuss a little bit later, just announced the discovery of 275 million new genetic variants in humans. And so we're learning more and more every day, and by that I mean a lot and lot more every single day. And because of all these things, people are really interested and excited in it. In fact, there was a study that suggested up to 10% of athletes have already had some sort of genetic testing done. In addition, many of you have also probably had it done already, you thought about it, or you've had clients, patients, athletes, or friends of yours ask you about it. And so because of that, I really wanted to get into what do we currently know about the science of sports genomics. And while I'm always a proponent of you learning more about your body, we need to approach this field carefully because it is so new and there are some potential consequences many folks don't realize.

Dr. Andy Galpin

For example, there are data initially showing that people will take nutrition and exercise advice that is based on their genetics more seriously than when based on other factors. Now, this can be good or bad. Obviously, the positive here is if that helps you drive adherence. We know this is one of the number one problems or limitations with successful nutrition or exercise interventions, is people being consistent and sticking to their program. So if this can help with that, that is fantastic. However, it can lead to feelings of hopelessness, if you will. So if your genetic report came back and told you that you're not going to respond well to exercise, that you can't eat a particular food type, or your body doesn't do something well, you can hopefully see how that can be really harmful to some people. It can kill motivation, it can make them feel like they're never going to get better, or any number of things.

Dr. Andy Galpin

And I don't want to put emotions and thoughts into people's head, but you can understand how this can be really, really detrimental. And so it's important for me to help you understand what this data really means, how to properly interpret it, how to properly contextualize it so that you can use it for your advantage or at least try to minimize the potential downsides. For example, some data actually suggests that the impact of your belief in your genetics outpaces the actual impact of the genetics themselves. For example here, if you had a particular genetic profile that improved muscle growth by 5% in response to exercise, well, your actual belief that you have the genetics for that might make you grow more so that 5% than the actual explanation of the genetics themselves. And so if you were to get testing done, recommended, or know of

somebody that has some genetic testing done, their belief in what they think is going to happen positively or negatively is really, really impactful, and we know this objectively in peer-reviewed published research.

Dr. Andy Galpin

And so again, this is why I think it's important that we really get a better understanding of what is genetic testing for performance, what does it really mean, what do we know about the data, how seriously should I take it, what can we use it for, what shouldn't we use it for, and what is maybe more in the middle that we'll leave up to you for interpretation. Now, before we go too much further, I'd like to take a quick break and thank our sponsors because they make this show possible. Not only are they on this list because they offer great products and services, but because I actually personally love them and use them myself. Today's episode is brought to you by AG1. AG1 is a foundational nutrition greens supplement. What's that mean? It means that AG1 provides a comprehensive variety of vitamins, minerals, probiotics, prebiotics, and adaptogens in an easy-to-drink greens powder. Getting your nutrition right is hard for many people.

Dr. Andy Galpin

I certainly know that I have clients who really struggle, for whatever reason, to get the proper nutrients from whole food sources. Now, AG1 is not a replacement for eating high-quality whole foods, but it is a great foundational supplement for filling in the gaps where needed. I've also personally found that with many of my clients, AG1 helps move them just in the right direction for eating more high-quality foods because it helps them with cravings, digestion, and many other benefits. I especially personally like taking AG1 when I'm on vacation or traveling because it helps me just sort of stay on track with my nutrition. I know that missing a few days of getting the proper vitamins and minerals and other micronutrients is not a big deal at all. That's not really how those things work. But for me, again, I just like knowing that I'm kind of staying somewhat on track when I'm definitely not making the best nutrition and food choices of my life.

Dr. Andy Galpin

If you'd like to try AG1, you can go to drinkag1.com/perform to receive five free travel packs plus a year's supply of vitamin D3 plus K2. Again, that's drinkag1.com/perform to receive five free travel packs plus a year's supply of vitamin D3 plus K2. Today's episode is also brought to you by Rhone. Rhone is a premium activewear company that is easily my favorite in the world. Few things have aggravated my wife more than my clothing choices. Let's be honest, fashion is not exactly my strong suit. Partially because I have just no sense of style, but also because I'm neurotic about texture and feel. There's not a single brand I've tried over the years that has the same quality, feel, and fit that Rhone has absolutely mastered. Rhone uses best-in-class materials to allow their products to be lightweight and breathable, but still durable enough to last

even when you're training super hard. I remember the first time my wife wore it for a cycling workout, and she, who let's just say is well-versed in the activewear world, was genuinely surprised by how soft and stretchy but supportive the material was.

Dr. Andy Galpin

The Rhone women's collection actually just launched and is already filled with great reviews online. The Rhone base training shorts are brilliant as well. They fit perfectly and have the right amount of stretch to allow total freedom of movement. They also have pockets, which I like, and zippered pockets that are sneaky helpful for holding hotel keys and things like that. The Atmosphere tee and Commuter business shirts completely blew my mind. I do not understand how they made this material. I'll never go back. Trust me here, friends, just stunning craftsmanship all the way around. If you'd like to try Rhone, go to Rhone, spelled R-H-O-N-E, .com/perform to get 25% off your first order. Again, that's rhone.com/perform to get 25% off your first order. Let's get started by talking about what sports genomics actually is. At the very highest level, your genome is not the same as your genes or your genotype.

Dr. Andy Galpin

What's the difference here? All right. Your genome is the entire collection of genetic material that is transmitted from a parent to an offspring. So everything you got from Mom and Dad altogether is your genome. Now, that genome is a big, long strand of DNA. Your DNA is made up of actually basically four different things that are called base pairs. You may remember this from middle school or high school science class. You've got the A, T, C, and G. It doesn't even matter at this point if you know what those stand for, but you have all these base pairs. So in total, you've got about 3.2 billion base pairs. So 3.2 billion Cs, Ts, As, and Gs all strung together. So you put those all together, that becomes your DNA. All your DNA combined is known as your genome. A gene is actually just a specific portion of those DNA strands that encodes or makes a biologically active element, mostly RNA, that then turns into a protein.

Dr. Andy Galpin

Another way to think about this is you have a bunch of genes in your DNA. Those genes are a certain number of base pairs, typically about 1,500 long, plus or minus. So for every 1,500 base pairs, you've got a gene. That gene then makes an RNA. That RNA then makes a protein. And so your genome is a collection of all your genes, and all the proteins you make of that is called your proteome. Now, that word is important. We're going to come back to that later. Right? Genes control all the different proteins you make, but that's just potential. Just because you have a gene, it just means you have the ability to make a particular protein. It doesn't mean you're actually going to. So it's just the potential for protein, not actual resultant protein. One of the most important things we have to realize at this point is that all of us, all humans, have the exact same genes. In fact, this is when you've heard things like humans are 99.9% identical to

chimpanzees at the genetic level or something like that.

Dr. Andy Galpin

That's what they mean. We have almost the exact same set of genes. What makes us unique in individuals is the fact that within each individual gene, we have slight variations. Okay, now these variations is like 0.1%, and so most of humans are 99.9% the same. But that 0.1% has such a big magnitude when amplified into your actual protein and proteome that it creates the uniqueness that is all eight billion of us. And so really the thing that makes us special here, and a point I'm going to drive to a lot, is it's not the genes per se that make us unique and special and different. It's how those are actually transmitted into resulting proteins that allow us to be these unique human beings and to never have the same one of us twice. A perfect example of this is our friend from earlier, Eero Montooranta. Now, Eero actually had a really specific mutation where he actually had a G to A transition, so he had a G base pair instead of an A, at base pair 6,002.

Dr. Andy Galpin

Okay? Now, that was actually particularly significant for him. That actually caused a special thing to happen here, which is what's called a TGG, so a three base pair segment that was supposed to code for an amino acid called tryptophan. You may recognize that thing. That's the amino acids in turkey that makes you all sleepy. So it was supposed to code for that, but that little mutation, that single base pair switch-out, actually caused that, instead of making the tryptophan, to make what's called a stop codon. Just tells the gene to stop replicating, if you want to think about it like that. Now, that result means that when he created his EPO receptor That receptor actually then became 70 amino acids shorter than normal and made it hyperactive. So to recap, he had the exact same gene. He had the EPO gene that all of us share, but his had one base pair switch out. And so one base pair switch out had a huge impact on the resulting protein, which had then a huge impact on his overall body because it was much more receptive to the EPOR.

Dr. Andy Galpin

And so this is why, again, when they tested him, his EPO concentrations were normal, and in fact, this is one of the main things that led to WADA, the World Anti-Doping Association, generating and creating a program called the Athlete Passport, because they started to recognize that we can't just test for levels. And you see, prior to this, if someone just had a high hematocrit level, they would either not be allowed to race, or they would be flagged and banned because they assumed they were cheating. Eventually, WADA had to recognize there are some people who are just different, and this is normal for them. They're not cheating. And so the passport idea says we'll just track you over time, and if you jump way up or down in some biological metric, then we may have some indication that you're cheating. But back to our point

here. So everyone has the same genes, but some of us have these small variations in any individual or given gene that has a big impact on the amount of proteins we make, which has a huge impact on who you are as a human being.

Dr. Andy Galpin

But we got to go one layer deeper because, in fact, you actually have two copies of every gene. Now we call these alleles. One copy comes from mom, one copy comes from dad. So if we go back to our EPO receptor, it would actually function more like this. Let's say a normal EPO receptor is N for normal. And so what we would say is that EPOR gene would be EPOR-N for normal. And let's say the endurance one that Arrow got, we'll call it E for endurance. So you could either have EPOR-N or EPOR-E. But since you're getting one of each copy, you could be what we call homozygous, which would be EPOR-NN. Homozygous meaning the same. So you got an N from mom and an N from dad. You're normal-normal. You have the same exact receptor sensitivity. Or you could be EPOR-NE. You got one N from mom or dad, you got one E from mom or dad, so you're heterozygous, which means half of your genes there are going to be hypersensitive.

Dr. Andy Galpin

So in that particular case, you would have advanced endurance. Or you could be homozygous for the fun one, right? So you could have EE, one E from mom, one E from dad, and you would then be a bonkers endurance athlete. As I mentioned earlier, so the story goes, many of his family members had a similar genetic anomaly, so most likely his genotype would have been EPOR-EE, and that explained probably why he was ultra-mega, super-duper sensitive and had the phenomenal results he had. Now, I threw in a term there, and I want to make sure you didn't miss it, and that is genotype. So when we say the word genotype, and this is critical to understanding genetic testing because this is how it all operates on, genotype refers to the type of alleles in every given gene. So your genome is your genome, but your genotype is what alleles do you have for your gene for any protein. So again, we have all these genes, and let's just say you have a gene that controlled your eye color.

Dr. Andy Galpin

So what's your genotype for your eye color gene? What's your genotype for the gene that makes your quad muscle? What's the genotype for the gene that makes your fingernail length and your arm length and things like that? And so for every single gene you have, you would be able to describe the genotype for that gene. Hopefully, you're following me there. Genome is the whole thing, genetics are all of them combined, and the genotype refers to which specific variation or allele do you have of any given single gene. Another thing we really have to understand is that variations in your base pairs is really common. In fact, it's so common all of us have it. I gave the example of Arrow with his one base pair change, but the honest reality it is the average person

has about 20 million base pair variations. Right? So the average person not only has one or two or three, but they have 20 million variations that are different from what's called the reference genome.

Dr. Andy Galpin

This is context I'm going to come back to a lot when we start getting into genetic testing and we start talking about how many things they're testing, how many they're reporting to you, and how important and impactful those claims really are laid against the context of how much variation is normal and how much is even actually possible. If a variant in one of your genes is really common in the population, and scientifically we'd define that as greater than 1%, meaning you have this crazy thing happen, say in the case of Arrow, if we found that exact same variant in 15% of people, we would call that a polymorphism. Okay? If we find it in less than 1% of people, we call it a mutation. Now, typically, variants and polymorphism have less of an impact. Mutations tend to have a bigger impact. Very common variations are the things that determine your eye color. More extreme mutations are the things like the EPO sensor.

Dr. Andy Galpin

So uncommon, we tend to call it a mutation. Common, we call it a polymorphism. Functionally, it's really no different, right? It is an abstract number, 1% we put on it, and so really it doesn't make that much of a difference. Some of these things are super common, some of them are super rare, but it's really the same thing biologically. Now, if this mutation happened in literally a single base pair, we give it a fancy name called a single nucleotide polymorphism or a SNP. A lot of the stuff that happens in pop culture and media, people talk about SNPs, and most genetic testing will talk about that. That's exactly what they're referring to. If it is a mutation in more than one base pair we just simply call it a polymorphism. It really doesn't matter if you know the difference. There's no special functional difference between something that is a three or four or 100 base pair change or a one.

Dr. Andy Galpin

What matters is what's the functional impact, and there isn't a huge relationship between the amount of base pairs that are different and the impact. So for the average person, you don't really need to know the difference. I just thought I could clarify that for a lot of people. Maybe they're confused by it, didn't know the difference, and now you know what the difference between a polymorphism is, a mutation, and a single base pair polymorphism. Probably the most famous example of a rare mutation in our field is actually that of myostatin. Myostatin is what's called a negative regulator of muscle growth. And so I kind of double negative you there, but what happens is myostatin inhibits muscle growth. So if you inhibit the inhibitor, then you allow muscle to grow. And people will see this and talk about this. There are supplements that are marketed for myostatin blockers and things like that.

Dr. Andy Galpin

But this all goes all the way back to a classic "New England Journal of Medicine" paper from 2004, which they actually uncovered the case of an infant who had a genetic anomaly, a rare mutation, that actually blocked his ability to make the myostatin protein. This is actually a wild story. So the kid is born at normal, I think it was 75th percentile body weight, normal to term. They had no reason to think anything was going on there. The kid immediately came out, and his muscles were kind of twitching, and they were sort of concerned with what's going on, so they started running testing on him. He also visibly, and you can actually see pictures of this. These are online everywhere. They were actually in the actual publication themselves. His quadriceps muscles were enormous. Now, this is a newborn, been around for a couple of hours. His calf muscles were just off the charts as well. And so the doctors were like, "Man, what's going on?"

Dr. Andy Galpin

It took them a while to actually figure this out, but they actually eventually ran some genetic testing and realized that he had this very rare mutation that blocked this myostatin protein. I think they actually confirmed the mom had that mutation. I don't remember if it was confirmed in the dad or not, but it looks like probably this is a magical combination of an incredibly rare mutation and found rarely in mom and dad, probably led to this kid having it. I'm pretty sure this is the only scientifically validated case of a true myostatin-inhibited kid, naturally done. I actually think they followed this kid for many years, and by the time he was four and a half years old, he was doing front raises with three and a half kilos or something like that. So it wasn't just look, he was actually big and strong. And I don't think they found anything, according to the last update, wrong with him. I think he was a perfectly normal, healthy kid and just happened to be hyper-strong.

Dr. Andy Galpin

So these cases of these rare mutations really driving anomalies in human performance, it's understandable why people are excited about sports genomics. The other side of the equation are, again, our polymorphisms and our SNPs. And I'd like to give you two examples of that. Probably the most famous cases here are the ACTN3 gene and the ACE. And I want to bring these up for a couple of reasons. One, they were two of the very first genes found to be associated with elite athletic performance. They have the most scientific evidence by far. They are the most common markers you'll find in genetic testing. And we're going to come back to them the entire length of the show here. So we'll anchor against both of these in every single section, making sure you understand really the detail, what we know about the state of both ACTN3 and ACE, and that will hopefully give you a backdrop of the overall field as great examples.

Dr. Andy Galpin

I know there's a lot of jargon and terminology. If you're listening to this while you're trying to work or something like that, it's probably been really challenging. And so if we can kind of always come back to ACTN3 and ACE, I think this will help you stay grounded in some of the terminology and technicality that is just part and parcel of talking about the genetics of sport performance. Let's start off with ACTN3. Now, this is my particular favorite because it's the gene responsible for making a protein called alpha-actinin-3, which is required and necessary for fast-twitch muscle fibers. All of us have the ACTN3 gene, but some of us have a particular SNP variant that actually switches out an arginine for a stop codon. So if you have the ACTN3 gene that has the R transition or arginine, then you have the genotype of ACTN3R. If you don't, though, that actually makes that stop codon, which means you don't make the alpha-actinin protein, which means you don't have fast-twitch fibers, and so then you don't have those.

Dr. Andy Galpin

We give that a big X. So the genotype for not having it is X. That functionally leaves you with the genotype possibility of being ACTN3RR, RX, or XX. Now, there's a lot of literature on this one. It's been studied for over 20 years, and collectively, what you'll find is there's a decent relationship there between your genotype and the amount of fast-twitch fibers you have, such that if you are RR, you probably have a lot of fast fibers, RX has a little bit less, and XX has the least amount of fast-twitch fibers. That said, because you have less fast-twitch fibers, you also typically have more aerobic capacity, aerobic endurance, and things that bias you towards a long duration or endurance bioenergetics. Our next example, ACE, is kind of the other end of the spectrum. So that makes a particular protein called angiotensin-converting enzyme, and that's responsible for a bunch of things like your blood pressure, respiratory drive, tissue oxygenation, and other factors that are more commonly associated with endurance.

Dr. Andy Galpin

So ACE's particular polymorphism is a good example of not a SNP, but actually has a 287 base pair sequence change. And so, again, the naming here is nice. If you have the gene variant that has the extra base pairs in it, they are inserted into that gene, you get the I allele. If it is deleted from the gene, you get the D allele. And so ACE I means insert, ACE D means deleted. Okay, the ACE I genotype generally has lower serum and tissue ACE activity. And this actually has a similar story that ACTN3 did, such that we tend to see a pretty pronounced difference in ACE genotype based on higher functionality of endurance markers like VO2 max, fat utilization, endurance performance, and lower in those that are more of the fast-twitch, high-power, and strength athletes. I know we covered a lot of technical detail and acronyms there, but let me see if I can summarize it all really quickly for you.

Dr. Andy Galpin

Your genome is the entire collection of material you got from your parents. That then results in what's called a genotype. So we all have the same genes, but some of us have different variations in them. The specific variations we have alters and changes the amount of proteins those genes actually make. All those proteins together are called our proteome, okay? All those proteins come together to make what's actually called our phenotype. So the phenotype is the physical expression of all those proteins. It's how tall you are, how much muscle you have, how much hemoglobin you have in your blood, how many fast-twitch muscle fibers. So the actual physical expression of your characteristics is your phenotype. So to give you some actual numbers, humans have about 19,500 genes. This allows us to produce somewhere between millions and billions of different proteins. We actually don't know the total number of our human proteome.

Dr. Andy Galpin

Each combination of proteins results in a different eventual final phenotype. So from 20,000 or so genes, we're able to create an infinite list of different unique humans with slight to large variations in how we look, feel, and perform. I'd like to take a quick break and thank our sponsors. Today's episode is brought to you by Momentous. Momentous makes supplements of the absolute highest quality. For example, we've long known about the numerous health and performance benefits of fish oil. I've personally been taking it for probably 15 years or more. Now, you can get fish oil anywhere, but personally, I only use Momentous because it's never once given me a fishy aftertaste, and more importantly, every single batch is NSF tested to ensure the lead and mercury levels are undetectable for purity and safety. Their fish oil is pure, potent, and sustainably sourced. Another major benefit is that you won't find any fillers in their fish oil.

Dr. Andy Galpin

See, the dirty secret in the industry here is that most companies will add non-EPA and DHAs to their fish oil to keep their, quote, "fish oil count high," but to keep the active ingredients and therefore costs low. And it makes you actually feel like when you're purchasing it, you're getting more fish oil at a cheaper price, but you actually have to double or triple your dose to get the same amount of active ingredient, which means you end up spending more money in the long run, or you don't, and you get worse results. If you want to give their fish oil a shot or any other Momentous product, go to livemomentous.com/perform to get 20% off your order. Again, that's livemomentous.com/perform to get 20% off. Today's episode is also brought to you by Continuum. Continuum is a membership-only wellness club designed to help high performers reach their fitness and performance goals. Continuum just opened its flagship club in Manhattan, quickly making it one of the most sought-after memberships in the city.

Dr. Andy Galpin

Its location in Greenwich Village is incredible. In fact, it's stunning. It's a 25,000 square foot space with state-of-the-art equipment, a beautiful design, and everything you could possibly want in this unique mix of a gym, wellness center, and social club. Continuum members start with a thorough Olympic-grade assessment that results in a biometrically-driven, AI-assisted wellness program that updates in real time and incorporates everything from personal training and physical therapy to hyperbaric and IV therapies. By bringing together true fitness experts, best-in-class technology, and proven wellness services and amenities, Continuum delivers the most comprehensive solution to performance. I've been involved with Continuum, working as their head of performance science, since their founding, and I've been incredibly impressed by what the team there has built. If you're interested in joining Continuum, their team has agreed to give a select number of you, the listeners here, a fully waved onboarding, which includes VO2 max testing, DEXA scans, blood panels, sleep analysis, and more, all at their fabulous New York City flagship location.

Dr. Andy Galpin

To learn more, visit continuum.club/perform. Again, that's continuum, with two Us, .club/perform. Let's jump right in to investigate. Getting genetic testing done is easy and accessible for many people at this point. There are companies all over the world. What I really want to get into are what we call DTCs, so direct-to-consumer genetic testing for the perspective and sake of enhancing human performance. Direct-to-consumer genetic testing kits come in a couple of different flavors. The first are what are called whole genome sequencing. Now, these are about 1,000 bucks or so, and they allow you to actually get information back about millions, if not billions, of your individual base pairs. The second and more common with a longer history are kits that just test a small number of these SNPs or polymorphisms. They're often anywhere between literally one to maybe 20 to 50, with some kits I know doing up to as many as 70 different polymorphisms.

Dr. Andy Galpin

The cost there ranges with how many you're testing, so some of the kits that look at one to two or three markers are as cheap as \$90, and others are closer to \$300, maybe \$400 or \$500. So regardless of which style of testing you choose to use, if you choose to do so at all It's been my personal experience that people are often underwhelmed, honestly, with the results they get back, because they tend to be really wishy-washy, and they don't give a lot of really tangible implications and applications and action steps they can take from the results. And so what I hope to do in this next section, interpretation, is just share with you more about how to interpret these things on your own, which things can be used to take action with, what has strong evidence and information behind it to do so. From there, you can choose to take action on that or not. But that's what I hope to cover in the next interpretation section of this discussion.

Dr. Andy Galpin

One of the nice parts about this field being so popular is how much information is available and up to date. In fact, Dr. Ildus Akhmetov, a Russian sports geneticist, actually has published a series of papers called "Genes and Athletic Performance," and he just updates them every single year. It's almost like a little bit of a Wikipedia for peer-reviewed science. So that is a fantastic resource. He had a 2003 version that just came out. In addition, he also published a paper in February of 2024 called "Genetic Predictors of Physical Activity and Athletic Performance." And there's just a number of other articles. As always, all the papers that we've used for this entire show are going to be available in our show notes. But those ones I thought were particularly important for me to draw out as great starting place and points if you want to get a grasp of the literature in this field. In order to truly grasp the current state of the field, I have to walk you back through a little bit of how we got to where we are right now.

Dr. Andy Galpin

Sports genomics have been around for a long time. The first evidence we actually have came from the late 1960s and early 1970s Olympics, where they started identifying differences in red blood cell types among athletes compared to those who were not. And so from there, people were interested in the field and things were happening, but everything really exploded in 1990. That's because here in America, we started a project that I've already referred to once before, and that's the Human Genome Project. In that, the goal was ambitious, and that was to outline and understand every single gene in the human genome. At the time, they thought this was 100,000 genes, but really the thought was 100,000 is not that many. If we can figure out exactly what each gene does, we're going to know exactly how and why every person behaves and performs good or bad, exactly how they do, which was incredibly powerful idea.

Dr. Andy Galpin

A couple of years later in 1992, they started another program called The Heritage Project. Now, this was a 21-year study where they looked at heritage stood for health, risk factors, exercise training, and genetics. And what they were trying to do is answer that fundamental nature versus nurture question for exercise and performance. In other words, how much of your physical attributes, and body weight, and strength, and muscle mass are attributed to nature versus nurture, or your genetics versus your lifestyle? And the story keeps going. We go all the way up to the late 1990s and early 2000s, and the legendary physiologist Claude Bouchard comes out with a paper called "The Human Gene for Physical Performance." This was actually referring to the ACE gene we talked about earlier, but the title of that paper alone, "The Human Gene for Physical Performance," and that's because at the time, they really legitimately thought they had found the one gene that explained all human performance.

Dr. Andy Galpin

That's the power they thought they were unraveling here. Within this same time window, we see the release of things like the Arnold Schwarzenegger mice and the myostatin knockout mice. Now, these are studies from different groups of scientists at John Hopkins and the University of Pennsylvania, and they're doing things like knocking out a single gene and doubling muscle size in mice, and then they're living to be just fine. So again, we're really doubling, tripling, quadrupling down on this. Oh my gosh, if we can learn what one gene does, we can literally create superhumans. Bouchard also publishes one of the most cited papers still to date in the field, and that's called "The Human Gene Map for Performance and Health-Related Fitness Phenotypes." I mean, just think about the words in that title. He's a scientist, but yet there's clearly tremendous optimism for what this potential thing could be.

Dr. Andy Galpin

And they thought they actually knew the human gene map at this point for human performance. It's no surprise the same time we see the first scientific concerns about the possibility of gene doping and manipulation for sport performance. And things really continued to crescendo here up to 2002 and 2003. The very first paper from that Heritage Project came out, and we saw numbers that were mind-blowing. You're talking about single genes that accounted for 40% of the variance in oxygen uptake, 30% in resting heart rate, 27% in your heart rate response to training. And any optimism we had on this gene project was just increased. I mean, we're seeing, again, one marker that tells us a third of how your body's performing in a huge area like your cardiovascular fitness. We also announced the completion, or what I actually call the pseudo completion of the Human Genome Project. It wasn't actually done despite the fact that they said it was done, but it was close.

Dr. Andy Galpin

And we see the very first paper looking at the genetics of elite athletes, and that was actually ACTN3. Now, for those of you, particularly here in America, that's the same year we had the BALCO incident. That's our Major League Baseball players all getting caught and in trouble for all the anabolic steroid use. And I'm bringing that in right now because think about what's happening in the mentality of scientists and athletes. Genes are explaining huge chunks of performance. We're creating these mice that are literally Arnold Schwarzenegger mice. We're doing the same thing in humans, not with genes, yeah, but with hormones. Clearly, the ability to make these superhumans and super athletes is a real thing. It's not down the road. It's not the future. It is live and real in 2002 and 2003. And because of all these things, WADA, the World Anti-Doping Association, has basically no choice but now officially start listing gene therapy and doping and editing as an banned policy for athletes going forward.

Dr. Andy Galpin

Now, they didn't know what this was, how it would work, there was no technology that allowed you to do it, they didn't know how to test it, but they absolutely could see what was coming here, the potential for people to start trying this and exploring it without safety precautions. And so really, again, they had no choice but to put this on their list of banned activities. A couple of years later, 2004 and '05, things continue to get interesting, and the Salk Institute releases a series of paper that have been called the Marathon Mice. Similar idea to what happened with the Schwarzenegger mice and myostatin, but this time, they did it for the endurance perspective. So you're seeing 20, 30, 40% increases in endurance capability, running duration, performance with no exercise training, just changing and altering a few genes. We also saw a couple of interesting things in Australia, the first being the release of the first-ever consumer genetic sports performance testing kit.

Dr. Andy Galpin

I think it actually only measured one thing, and that was ACTN3. And not surprisingly, an Australian rugby team also announced that they were using genetic tools for their personalized training and coaching programs. I remember being a graduate student during this time, and the medical, coaching, and scientific communities were on fire with this idea of sports genomics. Things then really accelerated from 2012 to '15. We actually saw the release of the very first gene therapy that was approved here in America. Uzbekistan announced that they were using DNA testing to screen kids for talent identification. And probably most importantly, is launching of several major scientific projects both here in America and in the UK, designed to increase our understanding of human genomics at a major population scale. The UK Biobank enrolled 500,000 people. Here in America, we started programs like the All of Us, the 1000 Genomes, and then even more globally, what's now called the Precision Medicine Initiative.

Dr. Andy Galpin

All of these projects were aimed at really saying, "Look, we get it. We buy in. Precision nutrition, precision exercise, precision medicine is the future."

Dr. Andy Galpin

Unfortunately, the science is limited by small sample sizes and individual teams and universities trying to get this stuff done. What we need are giant databases of hundreds of thousands or millions of people where we can go in and data mine and really understand what these things look like. As an example of that, the All of Us project aimed to enroll a million people in that. Now they've actually done, I think, to this date, 750,000, but they're going to get that, and you can imagine the inferences and learnings we can gain from that once we have sample sizes at that level. And all of this mattered because in 2017, when the UK Biobank released their first set of data, the entire field got flipped on its head. You see, remember, prior to this, the dream was we

will find one gene equals one protein, and there's not that many really genes to figure out, and we're going to know so much. And now we realize that most complex human traits are, in fact, polygenic.

Dr. Andy Galpin

Now, that word, poly meaning many, and genic meaning many genes, is the reality of it is, it takes many, many genes to see an actual phenotypical change. It's not one gene that determines your VO2 max, but hundreds, if not thousands. It's not one gene that determines how big you're going to be, how tall you're going to be, if you're going to be good at soccer or basketball, but probably tens of thousands of genes combined. Now, in order to accomplish that, scientists went away from this idea of a candidate gene, as you'll see that written in the papers, to what's called a polygenic risk score. And so what they're saying is, okay, if we know that, we'll just stick with the example of, say, VO2 max. A thousand genes are playing some role in your VO2 max. How many of them do you have in the right spot? If we put them all together, what is your polygenic score? So what is your score? How many of the thousands do you have in the right spot, and how much of your VO2 max does that actually explain?

Dr. Andy Galpin

So gone were the ideas of a single gene for human performance, a gene map, or the ability for one marker to determine 30% of performance. And in now were the days of saying, "Okay, what percent of variance does that one, two, or even several hundred genes explain?" And so really, that's how we want to think about the field moving forward. It's not about do you have one gene. I can break your heart right now. There are no athlete genes. As I said at the onset, we all actually have the same genes. There's no test you can determine that's going to tell you whether or not you're an athlete or going to be great or not. It is all about how many things can you stack in the right direction that gives you a better chance at having a certain physical trait that's desirable for a certain sport. And this is why I had to painstakingly walk you through what some of these terms mean. What's the background biology?

Dr. Andy Galpin

What are genes really, and how do they work? I had to walk you through the history. I had to get you up to a place you understand it's not going to be as simple as one to one. It really is how much variance can they explain, how much will it determine, and that is going to let you then decide is that enough for you to take action or is that not enough? I know where I stand in the field, but you may feel differently, and that's fine. I just want to give you the information as we know it now and let you decide for yourself. Let me give you some numbers to let that sink in just a little bit more. Let's assume you had a particular trait. We'll just keep saying VO2 max for now. And there were 100 genes that went into VO2 max. Honest answer is it's a lot more, but let's just say 100. I want you to think about flipping a coin and just using an analogy that we call heads

and tails. So if you were to go through each one of those genes and you treat that as a coin, and you could flip it to be heads or tails, and let's just say heads meant that the allele type resulted in greater VO2 max, and the tails was normal or reduced VO2 max, and you want to think about it that way.

Dr. Andy Galpin

In the best-case scenario, you would flip that coin 100 times, one for each gene, and if it landed on heads every single time, you got 100 of the best-case scenario of all 100 genes, your VO2 max would obviously be really, really high. If you got tails 99% of the time and head 1% of the time, your VO2 max would be low. That's really what a polygenic score is. You're flipping it, and you're trying to say, "Okay, great." You're not really going to find many situations where somebody's 100 out of 100. You're not going to find many where there's zero. It's more like this. The best athlete in the world is 60 out of 100, and the normal population is 45 out of 100. That difference of 45 of the right coin flips versus 60 of the right could absolutely be the difference between a normal person and a world champion endurance athlete. Okay, so that's up to 2017. Couple more important points before we move on to our next section.

Dr. Andy Galpin

In 2018, all this stuff caused WADA to then go in and further expand their definition of what gene doping and therapy is and what is illegal for sports. And that's probably also because China announced that they were using gene testing in their selection process and training process in preparation for the 2022 Winter Olympics. A year later, 2019, things get completely wild, and we see the first, and to my knowledge, only documented case of actual legitimate gene editing. And I'll talk about the difference between gene therapy and doping and editing a little bit later. But now you're talking about because of the influence and understanding of our CRISPR-Cas9 technology that some of you've potentially heard of before, there was a case in China of a physician going in and actually changing the genome of, I believe, a set of twins. And so now we started staring down the barrel of possibility of changing your genome actually can happen, and that's something we need to be considering.

Dr. Andy Galpin

2022, the Human Genome Project actually is completed, and they end up actually finally coming down and saying, "We started this project thinking that there were 100,000 genes," and it is now down to something like 19,500. A really big milestone there, and we finally kind of wrap the bow on that big, many decades-long project. Which then brings us to 2024. As I'm recording this, a few weeks ago, a couple of papers came out, and I was like, "Oh my gosh, I'm so glad we didn't record this thing a couple of months earlier because these ones are really important." The very first one was basically a giant warning for the Paris Olympics for any of you athletes out there, saying we now have groundbreaking technology for the detection of gene therapy and gene

doping. Now, they're a little bit hush-hush on what that would be, and I don't know if it's going to be accurate, but that's an important distinction that they actually really feel confident that they can test at least some of the ways that this can be monitored.

Dr. Andy Galpin

Also, the All of Us project that I've mentioned a couple of times now came out. I told you they were now 275 million new gene variants. Importantly, though, and perhaps most importantly, they had a really significant word of caution that they put in there, and that's the fact that we need to understand over 90% of genetic databases are based upon Caucasian backgrounds. And this is incredibly important because as I'll show you later, and I'll go over the papers, if a trait has not been validated against a similar ethnic background, the trait shouldn't be used. I'm going to come back to this point a lot. This is one of the major things we need to consider if we're going to take any action insight off of consumer genetic tests.

Dr. Andy Galpin

One more time, the marker and the trait needs to be validated against your personal life background or close. If not, we have a very, very, very large chance of a false finding, and it could misrepresent your actual risk or benefit in that category. I'd like to take a quick break and thank our sponsors. Today's episode is brought to you by Absolute Rest. Sleep is the bedrock of human performance, which is why I always focus on it with my elite athletes. But despite trying every wearable and even sending people to full-blown clinical testing in sleep labs, we rarely got very far. That's why two years ago, I co-founded Absolute Rest, which redefines what it means to be a high-performance sleeper. After tremendous success, we are now ready for our next challenge, a first-of-its-kind sleep optimization program that combines advanced sleep technology with personalized coaching, all at a fraction of the cost of a traditional sleep study.

Dr. Andy Galpin

The Sleep Lens program allows you to run a full FDA-approved, clinical-grade sleep study from your fingertip every single night. Our team of sleep scientists then use your data to create personalized solutions that drive real changes in your sleep. No more overnight stays in creepy sleep labs, no more wearables with questionable accuracy, and no more wondering if the changes you're making in your nightly routine, habits, or supplements are actually working or not. If you'd like to try Absolute Rest, go to absoluterest.com/perform to secure your spot in the Sleep Lens program and save \$100. That's absoluterest.com/perform. Today's episode is also brought to you by Renaissance Periodization. If you want to put on muscle through science-backed training programs, look no further than Renaissance Periodization. RP, as we call it in the industry, guides users through effective and easy-to-follow lifting programs all through their hypertrophy app.

Dr. Andy Galpin

These programs are designed by the absolute best in the industry, including one of my absolute favorite sports scientists and professional bodybuilder, Dr. Mike Israetel. You may recognize that name because I've referenced him and his work countless times over the years. So whether you're looking to put on muscle, gain strength, or both These programs will help you achieve your goals and have produced results in literally thousands of men and women. Renaissance Periodization also has a diet app that is backed by the latest science and innovation in the fields of nutrition and takes the complexity out of dieting, helping you achieve your ideal body composition. If you'd like to try Renaissance Periodization, go to rpstrength.com/perform to save up to \$50 off of your subscription. Again, that's rpstrength.com/perform to save up to \$50 off your subscription. So to wind us all the way back, we know based on the Heritage study and similar others, that a large portion of your athletic traits are a result of your genome.

Dr. Andy Galpin

Depending on the study and the actual variable, it's about 50/50. Half of it's due to your genome, and half of it's due to your lifestyle, your training, your exercise, your sleep, et cetera. So let's focus on this 50% genetic part. In fact, this is the whole point, right? We're trying to understand how can I learn more about that side of me as a human. I think there's five basic questions you need to ask yourself when trying to interpret the results of your data in determining whether or not you're going to take action. The very first one is what gene or variation of that gene influences a given trait? So what genes are associated with my strength and how many genes predict VO2 max, or muscle mass, or testosterone, or injury predictability, or things like that. So what gene or variation influences a given trait? Number two, how much that gene actually contributes to that trait. Is it explaining 80% of the trait, 1% of the trait, or somewhere in between?

Dr. Andy Galpin

Number three, how likely am I to actually create a physiologically relevant change? So one of the things we don't often talk a lot about is just because you have the gene doesn't mean you will actually make the protein. It's just the capacity to do so. If it doesn't actually replicate itself into a protein, it's not turned on or it's turned off, then there would be really no physiological change. We absolutely 100% know just the gene itself does not determine the actual resulting phenotype. So number four then, what is the magnitude of that effect? So you have a gene, it determines a certain percent of a trait. The gene gets activated or turned on. How much is that changing? Is that increasing your strength by 40 kilos or 0.4? Is that contributing to you gaining some fat mass by 40 kilos or 0.4? It's different for every gene. We've got to consider that how much of an effect is it happening, and then finally, underlying all of this stuff, number five is has that been validated against someone who has a similar genetic background that I have?

Dr. Andy Galpin

And so what I'd like to do now is walk you through all five of these, share with you some of the data we have so you can have better context. Critical question number one, what gene or variant of that gene influences a given trait? As a reminder, when I say trait, I mean physical attribute, like your strength, or size, or muscle mass, or something like that. All those are collectively just known as your traits. By far, the most documented sports performance genes are ACE and ACTN3. You will find numerous papers showing their association between physical performance and actual direct sport traits. You'll see this in cyclists, marathoners, ultra-marathoners. You'll see it in Americans and British and Greek and Polish and Turkish and Russian, tons of data, men and women from many countries and many backgrounds, and it's very clear. Those that have the I allele, remember that's the insertion one, are much more endurance-based and successful in endurance sports.

Dr. Andy Galpin

Those that have the D, that's been deleted, are more likely to be successful short-distance sprinters. A similar thing is found with ACTN3. In fact, the very first paper by Yang and North in 2003, I believe, showed a really interesting pendulum, basically. So remember, the X variant is typically associated with blocking and X-ing out that alpha-actinin-3 protein, so blocking out fast-twitch fibers. So because of that, if you go to Olympic and world champions in sprinting and power events, they tend to have very little, if any, X. A lot of RRs and a lot of RXs. Very little XX. And as you come down the continuum there into maybe good sprinters, but not great, and then into controls, you start seeing more XXs, less RRs, less RXs, and if you continue to go all the way to the other end of that spectrum, and you look at really high-performing, successful endurance athletes, you see a lot more XXs.

Dr. Andy Galpin

So in the case of ACTN3 or ACE, it's important, it's not a good or bad thing. It's just determining kind of which of these traits you have. And in fact, because they are independent, which allele you have for ACTN3 doesn't affect which allele you have for ACE. You also see athletes that maybe have the fast "genome" for ACTN3, but the slow one for ACE. So maybe they're pretty good and have great endurance, or maybe they're not great at either because they don't have enough traits stacked in that category. This is the complexity with just two genes, and remember, you got 19,500 of them. So this stuff gets really hairy really quickly. I want to give you one more direct example here with ACTN3. I don't want to bore you in detail, but it's important for me to not just give you theory and fake numbers, which are nice and helpful to help you understand the context, but when we actually have the real data, let's share that.

Dr. Andy Galpin

And so if we look at something like ACTN3, as I mentioned, this has been done extensively like

ACE. In fact, almost every direct-to-consumer genetic test for performance is going to include both ACTN and ACE. They're going to be there. It's been done and validated in Powerlifters, weightlifters, bodybuilders, sprinters, soccer players. It's been done in Russia, Australia, America, Finland, Greece, just all over the place, okay? And here is what you're going to see in terms of athletes as well as by ethnicity. So these are actual numbers, and what I've done is I've taken probably, honestly, 20 or 30 studies and combined them to just say, all this kind of smashed together, what's it generally look like? So if you were to take any people from any of those countries that I just listed, on average, non-athletes are going to look something like this. About 25% of them are going to be ACTN3 RR. Remember, that's generally more fast twitch.

Dr. Andy Galpin

So right there, 25% of just normal people have the "fast twitch," the double fast twitch, but they're not even athletes. Maybe they would have been if they trained, or maybe they wouldn't have been. It's only one gene. But nonetheless, it's not a thing you're going to see as only in athletes or some special thing. 25% of the normal population has the double fast genome, RR. Okay? Now, about 60% have RX, which makes a little bit of sense. You get a little bit of both traits here, endurance and speed, which leaves about 15% of people that are truly an XX. Remember, hard having fast twitch fibers as XX. If you start looking at power athletes, instead of being 25% RR, it's more like 50% RR. So a significantly higher likelihood that you'll be RR, but it's not 100% either. RX then goes from 65% in controls to 45%, and things do get interesting at XX. About 15% in controls, and it's down to anywhere between zero to 5% in power athletes.

Dr. Andy Galpin

I think this stuff gets more interesting as you go to the top levels, though. You all know me, I am most interested in the world's best. I always want to bring that out for you in every episode. I try to share with you what the best, most elite look like. If you look at the Olympians, these are studies that have been done where they look at actually not only Olympians, but the world record holders and gold medalists and things like that. Their RRs tend to be a little bit higher. So instead of being 50%, it's 55%. And their RXs are a little bit lower, still around 45%. But you basically see 0% of them that are XX. And so what this tells you is, hey, just because you're RR or RX, that doesn't mean anything about your ability to be a sprinter or be a great one. But it might be fair to say if you are XX, it's going to be really challenging to be a world champion sprinter. That, I think, is a fair assessment.

Dr. Andy Galpin

Now, we'll talk about talent identification later because there's a lot of ethical concerns. But if that's all we're interpreting as saying, look, you can maybe be a good athlete, a power athlete, and be XX, though it's unlikely, probably only about 5% of power athletes are going to have that. But it's probably really challenging to become a world champion in a power or speed sport if

you're truly ACTN3 XX.

Dr. Andy Galpin

That said, you got to throw all that out the window if you're not Caucasian, because here's the reality. About 15% of Caucasians are going to be ACTN3XX. The data as we know it now, about 25% of East Asians are. And so right on the face right there, the story is different if you're East Asian versus Caucasian. If you're East or West African, I'm not talking about world champion, I'm not talking about power athletes, I'm just talking as a person from that kind of an ethnic background, the XX variety is in somewhere between zero to 1%. You just don't see it in these populations. So that will not differentiate your sprint ability or power ability at all if you're from East or West African descent because nobody in your population has it anyways. And so really, again, you have to understand the context of these things, and many of these markers have not been validated against all ethnic backgrounds, and so you need to take the context appropriately there if you're going to make decisions about talent identification or anything else based on something as simple as ACTN3.

Dr. Andy Galpin

Now, I know that sometimes sounds a little bit negative. I will tell you a little bit later in the show at the end, I'm going to share with you some of the good news and the fact that there's a lot of data being collected to solve these specific problems. So hopefully, this is a barrier we'll be able to cross in the near future. That's what it looks like if we dive into one particular gene. I want to actually zoom out now and try to answer the original question, which was how many genes actually go into defining a physical trait or attribute? To kind of summarize all the literature as best I can, in my interpretation of it, if you look at things like your overall lean muscle mass, as things stand right now, there's about 1,000 different gene markers that go into that. Your testosterone level, 855, grip strength, 170, and so on and so forth. So now if you're thinking about this in the context of the genetic testing you did, if you perhaps used a kit that looked at three or five or even frankly 50 markers, and they tried to make strong claims about how much that'll explain your testosterone, your strength, your muscle mass, I hope you can start to realize maybe they left some things on the table there.

Dr. Andy Galpin

If I know that 1,000 gene variants are actually responsible for my lean muscle mass, how strongly you choose to interpret the results of two or three or again, even 10 or 12 of those, I'll leave that up to you to decide. But again, I want to give you some real numbers here. So let's take the sports trait that is by far the most studied, and that's actually your height. So how tall you are to date. From the heritability studies, we know that your physical height is somewhere between 70% to 90% a result of, again, heritability. That's your genome. So it's not a trait you can really train. I suppose actually there's some technologies that pull people. I actually saw that

people are getting their femurs cut and stuff like that, so we're not going to count those things. The reality of it is most of your height is determined by your genetic inheritance, and a small percentage of it is actually honestly nutrition or rather malnutrition.

Dr. Andy Galpin

But let's just pick the number 90% to make math here. So 90% is a result of your genome. All right, great. There are over 12,000 single nucleotide polymorphisms that are responsible in combination for how tall you are. But it gets worse than that. Of those 12,000, they only explain about 40% of your genetic height. So if we say your height is 90% genetic, of that 90%, 12,000 SNPs explain 40 of that 90%. So where's that extra 50%? Well, by basic math, that tells you by the time this thing's all said and done, there will probably be another 12 or more thousand SNPs. The final number is probably going to be something like 25,000 of these gene variants that all combine together to give you that 90%. Each individual loci then is explaining something like, again, 0.0003%. It's not much.

Dr. Andy Galpin

I wouldn't take much action at all. I don't know what actions there are to take with your height, but this is unfortunately how some of these genetic testing services work, is they might test two, three, four, five, et cetera, and the honest reality is for something like your physical height, unless you're looking at thousands and thousands of these SNPs, you're really not going to be able to explain much of the variance at all of how tall you are.

Dr. Andy Galpin

It's not necessarily their fault, though. I don't want to be overly critical because the reality of it is it took 5.5 million people in a database to learn those 12,000 variants. In fact, I think the prediction is something like they'll need 100 million people from the same ethnic background to be able to complete that database and understand all of the possible gene variants that go into determining simply how tall you are. That's actually not a super complicated thing to figure out. How do you think that looks when we expand to traits like sport performance that encompass a lot more than just how tall you are? I've said this a number of times, and I really want to be clear here. When I say things like your physical attributes, it's hard to get these from single genes or even a couple of dozen genes because a single physical attribute is not explained by one thing. We'll continue to use the VO2 max example.

Dr. Andy Galpin

There can't be one gene to determine VO2 max because VO2 max is a combination of a lot of physical attributes. If you want to know exactly what I'm talking about, please check out one of our other shows this season on the cardiovascular system and cardiac muscle. But your VO2 max is a composite of things like your lung size, how tall you are, your slow-twitch fibers, your mitochondria, capillarization, et cetera. So many things go into your VO2 max. Each one of

those has many then genes that go into it. And so if you're looking at a polygenic risk score and you're looking at 20 or 30 or 40, the reality of it is you need hundreds to just determine lung size, and you need hundreds to determine slow-twitch fibers, and hundreds to determine capillarization. And so getting all the way up to an attribute like VO2 max becomes really challenging. And now, if we think about actual sports, when we know sport performance is a combination of VO2 max and strength, we realize now this becomes really challenging to predict sport performance because we've got many layers above what the actual gene itself can control, which is just a small number of proteins, and millions of those go into an actual trait, bunches of traits go into an attribute, and a bunch of attributes are needed to play sports.

Dr. Andy Galpin

That said, there actually is a decent amount of data on what SNPs, variants, and polymorphisms are associated with actual sport and physical performance. Now, I'm actually pulling this directly from the February 2024 review article by Dr. Akhmatov, and what's really important here, he boils these numbers down to only those that have been double-validated, which means in multiple studies. So as it stands now, there are 29 double-verified markers associated with soft tissue injuries. There's 149 variants associated with physical activity traits. Again, think strength, power, speed, endurance, things like that. And 253 polymorphisms related to athlete status. Now, what I mean by that specifically is markers that separate the best in the world from just international, or football players from basketball players, or things that have been directly verified, typically in high-level or professional athletes.

Dr. Andy Galpin

Now, because that one is of most interest to me, I can actually further break that down. So of those 253, there are 41 endurance-related, there are 45 power-related, and there are 42 strength-related. These articles are great. I think they're open access, but nonetheless, we'll have them for you. In these articles, they have the full tables. They have all 253 listed. So if you've got any genetic testing done and you want to look in and see if they're on your test and compare it, you can absolutely do that, but I don't think anybody out there wants me to read off 253 genes right now. That'd be a challenge. So what I would like to actually do is just kind of run off the five or six most promising for each one of those subcategories.

Dr. Andy Galpin

This is all acronym, so bear with me here, and I tried really hard to not do this the entire length of the show, but this is the one time I will do it. So here you go. The seven most promising of these 41 endurance-related genes are the following. I'll try to pause in between each one because you're basically just going to get a big list of letters and numbers. So the very first gene is called AMPD1, and then CDKN1A, HFE, MYBPC3, NF1A-AS2, that's one gene right there, PPARA, and then finally, PPARCG1A. Now, the most promising of the 45 power-related variables are the

following: ACTN3, which we've mentioned multiple times now, AMPD1, CDKN1A, CPNE5, GALNTL6, IGF2, NOS3, and TRHR. For the most promising of the 42 strength-related variables, we've got a little bit of a shorter list here. ACTN3, of course, here, and then LRRPPRC, MMS22L, PHACTR1, and PPARG. Now, there's a series of studies I'm thinking of that do a really good job of highlighting this idea of a polygenic score.

Dr. Andy Galpin

Now, these are done in weightlifters and powerlifters in Russia. It was later replicated in Japanese weightlifters. It's essentially saying the same thing, so I'm going to summarize them right here. Now, what they actually did is they looked at this, and in their study, they found that there are 28 markers associated with performance. Now, this is important because later I'll talk about how many total markers are needed to predict muscle size and strength. But for right now, they only, for whatever reason, found 28 that were significant in this population. What's interesting is they ran these polygenic scores on them, and they said, "Okay, if we take our athletes and we compare them to people also from Russia that are not athletes, what do we see?" So if there are 28 genes that related to performance, what they found was 100% of the athletes had at least 22 of the 28 that were in the right allele.

Dr. Andy Galpin

Remember, this would be heads. They got head in 22 of the 28. But somewhere between 70% and 80% of the controls also had 22 or more. So one more time, just because you have 22 or more doesn't promise you anything about being a great athlete. That said, there were not any athletes in this database, weightlifters or powerlifters, that had less than 22. It gets really interesting when you go a little bit higher, though. In those that had 26 of the 28 that came up heads, of them, the controls were about 25% to 40%. So again, really pretty common to have a lot of strength alleles and not be an athlete at all. But what's interesting to me here was what separated the highest elite group from the next elite. The highest elite group, 85% of those athletes had 26 of the 28. The next elite group, so sub-elite, good, but not as good as the best, only 65% of them had 26 of the 28. So again, a little more evidence to say, hey, if you want to be good, more traits is better.

Dr. Andy Galpin

But if you want to be really world-class, you probably need to have, in this case, at least 26 of the 28. As I briefly talked about a few minutes ago, using even a couple of hundred markers or even all 253 in this case, and being able to identify talent is a big stretch. And the reason is explaining a trait, how strong you are is one thing, but taking that and leaping all the way to performance is complicated because sports involve more than just your physical ability. It's your reaction time. It's your intelligence. It's your decision-making. It's your psychology. All of this stuff combines to make an athlete, and this is why people can spend millions of dollars at an NBA

combine or NFL combine and still not really know who's going to be best when it comes to the next level. It's really, really challenging. It's not much easier in genetics. And this is one of the things I actually found really refreshing in reading literally hundreds of articles in preparation for this show, and that in almost all of them, where they are going after or analyzing talent identification based on genetics, basically unanimously, they warned against doing it.

Dr. Andy Galpin

The scientists in this field are really, really clear. Talent identification based solely on genetics is a poor decision at this point. Perhaps information will come in the future, but they were very strong, and that's not something you typically see in scientific papers. But I think that the concerns of ethics, and especially with children, really struck a nerve in a lot of these scientists, so I commend them for making sure that while they're doing studies in this area, they are very clear. Talent identification based on only genetics is very, very shallow at this point. So while there's a lot of things positive and things we can take from sports genomics, I think the evidence is clear. At this point, those are probably not two things we should be spending a lot of effort and energy on. Moving on now to our second critical question, and that is how much does each gene explain a given trait?

Dr. Andy Galpin

The term you're going to hear a lot here is variance, and that's the science way of saying, okay, if I want to understand what is explaining 100% of my strength, that's clearly not going to be one thing or two things or three things. Your limb length, your technique, and all these things will combine to contribute your 100% of your strength. And so when we go after fields like this, what we're trying to find is what's called variance. So how much of that variance is explained by that trait? And another way to think about it is something like if your technique explained 20% of your strength, then that would be 20% of the variance. That's typically how overall physical traits in human health is described. It's rarely one thing. If ever, it's usually hundreds, if not thousands, of elements that go into a human being. So the variance, the different amount of strength that's between me and you How much of that difference is explained by a given trait?

Dr. Andy Galpin

1%, 2%, 8%, 90%, et cetera. Let me hit you with a couple of specific papers. One of them actually was pretty cool. It looked at a couple of hundred Flemish men aged 19 to 73, and effectively what they did is they kind of combined everybody together, and they were able to find 153 gene variants that predicted muscle size and strength. And then they put them into four different mathematical models and said, "Okay, let's see what we can come up with. How much of actual strength and performance is explained by these variants?" Well, one of the models was able to explain 7% of the variance in leg strength, but 0% of muscle mass. The next best model could only explain 2%. And so what we're looking at here is at best 7%, 0% of muscle mass, and

probably more realistically, something closer to 2%. And this is, again, it's informative if you think it is, but considering that we know things like your exercise training and your nutrition and sleep are going to predict 50%, 60%, 80%, again, I'll leave it up to you to determine if that matters or not.

Dr. Andy Galpin

Bringing us back to VO2 max, as we've done so much, the UK Biobank released a study just last year from 450,000 participants. They found 170 different fitness-related loci, and they explained a total of 1.08% of the variance in VO2 max. Similarly, another study actually looked at oxygen saturation at altitude and found our friend ACE explained 4%, when they compared that directly to just the fact of acclimatization, that was 44%. So again, it's not nothing, it's contributing. I'll let you decide if that matters. A way to think about this is when you're trying to be accustomed to higher altitude, your oxygen saturation is a big deal, and there's a lot of factors that explain your oxygen saturation. In this case, your acclimatization explained 44% of that new oxygen saturation concentration, and your ACE allele explained 4%. It's not nothing, it's clearly contributing, but you obviously would want to pay most attention to the 44% and not as much attention to the 4%.

Dr. Andy Galpin

Critical question number three is what's the likelihood this polymorphism actually results in a physiologically meaningful change? And number four is what's the magnitude of that effect? Now, I'm going to combine these, and I think you'll see why as I'll just cover a couple of examples. But really what I'm talking about here is even if I have a certain polymorphism, what's the likelihood that it does something at a level that I actually care about? And that's really what I'm getting at with points three and four. I want to cover a couple of examples directly from a 2019 paper by my colleague, Dr. Tommy Wood, and the first one is on a gene called FTO. Now, this is associated with obesity and specifically body fat composition. In his analysis, he found that FTO explained about 0.4% of the variance in your body mass index, and the eight most significant predictors all combined into a polygenic score still only explained about 2% of BMI.

Dr. Andy Galpin

So the variance explained is low, like we've talked about with point number one and two. But more importantly, what's the likelihood that this actually matters to me, and what's the magnitude of effect? And this is where I think things get really interesting. So in this particular case, the risk associated with this score was 0.3 kilograms per meter squared. What that effectively means as an example is if your BMI was 24.43 and you had the worst combination of alleles, that might make you heavier, and that would take you from 24.4 up to 24.8. And if you had the best combination, instead of being 24.4, you'd be 24.1. What this means, and I'll use American units here, sorry, international friends, if you're 5 feet 10 inches tall, this would be the difference

between being 170 pounds or 173 pounds, or 170 pounds and being 168 pounds. And so the magnitude of effect is really a couple of pounds.

Dr. Andy Galpin

One more time, that might be of importance to you. In my personal coaching, it's generally not. I know that any of the number of things we are playing with in terms of training or exercise or sleep are probably going to be much more of a magnitude of effect, so I'm focused more on those, but it's not nothing either. The next particular point is what's actually the likelihood of this happening? So we know the magnitude of effect is small, but one other thing that was really interesting in his paper is he was able to calculate the likelihood that it actually happens. Remember, just because you have the gene, it doesn't mean it'll be expressed. So what's the likelihood that actually happens? And what he found there was the null effect, so the likelihood that it doesn't actually happen, is somewhere between 93% and 97%. And so even if you have one of these poor, say, polygenic scores for obesity, it's probably not going to explain much, half a percent.

Dr. Andy Galpin

The magnitude is going to be a pound or two, and there's a 95% or so chance that that won't even happen. So to me, when I interpret this entirely, that's why I don't put a big emphasis on this type of testing for our clients, but I'll leave that up for you to decide. You'll see a similar thing here in terms of strength. A 2023 paper came out, had 340,000 people in it, and they tried to predict grip strength. In that, they found six genes that were related, and that showed a combined 0.6 kilogram difference. All that to say, it explained about a pound of your grip strength. I don't want to come off overly negative here, and so I really want to make sure I'm explaining the fact that these data and types of studies are actually very important and really insightful at a population level. Understanding why people are a little bit heavier or weaker or have any physical traits across hundreds of thousands of people is actually really informative and helpful for scientists.

Dr. Andy Galpin

It's just that when we take it from a population level down to the individual coaching level is when we start having the problems. So to me, this is why I love this stuff and look forward to seeing more research on the population level, but it's not something that I use to take action on when I'm coaching my clients and athletes. This brings us now to our fifth and final critical question, which is, are questions one through four true across all genetic backgrounds? If you've been paying attention thus far, you know that we actually know pretty clearly that is not the case. I mentioned earlier the All of Us project, released in February 2024, even remarked that over 90% of our databases are on Caucasian genetic backgrounds. But it's even worse than that, to be honest. I know of some studies where they have taken white individuals from the UK, run the

same analysis on white individuals from Germany, and failed to replicate the findings.

Dr. Andy Galpin

So even within populations of, say, skin color, if they're not the same genetic background, the same variables may or may not hold true. I've said this a couple of times now, and I really want to make sure we put specific data behind it. The ACE gene, as I told you, in general, that seems to relate to a whole bunch of proteins important for blood pressure regulation, oxygen saturation, things like that, generally endurance-related items. Having said that, just because you have the gene doesn't always determine the resulting protein, and that's important in this context, because if you look at the data from Caucasians, that seems to predict something like 20-plus percent of the variance in the resulting gene. However, in the Pima Indian populations, that gene predicts only 6% of the resulting proteins. In Kenyans, it's only 13%, and in African American and South Africans, it's 0%. Not only is it not predicting performance like we talked about earlier with ACTN3, it's not even predicting the amount of resulting protein.

Dr. Andy Galpin

Looking at genes is important, but we have to ultimately know what is the result on the protein level and what is the phenotypical actual physical attribute change. And so in some populations, ACE might matter a lot and be helpful, in others, it might literally be irrelevant. I could give many more of these examples. Genetic background is incredibly important for interpreting and properly contextualizing reports from a sports genome test. So to summarize all that, we had five critical questions. The very first one was how many genes or variants actually determine a given trait? And the answer is anywhere between one to up to 20,000. But most of the time, we're looking at somewhere between 100 and 2,000 is a fair number. How much do these individual markers explain in terms of performance? Somewhere between zero to 1%. What's the likelihood that they will actually create a physiologically meaningful difference in me?

Dr. Andy Galpin

Somewhere between, again, statistically zero to 7%. And then the magnitude of effect is zero to 5%. And then finally, as we just mentioned, is this true across all genetic backgrounds? And the answer is clearly no. This allows us to now finally get into our third and final I, intervene. I will give you warning, though, this is significantly shorter because I feel like most of the work needed to be done in interpretation. You're getting the feel by now, I'm sure. These things are often over-interpreted, and they aren't useless. They're informative, but there is not a lot of direct action that probably should be taking based on these things. In the future, though, as we learn more, we're going to change our tune almost surely. But right now, I wanted to really make sure you understood the validity and accuracy and reliability of the current field, and so we'll keep this next section fairly short, as I think you're getting the context by now.

Dr. Andy Galpin

To me, there's three real areas of possible intervention here. The first is actually, are you using genetic information to personalize or optimize your physical training? Are you using it to customize and be high precision with your nutrition? And then finally, can you use therapies and drugs to turn on or off the genes that you want on or off? Or if you are really extreme, can you go in and actually change your genome? We're actually going to start in the reverse order with gene doping. Gene therapy is actually a medical treatment. It's been around since the 1970s. It's been in over 1,000 clinical trials, and there's a lot of real true disease use cases for it. It's expensive, generally over a million dollars, but it's been around for a very long time. What I'm talking about here is gene doping, and that is the use of drugs or therapies specifically designed to alter activation or utilization of your genes to get a competitive advantage.

Dr. Andy Galpin

The other one I've talked about is gene editing. So think about gene doping as, again, taking a drug to turn on a gene more so than you would get out of nutrition or exercise or a normal intervention. And editing is actually going in, changing your genome, and having a new baseline. To date, I'm not aware of any human adult who's ever used gene editing. There are papers and examples of it being done in embryos, and that's because it gives the body ability some time to adapt and change. Not really sure it's ever been done on a successful adult human. However, there are lots of studies arguing that it is plausible and possible, and animal studies and other things like that suggest it might happen. And so this is something that may be possible in the future, but as of right now, the risk is extremely high. There's been multiple cases of people dying, unfortunately, from cytokine storms and excessive immune responses because of it, and so it's not clear to me that this is actually happening in the world right now.

Dr. Andy Galpin

I won't say it isn't, but I don't know of any scientifically documented cases of that happening. As well, it's not legal. I work with athletes that are in sports subject to drug testing, and so I can't use it. I don't know that it's safe, so I don't really see a need to talk that much more about it. I want to share with you what it is, and I think it's exciting and interesting, but there's not a lot of action steps I think you should be taking on gene doping therapy or editing at this point. So what do we know about personalized training and nutrition based on your genetics? There actually have been a number of studies that have done this, but my read personally of the literature is you're going to see studies on both sides here. There have been a number of studies from people like Craig Pickering. Craig actually was an elite sprinter, like almost a 10-second 100-meter hurdler, and then got into the field of genetics.

Dr. Andy Galpin

He's done a lot of fascinating research in this area, and he himself has published studies finding

positive results in terms of running an analysis on somebody, running a polygenic score, potentially even sometimes adding things like blood markers, putting them into various groups, and then either matching them or mismatching them for their, quote-unquote, "genotype" and their training. So think about this as classifying people as either power people or endurance people, and then giving the power people either power training or endurance training, and giving the endurance people either endurance training or power. So matching them to the genotype or mismatching them. And again, a number of groups have done things like this.

Dr. Andy Galpin

My honest answer, having read all those studies in detail a lot, I don't think there's anything there. Some findings, some studies say yes, in some areas, but my interpretation collectively, again, other scientists may completely disagree with me, I personally don't find them particularly impressive. And so I'm interested to learn more. I think those will get better as the polygenic scores get better, as we get more data and more SNPs to incorporate. But right now, I don't think there's much rationale to be deciding how you're training based on only your genetic score. When it comes to precision nutrition based on your genetics, honestly, the story's a little bit brighter here. We'll have to come back and do this in another episode. I got to be honest with you, I intentionally tried to tease this here. I knew we wouldn't have time to get into this. We're already probably farther along than we should be in a single show, especially one that's this complicated.

Dr. Andy Galpin

And so maybe if this is an interest, we'll come back to do this. But I actually do think there's-- Well, I'm very confident there's more actionable steps that can be taken at this point with genetics for nutrition. Really quickly, as a couple of examples, there are some interesting data from things like caffeine, and so some data suggests that some people actually may enhance their physical performance with caffeine. Others may not have an effect at all, and then some might get worse. And you might be able to predict some of that by a couple of genes. And there's some other things like this, but again, we're too far down the road in this episode to get into those details now. So I'd like to round all this out with a very, very short discussion of the future of this field. So I'd like to tell you about some of the studies that are happening now, some of the concerns and other projects that people are working on, and some of the other aspects that go into understanding the real role of genetics in human performance.

Dr. Andy Galpin

I don't want to turn this into a course on medical ethics, but I also can't rightly do a show like this and not bring it up. There's a real fear of what we call the "Gattaca" experience. So some of you may remember that old show, but in fact, the name of the movie was that as an homage to your base pairs, the G-A-T-A-C-A-Cs. That's why it was named Gattaca. In that movie, if you're not

familiar with it, they use genetic testing to determine social class and who you can marry and what jobs you could have and things like that. There is legitimate concern here of doing things like talent identification and then not allowing kids to do certain sports or giving more benefit to other kids based on a field that's maybe not super established at this point. And even if it is, that may be something we are not interested in if we start thinking about why we want kids to participate in sports anyways.

Dr. Andy Galpin

Again, I don't want to be overly preachy on you, but these are fair things to discuss, and it's stuff I want to be in the forefront of your brain when you start thinking about potentially using or recommending others to do genetic testing. I've highlighted before, many of the manuscripts are very clear and specific about that point of using genetic testing for talent identification, particularly in children under 18 years old. In fact, one directly said, quote, "No child or youth athlete should be exposed to direct-to-consumer genetic testing to define or alter training or for talent ID." If you're an adult and you want to make a different decision, I fully, fully support that. But for kids, maybe let's be careful when making those decisions. And then finally, there are things that I mentioned earlier. It's not a free pass. There are enough data suggesting that there are negative and harmful effects in some people when they get these reports back.

Dr. Andy Galpin

It doesn't mean we necessarily have to stop doing it or throw it out, but we should at least consider that if we are particularly coaching individuals and we're recommending our genetic testing, that these results might have a negative impact on how they view themselves, their chances of success, their motivation, and other issues that we may or may not be potentially skilled or qualified to deal with. And so if you're going to deploy something like this, I encourage you to consider all risks and benefits, of which there are many on both sides here, and not just use these things haphazardly. But as I mentioned before, this field is only going to get better. I really do truly hope this show has come off as inspirational. I know it felt a lot of times like I kept saying this stuff is not that great, but it is clearly going to get better. There's a number of projects like the AthLOME Consortium.

Dr. Andy Galpin

That's 15 centers around the world specifically designed to work on athletics performance and genomics. There's the Football Gene Study that I mentioned in that group. There's the Elite Athlete Project at Stanford, where they're actively recruiting And trying to get the top 1% of all VO2 maxes in the world to come in and get genetic profiling done. So people are actively working on this problem, and I have no doubt we're going to get tremendous insight once we start getting these data in. So to summarize what we talked about today, I want to start by going back to our five big questions. The very first one was how many genes or variants of those

genes actually predict a given trait? And typically, the answer is going to be somewhere between 100 to potentially up to 2,000. And how much do any of those individual markers explain a given trait? Probably somewhere between 0 to 1%. Now, the likelihood of that actually mattering to you is pretty low.

Dr. Andy Galpin

Again, less than 5%, oftentimes less than 2%. And the magnitude of effect is typically a couple of pounds of weight, a kilo or two of strength, or some number in that ballpark. And then finally, the fact that over 90% of genetic databases thus far have been built on Caucasian backgrounds, and that represents a serious and significant problem for accuracy when applying these results to those not from Caucasian genetic backgrounds. To wind us back even one step further, I opened up by talking about what sports genomics means, and I'd like to walk you through my current summary of each one of these points. So in terms of using genetics for talent identification, to me, at this point, it's a hard no. In terms of interventions, would I use this to build personalized training and exercise programs? At this point, I don't think that's a good idea yet. I am open, though, to the possibility of changing on that topic, but I currently don't see utility in that.

Dr. Andy Galpin

What about for nutrition? Same answer, but there's a little bit more there. So I think there's some use. It's still very little, but I do anticipate this field to grow in the future. And then finally, we talked about gene doping therapy and editing. It is happening right now at various scales, but it is dangerous and not allowed in most sports, and certainly not something I recommend for anybody at all at this point. Taken together, I feel like if you're using genetic testing and only genetic testing to make important decisions about how you're going to train, what you're going to eat, or what sports you're going to do, I don't think the data supports that conclusion. I believe a better approach is to consider the entire package. Start with the human first. Remember, we're not coaching labs. We're not coaching blood markers. We're not coaching genes. We're coaching humans. So how does the actual athlete or client feel?

Dr. Andy Galpin

How are they actually performing? That's most important. From there, if you're trying to identify why they're feeling and performing that way, and you want to bring in the next layer of testing, I think this is the appropriate place to bring in things that test protein level. So test your actual blood. Get markers done there to know what's actually going on in your body. And then from there, if you still have questions and can't get answered, maybe at that time, you can glean some information or some insights from going all the way to the bottom level and seeing what genes or genotype you actually have for characteristics. I have absolutely no issue with that. I can tell you right now, personally, I have done countless things personally, as well as in my

coaching practice, that are not strongly validated in science. In fact, maybe they have no science whatsoever. I don't ever want to be in a position where you feel like you should only do things that have extensive randomized control trials behind them.

Dr. Andy Galpin

That's not the real world for a lot of people. And so I hope I didn't come off in that tone. I also think that there is a completely acceptable answer here, which is just you're curious. You want to learn more about yourself. It's exciting to you and interesting. I think that's always a reason to learn more information about yourself, and I'm always down to ride that train. So I hope this helps some of you who've either done genetic testing in the past and didn't know what to make of it, or gave others that are maybe thinking about it or get questions from your clients and athletes about it, and you didn't have a resource, you didn't know what to say, you didn't know where to point them if they wanted to learn more about that. I hope I've filled in some of the gaps for any of those cases. I hope I've inspired you and we've entertained you, you've learned a lot from this, and I really, at the core, thank you for coming along for the ride.

Dr. Andy Galpin

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Dr. Andy Galpin

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