Biomechanics of Sports

(Opening Tease)

(Narrator) Did you ever consider the mechanics behind how our bodies move?
How divers seem to defy the laws of gravity.
And just how glamorous is it to be a young hockey player on your way up?
Find out how our past is propelling us into the future.
Next on Quest, come and see the science in sports.

(Underwriting spot)

(Announcer) Major funding for production of QUEST: Investigating Our World on Maine PBS is provided by the National Science Foundation. Additional support is provided by Irving Woodlands, seeing the forest for more than just trees, a team dedicated to sustainable forest management in Maine and by gifts to More Connected, More Maine. The Campaign for Maine Public Broadcasting's Programming.

(Education Promo)

(Announcer) Looking for easy-to-use lesson plans? Go to the QUEST website at Maine PBS-dot-org.

(Opening theme music)

(Linda Greenlaw, host) Hi I'm Linda Greenlaw. If you're anything like me, whether I'm swimming at one of Northern New England's beautiful beaches or teeing off on our spectacular golf courses, science is the last thing on my mind. Yet the physical activities we enjoy are scientific medleys of motion. From lessons in anatomy to the laws of physics – it's all unfolding right before our eyes. How do we optimize an athlete's performance and what do we do when something goes wrong?
Join me in finding the science and marvel of our bodies in motion.

(Moulin Rouge- Can, Can)

(Narrator) Sports. Whether we're out on the field or watching from the bleachers, Northern New Englanders have a love affair with sports. But few of us ever stop to consider how science affects us when we engage in the sports we love. And the working scientists who bring their craft courtside. Biomechanics is the study of how the body moves. It looks at the tremendous energies and forces that operate on our bodies and how our bodies respond to those forces. As applied to sports, biomechanics frequently looks at performance enhancement and injury reduction. Frequently unseen, advances in biomechanics keep us from harm.

(Narrator) The coach bridges the gap between the laboratory and athlete. When training young athletes, they need to be vigilant about protecting athletes growing bodies from the serious injuries inherent in all sports.

(Chris Hamilton) Slow down. Why are you in such a hurry?

(Narrator) Chris Hamilton is the head coach of the Dartmouth College diving team but he also teaches some of Northern New England's youngest diving hopefuls.

(Chris) I want, I want them to enjoy the sport they way I did. I mean I grew up doing this. My whole life, from six years old on, I mean I was diving at least 3-5 months a year. During the swim season I was diving

(Narrator) One of his top diving prodigies is Kirsten Dahlberg.
Kirsten is 15 years old and has been involved in organized athletics for 11 of those 15 years.

(Kirsten Dahlberg) Well when I was four, I started gymnastics I and did that for about ten years til I was fourteen and I hurt my back so I quit.

(Narrator) Childhood is when the skeletal system develops most of the bone density needed to last a lifetime. Kirsten's rigorous gymnastics training took a toll on her developing spine. At age 14 she developed a stress fracture in her lower back.

(Chris) …I think she did so much repetition in gymnastics. I mean her mom and I've talked about it she used to you know she traveled 2 ½ hours a day to Boston to do gymnastics from Hanover. So I mean, she's very dedicated to the sport. She's always, you know 6 hours in the gym a day, there's a lot of repetition going on.

(Narrator) Repetition is a necessary and vital part of athletics. But without proper understanding of biomechanics, too often young bodies are pushed too far.

(Narrator) Today, thirty-one percent of all sports injuries occur in children between the ages of five and fourteen.

(Chris) 02:34:53.08 You can physically over train.

02:35:28.28 …you can be in the weight room too long. You can be lifting too much. You can not be stretching enough. I mean, there's so many different ways you can over train…

(Narrator) Besides keeping our children safe from the dangers of physical overtraining, coaches also have to consider the risk of mentally overworking their athletes. Because of her earlier experience with gymnastics, Kirsten's decision to become a diver was not an easy one.

(Kirsten) 00:31:26… At first I was like, I don't know. It's gonna be just like gymnastics and you know with gymnastics it takes up a lot of time. Cause before I was going six days a week, four hours a day. And in the summertime it was eight hours a day and you just, you just got worn out. Whereas with diving right now you know I go to school. I have friends. I have my Friday nights off. Which is nice, so I can go out and do stuff. And Chris has made it a lot more fun than, than my old coach. My old coach was really strict and you know it's like have fun outside the gym…

(Chris) My goal is basically to make the kids the best they possibly can as a diver. And to also enjoy themselves. Who knows what these kids are going to do with their lives. Hopefully, you know, they can turn back and say, you know the structure of my diving or the structure with my coach has made it possible for me to be successful in life. Hopefully, you know I help in some way to make their lives a little bit better.

(Narrator) Kirsten's story is not unique to her or to gymnastics.
Today over 30 million children participate in organized sports. During childhood, more than one in three children will suffer a sports related injury. Injuries from basketball, football and baseball are responsible for almost 60% of all childhood sports related emergency room visits.
Studies in biomechanics have shown that child athletes are not miniature versions of adult athletes and must be trained differently. With a larger surface area for their weight compared to adults, children are more prone to injury from a collision with another athlete or a piece of equipment like a baseball. In a sense, more of a child's body is exposed to injury. And since their bodies' proportions are continually changing through early adulthood, child athletes are continually relearning how their bodies work.

(Narrator) But, it's a fine line that Chris has to walk, because the bottom line is, these athletes have been brought here to learn diving.

(Chris) …one of the hardest parts of diving is to teach landing on your head, because for most kids it's not natural. I'm not

going to get you up there and tell you to throw a front 3 and a half the first day of practice. We're gonna go through the progression steps the way we're supposed to be learning. I mean, you wouldn't ask somebody to do calculus if they have never done algebra or something like that; it's the same thing here. I want my kids to do the right steps.

(Chris) Stay on the board. Ah. Where'd your hands go? Where were your hands? You came off the board and they were down here. Stay on the board. Reach, extend, and drive the knees up, ok?

(Chris) They don't know the limits or what they could do…they just don't know their bodies…With the younger athletes I have to push them more. I really do I think not push them in a bad way, but I need to make them realize that we need to do a lot of repetition we need to do it over and over and over and over…I'm just trying to get them to, uh, muscle memory. So they get to know they can do this without even thinking about it. Pike, good, excellent, I like that.

(Narrator) Muscle memory or motor memory as it is sometimes called, is a term athletes use to describe when the body has learned a particular movement.

(Chris) Good

(Narrator) Through repetition this movement seems to become an automatic action, requiring almost no conscious thought.

(Chris) With the younger kids you need to say hey you can do this, you can do this, let's do it in the belts, let's do it in the tramp. Get done with them then; all right let's go do it.

(Chris) Get them up there and they'll throw a front two and a half and they'll come and go, "WOW, I didn't know I could do that!" Well, that's just it. You don't know that you can do it, but I can see it.

(Chris) All right, with arms. I want to see the arm strength. Clap.

(Narrator) One of the most basic steps in diving is called the hurdle.
Until this step is mastered, a diver cannot control the propulsive force of the board.

(Chris) Hold them high, hold em. Good. There, very nice.

(Chris) What makes a good dive is pretty much the hurdle. The hurdle if you have a good hurdle and you set yourself up well on the board your dive should be done very easily…

(Narrator) During the hurdle, a diver's arms and leg swing up, pushing extra force down into the board. The diver wants to drive the board down as far as possible. It is at this point, when the board is depressed and before the diver leaves the board, that the diver must commit to the motion that will make the dive successful.

(Narrator) Chris's predecessor at Dartmouth, Ron Keenhold, explains it this way.

(Ron Keenhold) All the mechanics, all the principles of physics that happen in that period of time, really determine how successful that dive is going to be. And if, if you are not consistent – t the way you get off the end of the board correctly, then every time you try to do a dive - no matter how may times you do it over and over and over to perfect it, if you're coming off the diving board differently every time, every every dive is a is a trial rather than the accomplishment of really getting it into a successful pattern and way of doing it…

(Narrator) Like the bands of a slingshot, the diving board releases the energy received from the diver. As the diver rides the board back up, the diver becomes a human projectile.

(Chris) …what other sport do you get to throw yourself off a platform and go 37 miles an hour and hopefully hit the water correctly

(Narrator) Most dives are built on two basic rotational maneuvers. The first is the somersault.

(Chris) Well your body is going around your center of gravity, its basically like if you stuck a pen though your hips. What you want to do is to get, the closer you get to the center of gravity the faster you are going to go…

(Chris) When I throw I don't want your ankles to meet your hands, I want you to throw and chase your ankles so eventually it's like driving a car, you know, if I pull this way and my hand is here, what's going to happen? My hand is going to go with it. But if I pull this way and I pull this way I'm not going anywhere. So what I want them to do is throw with their hands chase to their ankles and they'll be done with half a summersault before they're even in a tuck.

(Narrator) The next rotational maneuver a diver needs to master is a twist.

(Chris) With the twisting action you are still going around the center or gravity, but your center of gravity is not in the ball anymore so you want to snap, get to the right angle that's when the twisting becomes much easier. If you are off tilt just a little bit a lot of times you can't make the twists or you twist too far. The diver has to ride a diving board, everything has to be right. Plus we're trying to defy gravity we are trying to do things, you know in a different axis a different, different than any other sport.

(Music starts)

(Narrator) When everything goes right between the time a diver leaves the board and enters the water the laws of physics and the grace of our bodies merge to create an elegant feat of agility.

…It's grace and power…

(Narrator) Swimming is a relatively injury free sport. Because of water's cushioning effects, many swimming injuries are due to the repetitive nature of the strokes. Whether a competitive swimmer or a child taking lessons for the first time, research in performance enhancement and injury reduction is aiding our working scientist to bring out the best in all our swimmers.

(Narrator) Water is 773 times denser than air. In order to overcome drag and energy lost to turbulence, swimmers must use muscle strength and scientific know-how to propel themselves forward.

(Dee St.Cross) 01:02:54 .. I think over all the science of swimming, or swimming as a science, is better understood. There's more information out there. There's more ability to understand what happens, with a swimmer, with a stroke, underwater. Where as in time's gone by they didn't have the capability of really studying strokes underwater. They didn't have the ability to get anaerobic, aerobic, all of those -- all of that information. Now we, we have that as a science base.

(Narrator) Dee St. Cross is the head coach of the Pine Tree Swim Team of the YMCA in Portland Maine. Pine Tree counts Olympic gold medallist Ian Crocker, among its alumni.

(Dee) Historically Northern New England perhaps has not been the powerhouse of swimming but over the last 10 to 12 years we've seen some, some good swimmers come out of New England. Jenny Thompson came out of New Hampshire, Ian Crocker was homegrown here in Portland and in fact started with the Pine Tree swim team…what they're doing is they're elevating the sport.

(Narrator) Advances in pool design and swimsuits have contributed to increased swimming speeds, but by far it is our understanding of how our body moves through water that has had the greatest impact on our speed records.

(Dee) When you look at it in swimming you see some stuff around suits and pools improving but I think the bulk of that, the improvement in times and performance is in fact coming from a better understanding of the stroke – The mechanics of it…where we are today is really built upon where we were in the past.

(Ron) When I was swimming in high school basically as I recall we pretty much put our arms in the water like a long straight paddle and just pulled back through the water.

(Narrator) With little scientific understanding of how the human body traveled through water, swimmers were initially taught this

awkward and inefficient stroke.

(Narrator) Ron Keenhold, now a retired collegiate swimming and diving coach, experienced the evolution of many swimming techniques during the last 50 years.

(Ron) Somewhere around the late 50's and early 60's, I think that was a period of time where we really started to move more into what I would refer to a more modern era of the technique of swimming fast, regardless of what stroke. A lot of coaches started to understand more or take real serious consideration of Bernoulli's principle…

(Narrator) Although Bernoulli's principle was first introduced in the 1700's it wasn't until the 1960's that swimmers turned to this scientific discovery to improve their performance. Simply stated, Bernoulli's principle says that a fast moving fluid exerts less pressure than a slow moving one. Swimmers, it is thought, have learned to use this principle to maximize the power in their stroke. This can be seen in the s-stroke.

(Ron) The way that I that I use it, and their might be some scientists out there listening to this who might not like this explanation, but I apply it from the principles of, of the propeller on the back of a boat. And the blades are curved so that the leading edge of the blade, of one propeller of the many that might be on on a propeller of a boat. The leading edge bites into the water and throws the water off the trailing edge. But it is it's a curved blade, so to relate that to swimming if you will. Uh if you scull your hand back and forth through the water to move your body forward, instead of being a propeller going around 360 degrees, you're using a propeller where you can change the angle of the blade depending on whether you're going outward or inward. And so in a good freestyle swimming stroke today, when a swimmer puts their hands in the water, slides their hand in the water first of all rather than slapping the hand into the water. You slide the hand into the water. In the beginning of the stroke, moves outward and at that point, the water's sliding from the little finger across the palm of the hand to the thumb. Then when you get out here, you change the angle of that blade the angle of the hand and slide in, so now the water's going the other way off your hand. And as it gets back towards the mid part of your body again you change the directions as you start to push backward and outward and slide the hand out. And come around to get ready to take the next stroke.

(Narrator) This s-stroke allows water to flow over the hand, similar to air flowing over an airplane's wing. Creating lift and propelling the body forward in the water.

(Narrator) In some cases, experimenting with strokes have led to entirely new swimming events.

(Ron) I happened to be in college when some parts of the breaststroke started to become the butterfly stroke… everybody was swimming the breaststroke. The rule said that after the, the breaststroke the arms must recover in a simultaneous pattern before the next stroke begins. So the breaststroke was always underwater with the arms moving this way. And somebody got the idea that they didn't say it had to be underwater. So I can pull back further and harder and recover my arms over the water. And so that's how the arm stroke of butterfly started to come along…

(Narrator) Because water is thicker and heavier than air, a swimmer has to work much harder bringing his hands back under the water to set up the next stroke. By bringing the hands and arms above the water, much of this wasted energy is eliminated.

(Ron) … but coaches and guys on the rules committee started saying 'Wait a minute, this is a whole evolution. This isn't breaststroke anymore. What is it?' And so they said well, ok, let's call it butter fly. Why didn't they call it bird fly, I don't know, but they called it butterfly.

(Ron) Pretty soon or almost simultaneously swimmers were starting to experiment…because a lot of guys were swimming butterfly with the arms with a breaststroke kick…some guys started to experiment with the dolphin kick where you keep the feet and legs moving up and down simultaneously. And if you will, it's the same kind of motion that fish use to swim through the water. And the tail moves back and forth. They undulate, they wiggle the body back and forth and by having loose ankles in a nice fluid motion, you know, like this with the legs. You can propel yourself forward through the water.

(Narrator) Like diving and children's athletics, swimming has benefited from a deeper understanding of how our bodies move.

(Narrator) Although biomechanics teaches us there are physical limits to the human body, the human spirit continues to redefine what those limits are.

(Music: The Hockey Game)

(Narrator) Northern New England is a hotbed for hockey, and like all contact sports, injuries are a part of the game.

(Narrator) Like Chris Hamilton and Ron Keenhold, Angel Soutuyo is a working scientist bringing his knowledge of biomechanics to our Northern New England athletes. Angel is the athletic trainer of the Portland Pirates -- the AHL farm team of the NHL's, Washington Capitals.

(Angel) Well in college I wanted to be a doctor, but things weren't working out too well and actually I was student trainer at the school and I really liked that and it kind of combined my two favorite things, medicine and athletics so I thought it would be a good idea I put them together and it worked out pretty good for me.

(Angel) Are you tired today?

(Nolan Yonkman) Uh, not too bad, I just gotta get used to waking up this early.

(Angel) … to be a trainer you gotta have a good bedside manner. You gotta, you know you have to have a good personality, you got to be able to be cheery almost every day, you can't have a bad day cause you got to, some times a player will have a bad so you've got to bring them up. And you've got to be willing to accept all situations because some days you are going to have bad days where 3 or 4 guys get hurt, other days you'll have no injuries. It's a long season and you're going to have bad stretches and you're going to have good stretches you have to be able to roll with the punches.

(Narrator) Angel is responsible for the physical health of the team. And when a player goes down he is first to respond.

(Angel) Did you black out at all.

(Player) No

(Angel) No, okay. Is your neck sore?

(Player) No

(Angel) Okay.

(Narrator) On December 6th, three months into the start of the hockey season, Pirates defenseman, Nolan Yonkman was hit by hockey's equivalent of a freight train. A 200 pound hockey forward traveling 25 miles-per-hour.

(Announcer) Nolan Yonkman's in trouble… it's his wrist.

(Angel) I did, I knew something was up with him right away cause he grabbed his wrist right away. Before I even got to him he was skating in the other direction to get off. I couldn't even keep up with him. And we knew it was broken by that time.

(Angel) I'm just thinking about calming him down. Ah I start thinking about how long is he going to be out, what's the next step. Right away I gotta start thinking what am I gonna tell the coach. Just cause coaches wan to know what it is, how long is he gonna be out, does he need surgery all those things start going through their mind. In the case of Nolan and where he fits into the grand scheme of the organization he um he has ramifications um our coach is then gonna contact the general manager for the Capitals and he is gonna want to know what is going on, the president of the team is gonna want to know what is going on. So the information has to come quickly.

(Narrator) Standing 6'6" at 240 pounds, Nolan Yonkman was a second round draft choice for the Washington Capitals.

The Capitals have a lot invested into his development. Angel's job is to protect this important asset with every skill he has available.

(Angel) You know what I would recommend. A lot of laps.

(Angel) Very important. Physically 6'6", two hundred, we'll round it off say, thirty, forty pounds. He's really come along. When he first got drafted he was a raw, raw talent and (stutter) they could see a lot of potential there as a big kid. ~~It's~~ like basketball, if you're 7'1" you're gonna get drafted. Well this kid is 6'6" so he got drafted. He has skill he has talent he can really skate for his size When he is on the ice the potential is enormous and the Capitals see that and ah I think in the very, very near future your gonna see him playing in Washington.

(Narrator) After the break, Nolan's bones were set and placed in a cast. Angel had to draw heavily on his working knowledge of biomechanics to put Nolan on the road to recovery.

(Angel) In rehab it's very important to do the sport specific motion. There's two components to rehab. You want to do the rehab that's coming directly with the injury, strengthening it, range of motion. But then you also need to keep in mind the sport specific aspect cause an athlete is not in a bubble. There's ah outside ah factors ah he's getting hit, he's shooting the puck, it's a very dynamic sport. So we have to try to incorporate both of them together and they come together, mesh, now.

(Angel) The slideboard is a piece of, almost like a piece of Plexiglas. And what we're doing there is trying to duplicate the hockey motion, the skating motion. It doesn't completely do it because when you are skating, you're not just going side to side. There other factors, the the shape of the ice, the condition of the ice, ah somebody hitting you. On the slide you're just going back and forth. There is no other movement allowed, but it gives us something.

(Angel) These two are dynadiscs we call them. And basically, it's an unstable surface, cause hockey's played on an unstable surface, ice. A ¼ inch of steel and a guy's hitting you. So what we're doing here is he's gonna squat down, and tries to hold his balance. As you can see it's difficult. Now if he didn't have the cast on, I could throw a medicine ball at him, at make it even more difficult. Now the ball between his legs, it's making his groins work. So, when you squat down, the primary muscle you use are your hamstrings, your gluteus, which is your butt, and your hamstrings. By making him squeeze that ball between his legs, he's also working his groin.

(Nolan) It has been uh kinda a rough year. I'd only played eight games um into the season and when I hurt my ab and my groin. Um I missed about the month of November because of that. And coming back, December 7th, um, or 6th and then 7th, my second game back I… I fractured my my arm. It's um been kinda a slow year, not really playing a lot. I've only played ten games, so, um I'll be really excited to get back. Tomorrow's a big day, um when I get my cast off, and start the therapy there.

(Natural Sound: Cast being cut)

(Nolan) Doesn't hurt, don't worry.

(Dr. Sullivan) How's it feel?

(Nolan) Really stiff

(Sullivan) stiff?

(Nolan) Yeah

(Sullivan) okay

(Narrator) The Team's physician is Dr. Dennis Sullivan.
Dr. Sullivan is one of the key members of Nolan's rehabilitation team.

(Sullivan) The place where Nolan's fracture was, was right across here sort of at the end of the radius. You can see the appearance of the wrist looks normal, in terms of the alignment of the wrist. But if we compare it to his other wrist, you can see how thin the muscles have become in his forearm, so he's suffered considerable atrophy of the forearm muscles in the cast.

(Angel) I think Dr. Sullivan and I have a great working relationship. We speak just about every day.

(Sullivan) Hello, Angel? How are you. All done with Nolan, we took his cast off. We made him a splint he that he can wear under his glove, so he can practice, in terms of skating and puck handling. He's got a second splint he should wear when he's not practicing, just to protect the wrist. His wrist is quite stiff. And, I think our original estimate of coming back right after the All Star break is probably the most accurate one.

(Narrator) At 7:00 am, an hour and a half before the rest of the team arrives. Nolan with his newly freed arm meets Angel in the training room.

(Angel) The players get up early for rehab because I have a them, I need them to accommodate to my schedule. When they're injured, this is a harsh way to say it, but when they're injured they're messing with everybody's schedule. Cause now they're injured, they're not in the lineup, so we have to you know get them back in the line up, so they have to accommodate to us…. I've got twenty-two players here that I have to take care of. Is it fair for one guy to take up the time of twenty-two guys that are trying to win us hockey games, no. so he needs to be here at seven in the morning, which is the time I usually dictate. So that gives me an hour and a half to work with him individually one on one

(Angel) You've got two ligaments on either side of your knee, you've got two ligaments on either side of your wrist. And they're tight right now, they won't, they don't want to stretch, they don't want to get long, they wanna stay short.

(Angel) How painful is that right now?

(Nolan) On a scale of one to ten, seven.

(Angel) How painful is that right now?

(Nolan) Ahh… eight.

(Angel) So I take the measurements um of flexion and extension of the wrist. Then I take them on the injured, ah wrist. And we have something to compare to. And I tell Nolan this is what you need. This is where we have to be and ah if you want to play hockey.

(Angel) Okay, I want you to move it back and forth like this. Side to side, circles

(Angel) When I get the cast off the first two things we're thinking of is strength and range of motion. I'm not thinking about sports specific exercises yet with his wrist, cause he can't do those yet. So I need to get his range of motion where he can fully bend and extend his wrist.

(Angel) Now when you bend it, do you feel the pain? Is it along the fractured side? Or do you just feel it's tight?

(Nolan) Pretty much fracture side

(Angel) But is it like, is it just tight, or is it painful. How can you describe the pain compared to when you broke it?

(Nolan) Actually, this movement hurts a lot. This seems really tight.

(Angel) More tight than anything?

(Nolan) I don't know.

(Angel) We're gonna ultrasound Nolan's wrist now. The ultrasound waves go inside, they bounce off the bones and come back to the skin, and that's what gives him a warming feeling. The muscles in Nolan's wrist have atrophied from being in a cast for six and a half weeks. It's just like someone that's bedridden when they're paralyzed their muscles atrophy right away. Luckily for us we have what's called muscle memory, and Nolan's muscles are going to recover quite quickly. And I'll get you in the shape so when Dr. Sullivan clears you next Wednesday, at least you'll be in shape.

(Nolan) Yeah

(Angel) When it comes to the human body no matter who it is when you break a bone it takes a certain amount of time to heal. What comes into play for in terms if whether you're a professional athlete or someone like ourselves is when the cast comes off, how hard can he push it, how hard can he go, and how much pain can he sustain, cause once the doctor says ok the cast is off you can't do any more harm to it. At that point you have to tell him listen the doctor says you can't do anymore harm to it no matter how much pain you feel then he's gotta push through the pain And he's got to go and then yeah that's when the difference happens, that's when separates himself from the everyday athlete.

(Angel) So each time I just push it a little bit more… a little jumpy?

(Nolan) [grunt]

(Angel) How about if I hold it right there. How's that?

(Nolan) That's good.

(Angel) That's good right there. No more?

(Nolan) No.

(Angel) Where I have to you know push and get the wrist to bend that's part of the job and that's part of his job. He's gotta, he got hurt, now he's got to help me rehab him. I mean without him I'm not going to be able to do anything. I need his cooperation.

(Angel) He was having some pain and I was watching his, you know facial expressions. You got to push a little bit. Cause you're not gonna get any, you know no pain no gain is kind of a you know a saying that you have to go by in that case. Cause you're not gonna gain anything if you just the first grimace he gives you're not gonna, you're not gonna move that wrist at all. So I push it a little bit give it a good you know, push or jerk and then I you know lay off. And the next time he knows he's gonna expect that and he's got to be ready for it. But obviously I'm pushing on the fracture site, so it's gonna be, it's gonna hurt, so try to avoid that a little bit and work around the area, but at the same time that wrist has got to bend. So he knows that and he knows what to expect the next time, so it's not a surprise.

(Angel) Squeeze, squeeze hard, you're not gonna hurt me. So I can feel the difference here, the good hand, compared to his fractured wrist. Go ahead, lift. See he's gonna get tired just from me doing this. It doesn't look like a lot, but his wrist was in a cast for six and a half weeks, it's a lot.

(Angel) One more. Okay, turn over. He likes this one, he's good at it. You gotta let me come down though, you're not going to do any good…

(Nolan) Hear the crack.

(Angel) That's just your ligaments. Everything's stretching out. Curl, curl. Now go like this. So when he can get, he's gotta be able to get them both together like that, then we're in good shape. Get the healthy one all the way up here. So that's things you can work on at home. Turn it over. Like this. See the difference. Use the good one to push that one.

(Angel) If the camera at all doubted that Nolan was tall, evidence of his stick being taller than me. We were demonstrating, his top hand, is what controls the stick. So when he's skating, sometimes they skate with only one hand on the stick. Or when they're paying defense, they swing it like this. I'm not even strong enough to handle the stick, it's so heavy. It's so long, it's bottom heavy, cause he uses a graphite shaft with a wooden blade, so it's heavier on the bottom. And so he has to move it back and forth. When he's ready to go, he'll be able to turn the stick over like this. And he can't, I can guarantee he can't do it right now. As he's thinking right now, I want to try. No.

(Nolan) I want to try.

(Angel) From the first day of training camp to the last day of the season no athlete on this team doesn't have some injury at some point or maybe the whole time. The healthiest you are going to be is the first day of training camp after that, you are not going to be healthy again until the season is over.

(Nolan) I kind of agree with him too. I mean we, I think go through a lot of stuff, a lot of pain… we get flying around there… it's one of the fastest games, you know that hockey players play in. We get bumping and grinding we always kinda go through an injury and you want to get through it… And it's just something you become accustomed to. I mean you take a hit and you try to just rub it off and stuff. But it's part of our job, you know, you get used to that kind of stuff And you want to do whatever it takes to get back and get better.

(Narrator) Nolan continues his rehab under Angel's supervision.

(**Angel)** We don't even have to warm you up today, Nolan you're in good shape. Slide down a little bit.

(Narrator) After just 5 days, the difference in Nolan's recovery is astonishing.

(Angel) He's pretty close, that's ninety degrees right there.

(Angel) Very important Nolan can turn his wrist around with the stick. And simple physics. It's simple physics as you get further down the stick, the shaft of the stick it's harder because you have more weight to turn over. He's almost down to the butt end right now

(Angle) When you break a bone, I would say it's stronger after that. Because, you get like a, the way you get a callous on the bottom of your feet, you get a bony callous on the fracture side, so it's supposed to heal even stronger. We'll know tomorrow when he gets a x-ray from Dr. Sullivan, and we'll know how strong it is.

(Sullivan) How's the motion coming?

(Nolan) Yeah, it's, things are working pretty good.

(Sullivan) Let me see them both together, come on up like this. Good. Almost, not quite, but pretty close. Down like that. Okay, very close. Right in the middle, palms up, a little tight here.

(Nolan) Yeah, a little tight.

(Sullivan) Only a little tight. Palms down. Put your palms in like that. About the same though. Out like that. Shake my hand, hard. Okay. Shake my hand, hard. That's quite and improvement, isn't it.

(Sullivan) Is this tender at all?

(Nolan) No. A little on the fracture right there.

(Sullivan) Right there.

(Nolan) Yeah

(Sullivan) You call that mildly tender or mild.

(Nolan) On a one to ten, it's about a two.

(Sullivan) Okay, so no big deal. Do you trust it?

(Nolan) Yeah.

(Sullivan) Good, right here these are your x-ray from two weeks ago and you can see the fracture line really clearly then. Here's your x-ray today, all right, it's gone. Really that's filled in remarkably since the two weeks since you last x-rayed. My expectation is the next time you x-ray that will be gone.

(Sullivan) Right.

(Nolan) Okay.

(Sullivan) Okay.

(Sullivan) Let's make a plan here. The All Star break is this weekend. Then you have games the next weekend. I think that's a reasonable goal for you. Right now I think the thing to do is to start practicing with the team, start some puck handling.

(Nolan) Okay.

(Angel) The x-rays look good he said.

(Nolan) Yeah, there's just a little hairline or whatever

(Angel) That's probably what's hurting.

(Angel) Initially we don't let the players out on the ice for fear that they're gonna hurt themselves. For example, Nolan had his cast on we're not gonna let him skate, because for fact that he's a bit unbalanced. He's got a cast on one arm. If he falls he could jar the bones and move out of out of place. Ah once the cast comes off and the doctor says I think he's safe to skate, then he wears the removable cast with tape up and then he can go ahead and skate. So the fear is re-injury, obviously that's our biggest fear.

(Angel) Yonkman, 6 ½ weeks for getting your wrist crushed.
Being separated from the team is the number one concern that these players have and complaint. And that falls into the psychological aspect of things. They do feel separated from the team. They're not working out with the team, they're not skating with the team, they're not going on the road with the team. Going on the road is the number one bonding thing that these players love to do. They go to dinner together, they hang out together, they'll see a movie when they're on the road and they're not getting to do all that and, but that's part of being injured. It's not a punishment, but it's that's part of it. You don't want to be injured, it's another motivation, you know, I don't want to be injured, I want to be skating with the guys. How soon can I skate? And that's the first question so yeah it's a it's a big concern for them.

(Narrator) Donning a splint under his glove, an anxious Nolan is allowed back on the ice. It is his first chance to skate in six and a half weeks.

(Someone) He's got the furnace-face going… He didn't break his leg he broke his wrist… look at his face, look at him breathing… he was out there for ten minutes yesterday, it was me and a couple guys and the trainer. He came in like this, hugh. We're like, how long were you out there. Ten minutes. Are you kidding me, get back out there. The guys were giving it to him.

(Nolan) That's how you get in shape.

(Team Music)

(Narrator) Eight weeks after his injury, Nolan Yonkman is back.

(Narrator) But biomechanics doesn't just have meaning for the select athlete.

(Narrator) Golf novice, Linda Greenlaw is on her way to Ascension Technology in Milton, Vermont. Here she will learn about her own body's mechanics.

(Jack Finklestein) Today we are going to do a biomechanical analysis of your golf swing.

(Lee Johnson) Linda, we're going to put some straps on you that are going to let us retain the sensors very tightly to your body. So that as the, your arm moves, the sensors will move with it. And that will be the means by which we track each of your body's segments.

(Music: I'm Alright)

(Linda) This is great.

(Lee) As part of an assessment of your golf swing, it's important that we know whether you have any segment lengths that are different. If your right arm is longer than your left arm, you are going to swing differently. We are going to take those measurements.

(Linda) Okay, so like my measurements are going to be on PBS. Is that what you are telling me?

(Lee) I hope so. (Laughter)

(Music: I'm Alright)

(Lee) Give us a wave.

(Linda) This is so cool!!

(Lee) Everything has been scaled to your body type. So, the length of each bone is the length that we measured. Uh the joint centers are located at the center point of the two readings that we took around each joint. And what that allows you to do is a very thorough biomechanical analysis. We can actually calculate the amount of force or torque that's generated on each of your joints.

(Linda) Wow!

(Lee) So one of the things you can do, very quickly, is measure the amount of flexibility that your body has. So for example …arms out to your side. Follow me in a simon says. Very good, very good. Forward. Excellent. Perfect.

(Lee) One of the things we're going to do is collect just a baseline golf swing. And then Mike is going to come in and kind of explain what you did, because I won't have a clue.

(Linda) Alright.

(Lee) So the very first thing is just locate the ball.

(Linda) Now locate the ball you want the club at the ball?

(Lee) Perfect. Yup, that's perfect.

(Linda) Okay.

(Lee) Let's bring in an expert to tell you what it really looks like.

(Linda) Okay.

(Michael) When we look at your information here the first graph that we are looking at is your hips. So we're looking at how fast the hips can rotate, and when do they rotate in your golf swing. Right now your golf swing is what we would term a very rotational swing. We're not as stable as we could be, so we're putting a lot of external force on your spine.

(Michael) So looking at your old golf swing your feet were moving around a little bit. The placement of them a little bit, not as efficient as it could be. So we are going to make some changes from the ground and up.

(Michael) So the first thing that we're going is we're going to place your feet in a position to line up your ankles, your knees, your hips, and your shoulders. And then we're going to use the golf club up the front of you to line up your spine. So we're going to take the golf club and place the butt of the golf club against your chin, the sternum against the shaft, excellent, now to your naval there. Now we're going to go ahead and just flex our knees just like we do it in any athletic sport, yup. And then holding the knees in this orientation, I'm going to go ahead and flex my hips forward. Yup. And now you're going to reach down with your right hand and see if you can touch you're the top of your right kneecap.

(Linda) No

(Michael) If you can't, let's go ahead and flex a little bit more.

(Linda) Okay.

(Michael) And you should feel pretty strong from heals to toes that I can't move you around too much.

(Linda) Okay.

(Michael) That's your, you're nice and solid. So now from there, we can make a nice functional golf swing.

(Linda) Okay

(Michael) Go ahead and grip the golf club from there. Excellent. So a big change in just your setup posture that we've done. We'll be able to measure the difference of those two. I'm gonna move here to the right. And go ahead and hit one from there.

(Michael) excellent

(Michael) Okay Linda now we're going to work on some biofeedback. Now looking at the screen here, you'll see that the x is in the center of the screen. Okay, now go ahead and take your back swing. See where that x goes?

(Linda) Yes.

(Michael) It kind of goes up and to the left here

(Linda) Right.

(Michael) Alright, and let's go ahead and swing back down to impact. Good. So let's keep the hips here and just turn the shoulders. What happened to the x?

(Linda) It's just going sideways instead of horizontal.

(Michael) Uh-huh. So now we're going to add a little bit more stability in that lower body.

(Linda) Okay.

(Michael) So rather than for me to tell you that you should turn 20 degrees or 40 degrees or 80 degrees, let the system tell you what you should do and you're gonna feel whatever it is. So chocolate ice cream is gonna taste different to you than it does to me, and we can't explain that. I'm gonna hold your hips. Go ahead and swing back. Excellent. And again. So that's what your golf swing should feel like.

(Linda) With the hips not moving.

(Michael) Okay, you feel that they're not moving at all. Great.

(Linda) Right. So I should really slow my hips down.

(Michael) That's what you feel. Again I can't tell you that, but that's what you're sensing. The system tells us that's what is correct…

(Linda) Okay.

(Michael) .. for your body. Perfect, yup. Almost.

(Linda) Too much hips. Too much hip.

(Michael) Yup. Good

(Michael) Alright Linda, this is your posture before. So we can see how erect your body was. You have a lot of curvature in your thorasic spine here. This is just the way you came in the beginning.

(Linda) Right.

(Michael) Okay, so there's nothing wrong, it's just the way your body set up the old way. We find this posture here does create a very rotational movement in the hips and shoulders that will create an injury. So we can compare that with the new.

See it's a much different posture.

(Linda) Yeah, huge difference.

(Michael) So now the balls of the feet, the tip of the knees, the butt of the club, the tip of the elbows, the top of the spine are all in alignment. And the golf club and your spine are more at a 90 degree orientation. So now we can create a nice functional swing from here than where we used to be before.

(Michael) So in a very, very short period of time, just with this technology we can make huge changes. That use to take us years with the touring professionals.

(Linda) you just saved me a lot of money on lessons, too, didn't you. (laughs)

(Michael) That's right. Were going to get you out on the golf course and get you nice and healthy.

(Michael) Okay let's go ahead and square up our feet. We'll use the golf club for a posture stick. Tilt forward, check it with the right hand. Perfect. Go ahead and make a nice swing. Good.

(Linda) Yeah it felt good, thanks so much.

(Linda) This has been so much fun. It looks like the future has great things in store for the professional and novice alike.

We've learned a lot about better body mechanics and how the right equipment can make a huge difference in performance.

It will be fun to see how far we can go both with our bodies and technology.

Thanks for joining me on this quest And keep an eye out for me on the green. I'll be practicing my new swing.