DOPE LABS

Transcript of Lab 050: Gold Medal Physics

Titi: Did you see the opening ceremony?

Zakiya: You know I did.

Titi: Oh my goodness, the Olympics is the most wonderful time of the year. What did you think of the opening ceremony?

Zakiya: I thought it was really good, you know, to see the welcoming committee kind of on the sides dancing. They held their hands up for a long time, though.

Titi: They kept the energy high during the parade of nations. That was something that I noticed, too. I was like, I don't know if I can keep my arms up in the air for that long.

Zakiya: I know how I feel when I smile too long on a picture, like when people are taking photos and your cheeks start to hurt. I imagine it's the same thing for your arms.

Titi: Yo, there was one time I had to smile all day, and by the end of the day, my cheeks were spasming. Every time I tried to smile like, I know I look crazy.

Zakiya: One of the things I remember is an athlete from American Samoa who wore traditional dress, and it was maybe in the 20s or 30s there.

Titi: Yes, I think all of us remember when they had the Olympics in Beijing and they had all those drummers, and it was fantastic. But, you know, because of COVID and having to kind of like pair everything thing down, they switched from having it with a lot of people to having a lot of tech. So lots of lasers, lots of leds. It was very cool.

Zakiya: I was into it.

Titi: Me too. I was glued to the screen.

Zakiya: And if we're into it is probably a bet that some of our listeners are into it too. Oh yeah. So we're teasing apart the science behind the Winter Olympics today.

Titi: I'm Titi.

Zakiya: And I'm Zakiya. And from Spotify, this is Dope Labs.

Titi: Welcome to Dope Labs, a weekly podcast that mixes hardcore science, pop culture and a healthy dose of friendship.

Zakiya: This week we're talking all about winter sports, curling, the luge, bobsledding, skating, skiing, snowboarding, all of that. The Winter Olympics are in full swing, and we really wanted to know more about the physics behind some of our favorite winter sports.

Titi: Let's get into the recitation. So what do we know?

Zakiya: Well, I know, you know, about physics. Now that's not my strong point. But I know you're going to see us through.

Titi: Yeah, I know a little physics. I think one thing that we know is that when it comes to how we move on dry land versus how we would move on ice, it's very, very different. I think that all of us have stepped on, you know, an icy patch if we live in places that has snow and ice where things are a little bit slick. And so everything that you feel like you know about physics kind of goes out the window when you introduce these slippery surfaces. And I think we know that with the Winter Olympics comes snow and ice and those play a major factor into the physics that surrounds these sports.

Zakiya: And also, if snow and ice are a major factor, we know that those sports are dangerous.

Titi: Absolutely. So what do we want to know?

Zakiya: Well, I think I want to know how snow and ice both impact these different sports. How do they play a role in what athletes have to consider?

Titi: Right. I think I understand the physics of a lot of this stuff, but some of it still kind of goes over my head where I'm like, How exactly are you able to do this safely? How does this work out? Why did the physics come through every single time?

Zakiya: And is it just the same physics? The only thing I can think about is spin it around. That's some kind of I haven't figured it out in my head centrifugal or centripetal force, but that's the only physics that's I really and F=ma.

Titi: Yes.

Zakiya: But are there other physics factors at play that maybe are a little more advanced that I don't know about? You probably know about them, but I don't know about them.

Titi: I love these questions. Let's jump into the dissection.

Zakiya: But it's absolute. I guess for today's lab is Dr. Sophia Nimphius.

Dr. Sophia Nimphius: My name is Sophia Nimphius. I'm a professor of human performance. I'm also a sports science coordinator for Softball Australia.

Titi: Dr. Nimphius uses the physics of sports to maximize athletes performance.

Zakiya: All right, so let's talk about ice. We know that a lot of winter sports like figure skating, hockey or curling take place on the ice, and an ice rink has a lot less friction than, say, a basketball court or a soccer field.

Titi: So the definition of friction is a resistance that one surface or an object encounters when moving over another. So, according to Dr. Nimphius, there are two parts of friction when it comes to these sports.

Dr. Sophia Nimphius: There's the mass part. Essentially, how much whatever the object, sometimes that objects you, weighs or technically has mass, and then there's the interaction of you or the object on the surface. If it's ice, we think of it as quote unquote frictionless. It's never perfectly frictionless, meaning there's zero friction, but it's very close. And so the temperature outside or even how they've prepared the surface can get that friction value, we call it a coefficient of friction, closer to zero.

Titi: The benefit of the lower coefficient of friction is that you get to maintain your momentum across the ice. The coefficient of friction affects how long it takes you to stop. A higher coefficient of friction means you stop sooner. A lower coefficient of friction means that it takes longer for you to stop. So, for example, if you roll a ball across a table, it's going to keep rolling until eventually it falls off the table, right? But if you were to roll a ball across a lawn, it's probably not going to travel this far. That means the coefficient of friction is higher on grass than it is on a table.

Zakiya: Hmm. OK, so now I feel like I have a good understanding of how friction works, and this is a little bit different from the friction we talked about last week. So let's apply this to some specific winter sports, and let's start with curling.

Titi: I feel like curling is a sport that is always, for me, really exciting to watch because you don't really see it much. It's not coming on ESPN, you're not seeing it on your local news. You don't know who are the national representatives for the curling team are, but it's actually a really fun sport that takes a lot of strategy and skill.

Zakiya: So in curling, two teams of four people are trying to push a huge stone, forty four pounds to be exact, across the ice towards a bull's eye, which they call the house.

Titi: Two people on each team use brooms to smooth out the ice right in front of the stone, which can dramatically affect the speed and spin of the stone.

Dr. Sophia Nimphius: You'll have the thrower. They roll out that giant granite stone. And if the sweepers didn't do anything, you'll notice it's rotating and it could just rotate off the track, so to speak. And so you have this person in the back seemingly yelling, losing their mind.

Zakiya: This person is known as the skip or the team captain.

Dr. Sophia Nimphius: What they're really doing is they're throwing instructions out because they can see everything that's happening. They like the curve, but eventually they want it to go straight because maybe it's right on line for getting to the house.

Titi: The team, with the closest stone to the center of the house, gets a point. The team, with the most points after 10 rounds or ends, wins.

Zakiya: So once the stone is thrown, how is the sweeping changing the ice to the team's advantage?

Dr. Sophia Nimphius: They sweep in front to try to change the trajectory of that stone that's moving through. So it starts to melt the ice, and that little melting of the ice is like a lubricant. Instead of slowing down, it speeds back up, starts to go straight again. Or again they can adjust the trajectory depending if they're sweeping one side, the other side or just in front of it.

Zakiya: So just to go back to what you told me before, the sweeping is basically lowering the coefficient of friction we talked about. That way it takes a longer time for the stone to come to a complete stop.

Titi: That's really good and definitely a part of it, but it actually gets a little bit more complicated.

Zakiya: Hmm. I thought I had it.

Titi: You on your way, friend. There's all these things that contribute. When you're talking about physics there's so many different factors that play a role into all of these things.

Dr. Sophia Nimphius: This is funny, right? Because we think physics as it's an absolute there's no argument crazy enough in curling. There's a ton of argument of why this happens. There's one camp that's over here. It's all about friction. We're changing the friction. The other camps, like, no, actually, it's something totally different. It's around this melting of the water and the water starts to rotate to different parts, and it's actually the lubricant that's manipulating whether it goes straight or fast or slow. Like most things, it's probably halfway in the middle, so it's quite complex, but it sounds like by the person yelling in the background they know what's happening, so we can't exactly explain perfectly why, but they seem to have a really good take of how to manipulate that little granite stone to get in the house.

Titi: I feel like I have a whole new appreciation for the physics of curling. I really thought it was just people screaming and sweeping, but there is so much more going on.

Zakiya: Do you remember back in the 2018 Winter Olympics,

Titi: the Olympics in Pyeongchang?

Zakiya: Yes. If you remember that meme that was going around, it was Matt Hamilton from Team USA and they brought home the gold. But they were saying that he resembled Super Mario doing the curling sweeping stuff.

Titi: Well, put the meme in, the show notes.

Zakiya: Yes, well, they're going back. So I'm hoping for some more meme worthy content here pretty soon.

Titi: Yes, I'm definitely tuning in for the Team USA curling.

Zakiya: So what's our next sport?

Titi: Our next sport is the ski jump and this terrifies me for a multitude of reasons. But basically my understanding of it is that the skiers they get to the top of this really steep hill, then they throw their bodies down it as if they don't have a care in the world. And then that ramp when they get to the bottom, it launches them up into the sky. They fly for a few seconds and then they land. And most times it's on their feet.

Zakiya: Listen, now I don't understand a lot of physics, but I know gravity regular is 9.8 meters per second squared. You want me to come down a hill launch back up and then do they have cushion in the shoes? I mean, you want me to just land and take all that impact on my ankles and knees? Oh, it's not right.

Titi: I did a jump shot in my kitchen, you know, just throwing away a ball of paper. You know, Kobe and I twisted my ankle. So that just lets you know.

Zakiya: And you didn't even get that much air did you?

Titi: No I was about three inches off the ground.

Zakiya: So I've already been taking a peek at the events.

Titi: Yeah. What have you seen?

Zakiya: Yes. All right. So I saw the men's normal hill, the individuals and we saw Royu Kobayashi from Japan, take home the gold for that one.

Titi: Wow. And then I saw that in the women's normal hill individual last weekend that Irsa Bogataj won the first ever ski jumping gold medal for Slovenia.

Zakiya: I'm just glad it's anybody other than Norway because Norway has won the most medals in the Winter Olympics, and so I'm rooting for everybody except Norway, right now.

Titi: Yeah. So you got to give other people a chance.

Zakiya: Spread the love. Let other people and win for once.

Titi: You know, I want to be crying with my Gold Medal.

Zakiya: And so you have to ask, how are they doing this over and over again and not injuring themselves?

Titi: Yeah, it turns out there's a lot of careful planning that goes into ski jumping and it starts at the top of that steep hill leading down to the ramp. This part is called the in-run.

Dr. Sophia Nimphius: So they're going down, and the first thing they're thinking about is the friction of the ski and the surface. So they want to minimize that because they want speed, more speed, further launch.

Zakiya: And if that's not enough to be going straight downhill, they're actually adding wax on the bottom of your skis. So they're reducing the friction even more and able to pick up more speed.

Dr. Sophia Nimphius: The wax they use depends on the temperature outside what the surface is like.

Titi: Another thing they have to consider on the in-run is the shape and size of their bodies, so skiers will crunch down into almost like a ball and hold their arms behind them to make themselves as small as possible.

Dr. Sophia Nimphius: So the shape they have as they go down is going to minimize that air resistance or the drag so that you notice they get into this little ball shape and they've got their head forward. Then they go off the lip and you think, Wow, this is actually the point of no return.

Zakiya: And this is called the take off. Skiers have a split second to jump off the ramp using their legs and change the position of their bodies to go as far as possible down the rest of the hill. And that's called the flight.

Dr. Sophia Nimphius: And so when they're in the air, they've got two things. In theory they're just trying to maximize their distance. So they've got the shape, so they've got their head forward, they throw their arms back. And the other thing that's real obvious to someone who knows nothing at all about ski jumping is they all make this little v shape with their skis.

Titi: And that V-shape is all about aerodynamics with the v shape of the skis does is actually create a shape that's different in the front and the back. And the skiers also have to position their bodies really specifically to maximize lift and distance. Once they're in the air, they lean their bodies all the way forward, almost parallel to their skis to minimize friction while they're in the air.

Zakiya: Hmm. So that positioning of the skiers body over the skis is actually changing their speed. You want to create more speed on top and less speed underneath. That's going to give you the lift, and it seems like it's making their bodies function like an airplane wing.

Titi: Yes. The more lift, the further they can travel. So lift is a force that is super important when you want to keep something in the sky. Lift is what keeps airplanes in the sky, and in this case, it keeps the skier in the sky for longer. So what they're doing is making their bodies into a shape that increases the air velocity on top of them, while at the same time decreasing the velocity of the air beneath them. And what that does is create a difference in the air pressure, and that difference in pressure pushes them up into the sky. Their final score is factored in by the distance they jump, as well as their aerial style and landing. So you can't just fly through the air and crash, and just because you land farther.

Zakiya: Keep it cute.

Titi: Yeah, you got to stay intact.

Zakiya: And that's only the tip of the iceberg, because you still got to consider the height of the skier, the weight, what fabrics they're wearing, what the wind is like.

Titi: Yeah, there's so many factors. I mean, one false move, it feels like you're just going to flip over. . But what happens when they stop lifting and they start to descend to the ground?

Dr. Sophia Nimphius: They start to come out of that lift phase and they start to put their skis back parallel and then they split them. So that's kind of their version of brakes, and they're getting ready to have to land on their two little legs with the skis. Luckily, those skis are wider and longer than the normal skis that you and I would be on, but that's just giving them more area to land on more stability.

Zakiya: And this just makes me think about where all that energy is going, when they land. Is that going just to the knees and the ankles.

Titi: My knees and ankles cannot withstand. I know that for a fact.

Zakiya: Sophia explains that the reason why this all works out is because of the first law of thermodynamics, which says that energy cannot be created or destroyed. In this case, a large part of the energy is coming from the velocity the skier is building as they're going down the ramp.

Dr. Sophia Nimphius: You have to remember that it is slightly at an angle, and that's good because when we think about landing, we probably all think about, you know, jumping off a building and then landing on the ground and you stop your momentum. So energy at the top, energy at the bottom, the energy has to go somewhere. It's never created or destroyed. So the energy you had from potential energy jumping off your building and landing on the ground goes through your body. Well, in this case, and you maintain velocity and you just continue your velocity. But now you're on the ground instead of velocity going through the air, all that energy doesn't go through your joints because you don't stop.

Titi: Another physics quantity that also has to be factored in is momentum. Your momentum is determined by your mass and velocity. And for someone on the ski jump maintaining momentum through their form, waxed skis, and all those other things helps with their landing.

Dr. Sophia Nimphius: In fact, the better you land, the better momentum you maintain, but it is still a hard landing. They have to be exceptionally strong and exceptionally coordinated.

Titi: Yes. So as you're landing, if you land the right way, all of that shock won't travel through your body. It's actually distributed through your skis through the ground. You lose some of it to the air and everything in between. So that's the reason why doesn't look so painful when they're landing. But that makes me think about Simone Biles, who does a lot of aerial movement and lands on her feet.

Zakiya: Listen, her heels have got to hurt at the end of the night.

Titi: Yes, you see, Simone Biles hit that mat and my teeth would be chattering like

Zakiya: Shock just still going through there.

Titi: All the energy is being absorbed in my jaw.

Dr. Sophia Nimphius: That's the benefit of the Winter Olympics. Most of the time they get to maintain their momentum, like the pipe event for snowboarding. They're doing crazy things. But then they land, they maintain the momentum.

Titi: So that's what makes these sports so dangerous. So let's say you're flying to this guy doing the ski jump and something's off with your positioning or your balance in the sky. All of that affects all of these physical quantities, like your momentum, your velocity and everything to help you have a safe landing. So then when you hit the ground, that momentum and velocity and that sum total energy gets absorbed not only into the ground but into your body.

Dr. Sophia Nimphius: So velocity is your friend and your enemy. It's your friend when you can keep redirecting it and keep it going. But if you've got high velocity and then all of a sudden you stop because you crash, that is not good.

Zakiya: Let's take a break, and when we come back, we'll get into figure skating and the luge.

Titi: We're back and we're talking all about Winter Olympic sports with Dr. Sophia Nimphius.

Zakiya: I feel like if I had learned physics this way, I would have been so much more engaged.

Titi: It's exciting, right?

Zakiya: Instead, in high school, I got a needs improvement on my behavior in physics class.

Titi: What were you doing? talking?

Zakiya: Girl you know it. Talking.

Titi: Lord have mercy.

Zakiya: It's true.

Titi: OK, so up next, we're going to talk about figure skating. But first, we want to tell you about a very special lab we have planned for next week.

Zakiya: It's Black History Month. And so to celebrate, we're doing a deep dive into the HBCU experience with special guest expert Xavier Jernigan from Spotify's The Get Up. Like Me X is a proud HBCU grad and we're going to be talking about everything from camaraderie to friendship to homecoming. And we want to hear from you. Call and leave us your best shoutout. Tell us your name and the HBCU you're repping. Two oh two five six seven seven zero two eight. That's two oh two five six seven seven zero two eight.

Titi: OK, let's get back to the lab. I want to talk about figure skating because I feel like it's the crown jewel of Winter Olympics. Everybody is always tuned in for figure skating. It produces some of the craziest moments, probably some of the most heartfelt moments. I mean, folks are crying. You know, there's a lot of sequins and flowers and bears and hugs. So I think everybody loves it. Do you remember Surya Bonaly?

Zakiya: I do remember her. She was this black woman who did the backflip and landed on one skate, which wasn't allowed because they were saying it was too hard, which is also giving me very strong Simone Biles vibes.

Titi: Yeah, it's funny how these things work.

Zakiya: Well, we got some people to look forward to.

Titi: Oh yes. And I know everybody's going to be locked in. We have so many stars on Team USA, the U.S. team, including Nathan Chen, America's sweetheart right now, who skated a career best in the short program and helped Team USA clinch the silver medal for the team event.

Zakiya: Well, tonight the men's single final, come on. So we're still rooting for.

Titi: Come on Nathan.

Zakiya: Nathan Chen again. But next week the women are skating.

Titi: Oh yeah, and I'm ready.

Zakiya: And I'm just trying to get my ankle strong because, you know, I'm going to try to do that stuff in my living room.

Titi: Yes, I need to find a leotard, some sequins because I want to be ready. I'm coming in costume to support.

Zakiya: And so people are doing backflips and axles and spins, and some of these skaters are spinning so fast it looks like people hit the fast forward button. Dr. Nimphius told us about three different spins the standing spin, the sitting spin, and the camel spin.

Dr. Sophia Nimphius: They got the standing spin and you'll see them often throw their arms out in the air. So throw the arms out, slow down, bring it in. Fast spin so they'll come into their spin. They'll bring their arms really close together, or they'll put their arms out, and that's when they're doing their standing spins. And what they're doing is they're manipulating that distance that they're spinning about.

Zakiya: So here we're seeing how an athlete's mass and the shape of their body affects their momentum.

Dr. Sophia Nimphius: Yes, so they get to play with their momentum quite a bit too. So they might be doing something they're skating in. Maybe they're skating forward and you'll see them getting some spin and then they seem to stop on a dime and then all of a sudden they're spinning. Now what they've done, if they've transferred what we call linear momentum, they're skating forward into angular momentum.

Titi: Like we talked about before, energy can't be created or destroyed. So these skaters are using their forward momentum and transferring it into an angular momentum when they start their spin. So all that speed that they build up, which is why you see the skaters when you know they're about to do a big jump or a big spin, they kind of like round the rink, they start skating really, really fast and then the big jump comes because they need that speed so they can transfer into angular momentum.

Zakiya: Hmm. That makes a lot of sense. So that's the standing spin. What about a sitting spin? When they squat down and they're like inches from the ice that looks like so much muscle control.

Dr. Sophia Nimphius: So they'll squat down and they'll throw a leg out. And you've probably seen this in the Summer Olympics, too, because Simone Biles does what they called a wolf spin where she's on her foot and she puts her leg out and she's on the beam and she's spinning about.

Zakiya: Yes, I have never understood how she could spin around like that on the balance beam.

Titi: That's a really good point. And when we think about what Simone Biles is doing and we compare that to what's happening in figure skating, when they're doing a sitting spin and they stick a leg out, that makes them slow down for the same reason. So the reason is something called moment of inertia and moment of inertia determines how easy it is for an object to speed up or slow down. A larger moment of inertia, like when a skater or Simone Biles sticks their leg out will slow down their rotation. But a smaller moment of inertia, like when they bring their leg back in, will make them spin faster. So when they bring that leg back in they'll start to speed back up.

Zakiya: Hmm. So it's an inverse relationship. So if I am distributing my body out, making it larger, sticking something out, an arm or a leg, I'm lowering the velocity and it's lowering because I'm making my moment of inertia larger.

Titi: Yeah, it's about a redistribution of mass. When you have something that's not perfectly round and it has something that's sticking out from the side, it will cause a lot of disruption to the physics of that spin. So for figure skaters and for our good sis, Simone Biles, sticking that leg out redistributes the mass, which causes them to slow down.

Dr. Sophia Nimphius: And you'll notice they'll slow down and they're slowing down because that distance increases. And so velocity goes down because they can only manipulate the distance or the velocity. So if they want to go faster, they bring the leg back in and the velocity goes back up.

Zakiya: And so that brings us to the next spin, which is the Camil spin, and that's where the skaters are on one leg and they're leaning forward. So their torso is like parallel to the ice, and then they take that other leg and this behind them in a straight line and they're spinning.

Dr. Sophia Nimphius: And so again, that's like the longest you could make yourself. And so that spin seems real slow, but really hard because sometimes going slow is harder because you're balancing on a single skate. So they have three spins and it helps you change how long your body is. Your axis of rotation is our technical term. So you've got a long axis of rotation with your trunk forward and your legs sticking out the back. That's your camel, or you've got a really tight axis of rotation when you're standing and you've got your arms tucked in.

Zakiya: You know, this makes me think about?

Titi: What?

Roller skating, you know, we've seen roller skating all on the reels on IG. I've seen somebody's pastor a roller skating. I don't even know how that works for the ministry, but are we seeing these same principles at play in roller skating too?

Dr. Sophia Nimphius: Now when it comes to roller skating, there's going to be more friction because that coefficient of friction between the skate we have, the wheel, and the ground that's always going to be higher than it is on ice. So you'll slow down faster in your roller skating, but the concepts about what makes you slow down and speed up during spinning is the same. But the length of time you can maintain your spin from your momentum is less because the friction will slow you down.

Titi: I love that question, and since we're talking about skating, I want to know more about speed skating, too. So when we think about figure skating and speed skating, they have two different kinds of skates. Did you know that?

Zakiya: No.

Titi: The skates that people wear for speed skating have longer blades.

Zakiya: Why?

Dr. Sophia Nimphius: The major difference is that the speed skate, it's longer. But the real big difference besides that length is it has an axis, so it actually falls away from the boot of the skate. It's called a clap skate because it claps back down. So you've got the blade and it pivots about the front, and that sounds dangerous. And it is. But what it does is as they lift their boot, the skate blade stays in contact longer with the ice. And remember, in speed skating, it's all about speed, and the best way to go faster is to have more force into the ice. Well, if your blades off the ice, you can no longer put force into the ground or into the ice, so that little access to clap skate really changed speed skating because it gave us a longer time period to put the force into the ice and so they skate faster like that.

Zakiya: Wow, OK. It makes a lot of sense. But I want to know why that isn't the example in the physics textbooks like this is the stuff I want to know. Nobody's talking about this. I did not know that they had a whole different shoe. And why aren't the commentators telling us this either?

Titi: Right? See, they need Dope Labs on NBC Sports or whatever it is.

Zakiya: Give us a call.

Titi: OK, now I want to talk about the luge. So it's like a sled, but you're laying down on it, on your back. There singles and doubles, so one person will do four runs or teams of two will do two runs in. The races are timed to the thousandth of a second. The track is ice and folks are going really, really fast and it just seems almost impossible to do.

Dr. Sophia Nimphius: You know, when you're playing video games and you're just like leaning to the left and hoping that changes the direction of the person, well, you're practicing the luge because if you were really in that game when you were leaning your body to one side willing your Mario Kart to turn right quicker, we kind of know intuitively that if we manipulate our body to one side or the other side, we should be turning to that side.

Zakiya: Do we know that intuitively? I mean, I guess, does that mean I understand physics at my core?

Titi: Yeah, I think that that's a really great point is that our bodies, our minds are hardwired to do what is necessary to keep us from falling down, to keep us from falling over. We still fall here and there, but it's like instinctual. If you were to step off of a curb and you don't realize like how tall it is, your arms are going to go out, right? Hmm. You're going to lean to the opposite direction that you're falling because your body is trying to use physics to its benefit and recover from the fall.

Zakiya: Well, that should be the test then. Not can I do an equation, right? Don't you think?

Titi: Yes, I agree 100%, friend.

Dr. Sophia Nimphius: Now, there's a lot of the physics behind that. What they're really doing is they're changing the distribution of their mass on that sled. So you're going to put more weight into one blade because there's two blades right at the sled's got two blades. And so that's going to change the friction on one side versus the other. When we're talking about throwing the curling stone, if you change the friction on one side or the other, then you're going to get things to turn. In this case, you're manipulating the distribution in the mass so you change the friction. And then the other thing they're doing is there's slight changes in their foot shape. Now that's changing their aerodynamics, so you're getting more drag or less drag on one side of your body, which is going to help you turn or not turn to one side or the other. And that's all they have. There's no brakes. There is no control. They just have them and their body and that sled. And that's why when you see at the end and they have to stop, they jump up in the air and they just dig their feet and they're pulling the sled up in the ground because the best thing they've got to stop is to just pull the sled front up in the air because there's no brakes.

Zakiya: Do you think you have what it takes? I'm failing if it's just me and my body alone and no mechanics, no anti-lock brakes system, just my heels digging in to the sled to stop it's a wrap.

Titi: I don't have the best feet. I have flat feet. They're not very nice looking, don't ever look at my feet y'all. My feet are not going to save me on the luge. So that is not the sport for me.

Zakiya: It feels scary just doing that, and that's feet first. Everybody knows feet first is the safest way you do anything. You jump into a pool Feet first if you're using some caution now, if the luge isn't enough, there's also the skeleton, which is like the luge, but head first. And what is that? What are you using your ears to create drag? Like that just feels wild to me, right? Why would you want to do that?

Dr. Sophia Nimphius: It does, because your head is just a massive drag. You go slower in the skeleton because your head just produces way more drag than your feet do. And so you're like more aerodynamic feet first. That's why the luge is faster. They try not to pull their head up and all of these kind of events that go down this crazy track as fast as possible. You got luge, skeleton and bobsleigh. Really, they're memorizing those tracks, so they probably don't even need to look where they're going. They know these tracks. They're mentally rehearsing these things thousands of times in their head.

Zakiya: I don't believe that. I mean, I believe they have memorized them. But if I think about riding my bike, I'm not going as fast as they're going, but I need to look at where I'm going. No matter how many times I've taken the route,

Titi: I wouldn't trust myself.

Zakiya: I don't even want to walk anyhere.

Titi: What if I confuse this track for the other track and I lean right when I'm supposed to be staying straight and then I go flying up the wall? I don't know, but this reminded me of this documentary called Free Solo. Have you seen it? It's this climber? His name is Alex Honnold, and he climbs some of the most dangerous mountains with no harness. And they call that free soloing. No harness. So to practice, he'll have a harness, and he will memorize every nook and cranny in that rock face. And I'm not talking about, Oh, there's this place where you can. Grab on to I'm talking about things that are maybe a quarter or an eighth of an inch thick jutting out where he's like, I can put my toe right there, he memorizes all of it. He has a written out in a composition book and studies it.

Zakiya: This reminds me of the Alpinist. The Alpinist is about Marc Andre Leclerc, and he is doing this kind of free solo stuff too, and it's in these alpine mountains. Is there something about the cold air that's got you all doing this?

Titi: Well in free solo they were like the part of his brain that's supposed to be like your fear center is like his are so dull he doesn't feel fear. And when you talk to him, they're like, Are you scared? He's like, scared of what? Dying? no.

Dr. Sophia Nimphius: Every bad idea probably started as a good idea at the time. So I think that's like every sport in the Winter Olympics. Oh, this seems like a good idea until it's not.

Zakiya: I don't know what drives this type of thrill seeking. Either way, I'm not built for these winter sports, OK? I thought I needed to get rid of the summer sports because I was stopped on a dime. But the winter sports are feeling unsafe too. And so it probably doesn't matter because I'm not anywhere close to competing in the Olympics, and it's very clear to me why. But there's one part of the Olympics that I do like and is one of my favorite parts of physics, and that's G-force.

Dr. Sophia Nimphius: In the Winter Olympics, almost every one of these sports that the athlete has G forces placed on them. So Gs, we get this from our gravitational force and we're used to it. So like basically when you're standing on Earth, you've got one g worth of force applied to you. So standing on the ground, I'm one G. If you jumped up in the air and then you landed really fast, you might get two or three Gs. And so it's really about the acceleration, which is velocity squared. So the acceleration when you're flying downhill skiing is very high and they've got a very steep slope, but then they decide it's a good idea to turn multiple times. And so during those turns, they've actually got three, four, five GS pushing into them, maybe more, depending how fast they're traveling. When the snowboarders go up and they do a crazy trick and they come back down in the half pipe, they get to the bottom that half pipe and they feel like they're getting squished into the ground. They're having Gs pulled into them and they're managing those GS the same thing with those ski jumpers.

Titi: So G-force is gravitational force, and there's this equation that's associated with gravitational force. But what the equation means is that if you have two objects that are a certain distance apart, you can determine the force of gravity between them. So when we're talking about G forces, we are talking about the amount of force down into the Earth. So as G forces go up, you can physically feel those forces pulling you down to the earth. So when you're on a rollercoaster, when you're going up and then you reach the top and then all of a sudden you're flying down this roller coaster and you can feel yourself being lifted and pushed down and everything in between. Those are g forces. And so you can feel G forces on your body when you're in certain circumstances. So when you're just standing still, you just have one G acting on you. But then when you're on a roller coaster, you might have three, four or five GS pushing you down.

Zakiya: I didn't know these athletes were going through so much trauma at the bottom of those half pipes. Shaun White made it look so easy.

Titi: Yeah, they might be having fun, but I mean, some of this just it just doesn't seem right.

Zakiya: And so what about as you're going into all those turns? What part of your body is absorbing all of that? Is it your core?

Dr. Sophia Nimphius: They try to stabilize through the trunk, but then their hips and knees are primarily the ones that are managing that energy because, you know, with the downhill skiers, the ankle is fixed because of the boot. So the ankle kind of gets thrown out. It can't do very much for you. So then that actually increases how demanding it is to their knees and hips, primarily because they try to keep that trunk nice and stable.

Titi: I would fold like

Zakiya: origami, baby.

Titi: OK? It would be over.

Zakiya: Well, I'm looking forward to the rest of the Olympics. I feel like I have a new appreciation, a new understanding for what's happening. So I'm looking with fresh eyes.

Titi: Yes. Myself included. I mean, I feel like I understand the physics. But now, after all of the gems that Dr. Nimphius has dropped on us, I feel like now I can really, really appreciate it.

Zakiya: That's it for lab 050. Now I want to know from you. Did you learn anything new about winter sports? Are there any sports that you're looking at differently? Call us at 202-567-7028 and tell us what you thought. Or if you have an idea for a lab we should do this semester. Tell us that too. We really love hearing from you. That's 202-567-7028

Titi: And don't forget, there's so much more for you to dig into on our website. There'll be a cheat sheet there for today's lab and additional links and resources in the show notes. Plus, you can sign up for our newsletter, so check it out at DopeLabspodcast.com! Special thanks to today's guest expert, Dr. Sophia Nimphius.

Zakiya: You can find and follow her on Twitter at @docsoph

Titi: Dope Labs is a Spotify original production from Mega Ohm Media Group.

Zakiya: Our Producers are Jenny Radelet Mast and Lydia Smith of Wave Runner Studios

Titi: Editing and sound designed by Rob Smierciak.

Zakiya: Mixing by Hannis Brown.

Titi: Original music composed and produced by Taka Yasuzawa and Alex Sugiura

Zakiya: From Spotify our executive producer is Gina Delvac and creative producers are Barron Farmer and Candace Manriquez Wrenn

Titi: Special thanks to Shirley Ramos, Yasmeen Afifi, Kimu Elolia, Teal Kratky and Brian Marquis.

Zakiya: Executive producers from MegaOhm media group, are us

Titi: Titi Shodiya

Zakiya: and Zakiya Whatley**.**

Titi: What ankle exercises are they doing?

Zakiya: I don't know, but you know, I don't have strong ankles.

Titi: The last time I went ice skating, I was like, Something's wrong with my skates, my ankles are hurting. And so I took the skates back and was like can I exchange these because something's not right with these ones. They're really hurting my feet. No, girl, you're just weak.

Zakiya: It's you.