"SCIENCE AND SPORTS"
SHOW 405

Episode Open
Spring Man
Better Baseball
High Anxiety
Faster than the Wind

EPISODE OPEN

ALAN ALDA (ON CAMERA) Three strikes and I'm out. Well what do you expect when it's

JIM PALMER pitching?

JIM PALMER This is gonna be loose ....

ALAN ALDA (NARRATION) Science meets sports.

JOHN GARVER Ready...

ALAN ALDA (NARRATION) Tomorrow's All-Stars may take batting practice in the lab. Track stars may get springs in their shoes - thanks to this young engineer. The latest sailboats may be set to overtake windsurfers. And mountaineers may be able to make it to the top - without getting sick.

ALAN ALDA (ON CAMERA) I'm Alan Alda. Join me as we explore the science of sports, on Scientific American Frontiers.

back to top

SPRING MAN

ALAN ALDA (NARRATION) You really have to move around on the tennis court. I'm just about keeping up with my opponent - a remarkable young man named

HUGH HERR. Ten years ago, Hugh lost his legs in a dramatic accident.

ALAN ALDA (ON CAMERA) Aha, good! Great shot. How did you get to this point? This was a mountain climbing accident?

HUGH HERR Yes, in 1982 I went to New Hampshire to climb Mt. Washington in the winter. And after climbing a 1000 foot ice face, there was a tremendous storm and we got disoriented near the summit. Blizzard conditions, you and I wouldn't even be able to see each other. Tremendous white out. And to make a long story short, a day outing turned into four days. The conditions were minus 20-degree temperatures, we didn't have a sleeping bag or a tent, no food.

ALAN ALDA So you were completely exposed for four days, day and night.

HUGH HERR That's right. To survive we dug into the snow, and my partner and I just hugged each other to stay warm. From that I got tremendous frost bite on my lower leg, and after two months in the hospital they had to amputate it.

ALAN ALDA (NARRATION) Hugh had led an adventurer's life, which was now in ruins. But he was determined to stay active. He decided to become an engineer and inventor - to dream up ways for people to use their bodies with maximum efficiency. And he found inspiration in a technology that's thousands of years old.

HUGH HERR The bow and arrow represents a device that makes human beings more powerful. Clearly if I were to try to throw an arrow with my bare hands, I would not be able to pierce the target. But with the elastic bow, I can easily pierce the target. So it makes human beings more powerful in a sense.

ALAN ALDA (NARRATION) The secret of the bow and arrow is that a normal person can build up tremendous energy in its powerful spring. Right now, Hugh's wife Lee can't do pull-ups - but watch this. She's wearing a special spring suit designed by Hugh. As she reaches up, her pushing muscles build up energy in two bungee cords. Then the cords help her pulling muscles get her over the bar. It was Hugh's accident that set him thinking about how technology can overcome disabilities.

ALAN ALDA (ON CAMERA) Was that the motivation for your developing these devices and explore these new ideas?

HUGH HERR I quickly realized that there's no such thing as a handicapped, physically disabled person, there are only physically disabled technologies. I, if I had the correct legs and what not, I can run a marathon, I can win a marathon, I'm convinced.

ALAN ALDA (NARRATION) Hugh returned to climbing years ago, using an artificial leg of his own design. And here in the Colorado Rockies, he'll test his spring suit for the first time outside the gym.

HUGH HERR I'm nervous, I hope it works. First time I've climbed on real rock. And I hope nothing gets tangled. We'll see.

ALAN ALDA (NARRATION) Hugh's feet grip the rock better than the best climbing shoes. And the springs seem to be doing great as well. Just as when Hugh's wife did her pull-ups, extending the arms stores energy in the bungees. Then, when Hugh lifts himself up, his pulling muscles only have to put out half the effort. Climbers could go twice as far before getting tired. But this is just the beginning for Hugh Herr and his springs. Now he's putting them into running shoes - with the hope of revolutionizing the sneaker industry.

ALAN ALDA (ON CAMERA) I got this shoe on here, that's got these high class rubber soles, and they got air in there.

HUGH HERR What did you say, high class?

ALAN ALDA Well I want to know ....

HUGH HERR They are classy aren't they?

ALAN ALDA Well, I mean it's very technological, the shoe, I want to know why this doesn't store energy as well as your spring. Doesn't this spring, doesn't this rubber collect energy and then give it off again? Doesn't it contract and expand?

HUGH HERR It does. The problem is the materials being used here are not very efficient as far as being efficient springs. When you compress the sole of the shoe, yes it does store some energy, but it doesn't store a lot of the energy. The problem is, you put a unit of energy in and you don't get a unit out.

ALAN ALDA Where does it go?

HUGH HERR Heat loss, the sole of your shoe just heats up after running mile after mile after mile.

ALAN ALDA (NARRATION) To develop his shoe springs, Hugh turned to one of nature's best runners. Horses have natural springs built right into their legs. The springs are actually elastic ligaments that run up and down the leg. When the hoof is in the air, these springs are relaxed. Then as the horse's weight drives into the ground, the spring bends and stretches and stores up energy. Finally, the ligament snaps back as the hoof lifts off the ground - giving the horse an extra thrust forward. Though it may not look like a spring, this black wedge is Hugh Herr's version of a horse ligament - for human shoes.

HUGH HERR It compresses when the shoe hits the ground.

ALAN ALDA (ON CAMERA) Can I just, it takes a lot of pressure...

HUGH HERR But when you're actually wearing it, it's fairly soft. When the runner comes and strikes the surface of the ground...

ALAN ALDA With the heel...

HUGH HERR Right, this heel spring collapses and stores energy. And then as the runner's foot roils over to the forefoot region, that enables this spring to open up and it's like a hand on the bottom of the heel, thrusting - pushing the heel up and that energy in mm enables the foot to bend this second spring and then the second spring in turn helps the runner thrust forward and get this energy pop at the end. So effectively what the runner feels with this shoe is a nice cushion upon impact and then at the very end an energy pop.

ALAN ALDA (NARRATION) Early in the design process, Hugh and his partner tried to sell the idea to the major American sneaker companies.

HUGH HERR The heal spring here is compressed.

ALAN ALDA (NARRATION) Using a crude steel mock up, they explained how the energy efficient sole was supposed to work. But the marketing experts and engineers were universally unimpressed. COMPANY MAN Thank you very much gentlemen, we'll be in touch.

ALAN ALDA (NARRATION) One by one, the companies turned them down. Eventually a Japanese company agreed to fund their research -- providing sneakers and enough money to hire an expert in carbon fibers. Working with thin sheets of this space age material, he made a series of strong, lightweight working prototypes. In the first batch, the springs were simply slid into the middle of off-the-shelf sneakers - the whole sandwich held together with glue. Hugh tested the prototypes using student volunteers.

HUGH HERR Well what I want you to do is just run up this path. And I want you to run normally, don't do anything out of the ordinary.

ALAN ALDA (NARRATION) The task was to run over this force plate, which can measure how much energy goes into the ground or shoe, and how much gets returned to the runner.

HUGH HERR Alright Rich, I want you to run through again, except this time increase your speed a bit.

ALAN ALDA (NARRATION) With the prototype shoes, the force at impact was consistently low - meaning the spring sole was absorbing most of the shock. And a high reading at lift off showed the Sneaker was returning that energy to push the runner forward. In contrast, the most popular brand let the runner feel more shock - and gave less push at the end. So, at least in the lab, the spring sole looks like a winner. But this is a more critical test - whether the spring sole can really make runners go faster. Mike O'Connor is the editor of Running Magazine. Bobby Fisher is a respected amateur. And the third test runner is Kenyan-born Steve Kogo - a star 1-kilometer performer. They'll be competing not against each other but against their own best times on this particular track.

MIKE O'CONNOR They feel great. I feel like I have more energy already. I'm going to wear these to work today.

TIMER On your mark, get set, go.

ALAN ALDA (NARRATION) They'll do a 400 meter lap. So in just over a minute, Hugh and his partner will know if their invention is all they designed it to be. If the spring soles absorb shock better than other sneakers, and if that shock energy gets effectively redirected to thrust the runner forward, this could be the biggest advance in running shoe history. As the runners cross the finish line, their reactions tell the story.

STEVE My hamstring is more relaxed than the Achilles, and pressure on the knees, but I feel pretty good.

BOBBY I didn't feel it in my legs at all.

MIKE Yeah, me neither.

BOBBY When I work out like this, I would normally do it in about 83 seconds. I was 74 seconds.

MIKE 74, yes Bobby, no way, alright.

BOBBY And I didn't feel it in my legs.

MIKE Normally when I'm running repeat 400 meters, I'm running in between 75, around 75 seconds. Today I was 71.8, so that's a significant improvement, with the same effort. Yeah, I think you guys are on to it, it really feels good.

ALAN ALDA (ON CAMERA) I want to see what this feels like, I can't wait. If I could get around the court and get to those short balls sooner.

HUGH That's right.

ALAN I'll send you a bouquet. I'm just going t take a little walk with this.

HUGH How are they?

ALAN You know its great! How much you want for these right now.

HUGH I'll send you a pair, how's that? Free.

ALAN You know what there really good for?

HUGH What? ALAN When the game is over, this will make this part easy. Well not that easy. Work on that part will you.

HUGH With springs we can become stronger, more powerful, we can have greater endurance. I think this is the age of the spring. I don't think it's been done yet. I can think of 100 different devices that I can put springs into. So I'm not finished yet.

back to top

BETTER BASEBALL

ALAN ALDA (NARRATION) Jim Palmer - one of baseball's superstars.

JIM PALMER Remember this is gonna be loose...

ALAN ALDA (ON CAMERA) Right.

JIM PALMER We don't want this, we don't want it back in your hand...

ALAN Right.

ALAN ALDA (NARRATION) Jim hasn't been pitching in the big league - since his comeback in 1992 - but he's willing to share the tricks of his trade with someone whose baseball experience is an occasional game of softball.

JIM PALMER Did you learn that in Hollywood?

ALAN ALDA No I'm just, I'm just working on the seam part now...

JIM PALMER I know. O.K.

ALAN ALDA I get the arm later, I'm not, I don't want to do it all at once, like throw my brain. Why don't you throw the ball and show me...

ALAN ALDA (NARRATION) Jim Palmer once pitched a no hitter for the Baltimore Orioles - a game caught by Elrod Hendricks, who's now an Orioles coach. Great pitchers have an arsenal of different pitches.

JIM PALMER It's better than when I made my comeback

ALAN ALDA I think we've started something here. There's the curveball...

ALAN ALDA (NARRATION) Curveballs start high but then drop down. And of course the fast ball - that hardly seems to drop at all.

ALAN ALDA (ON CAMERA) What happens to the ball after it leaves your hand in a fastball?

JIM PALMER Well you hope it goes up to the catcher and doesn't get hit. But I mean basically when that ball comes out of your hand it's gonna have backspin. And the ball is actually going to hit the air and hopefully have a little bit of movement.

ALAN ALDA (NARRATION) It's back spin that keeps fastballs up... and the opposite, topspin, that makes curveballs drop. Batters have to start their swing before the ball's even halfway to the plate - and by then they must have decided just when and where the ball will arrive. Yet the average pitch is all over in half a second.

ELROD HENDRICKS You have a split second to make all the decisions and then to have a good swing at it and make good contact. And making good contact out in front of home plate. And then finding the holes.

ALAN ALDA Move out of the way.

ALAN ALDA (NARRATION) Put like that, it's amazing anybody can hit.

JIM PALMER You ready?

ALAN ALDA Watch out because I don't want to hurt you fella.

ALAN ALDA (NARRATION) But how could I resist one day being able to tell my grandchildren of the time I faced Jim Palmer?

ALAN ALDA(ON CAMERA) That was a strike?

ELROD HENDRICKS Yes.

ALAN ALDA Well if your gonna curve it like that, what chance do I have?

ELROD HENDRICKS See, see.

ALAN ALDA I touched it, right?

ELROD HENDRICKS Right. You fought it off, see.

ALAN ALDA Don't get upset, I was just kidding. I didn't really mean to touch the ball. Now he's mad, now he's gonna get me .....

ALAN ALDA (ON CAMERA) I only face a softball every five years, so I'm amazed to find myself here at all. What interests me is how hard it is to hit the ball. Not just for me, that's expected, but a professional baseball player, on average only gets a successful hit once every four times. It may be the only profession you can fail three quarters of the time and be successful.

ALAN ALDA (NARRATION) But now help is arriving for the beleaguered batter - from a very unlikely place.

JOHN GARVER Some people think it's a junk yard, but it's my supply yard for my inventions. All of these are things that I have a project for.

ALAN ALDA (NARRATION) Retired Ohio high school teacher

JOHN GARVER has a history of sports inventions. Many haven't made it out of his junk yard. But the first large head tennis racket now common in the sport - was built right here. Thirty years ago, he invented an air-driven gun that throws baseballs. Unlike most pitching machines, this one can quickly switch from throwing curveballs to fastballs. Many teams bought one - but batters wouldn't use them because they were too hard to hit against. The problem, Garver decided wasn't his machine - but that batters simply didn't know how to hit.

JOHN GARVER And it took me ten years to find out what was behind that. Ten years. Then another twenty years trying to convince people I'd found it out.

ALAN ALDA (NARRATION) Garver is now trying to sell his secret to ball teams. At first, his only success was with little league coaches. But today, he's been invited to test out his ideas out at Kent State University - one of America's best college teams. Many of Kent State's players So on to the major leagues. Yet their hitting needs all the help it can get. Head coach Danny Hall.

DANNY HALL I think that probably the majority of the guys that are hitting, whether it’s guys that I’m getting in a college program, or whether it’s guys that are playing professional baseball, have no idea what they’re doing. Whether it’s mentally, physically, what have you, I don’t think they understand what is going on when they’re trying to hit.

ALAN ALDA {Narration) To show batters how little they know, Garver begins his two-day program with one of his typical home-made contraptions. The task is to hit line drives.

JOHN GARVER And we want you to smack this hard, the rules are it's a good ball if it clears the infield dirt above the ground.

ALAN ALDA {Narration) Line drives give batters the best chance of getting on base. And when the ball is in the middle of the strike zone, there's no problem. In slow motion, you can see the bat meets the ball dead center. But now Garver repositions the balls to the top and the bottom of the strike zone.

JOHN GARVER Now lets see if that low one counts. Walk up to it... The umpire I know calls out a strike. O.K.

ALAN ALDA (NARRATION) Ground balls are usually outs.

JOHN GARVER That sound of grass on the ball almost makes you sick doesn't it?

PLAYER Yeah, it does.

ALAN ALDA (NARRATION) And pop-ups are usually caught. PLAYER I was very surprised, because I watched the first guy do it and I couldn't believe he wasn't hitting 'em on a line. And then I get in there and do it, and I couldn't adjust. When it's not moving and you can't hit it, how are you going to hit it when it's moving.

ALAN ALDA (NARRATION) Slow motion reveals what's happening. Batters aren't hitting where they're aiming - grazing the tops of the low balls, knocking them down ....and grazing the bottom of the high balls, popping them up. So Garver offers some radical advice - aim to miss.

JOHN GARVER The fix on the high ball is to swing above it. That would be the center Of the bat perhaps, across the top of the ball. And if we raise the ball up a little higher, you might have to miss the ball altogether with the bat. And the fix in the low zone was to pass the bat below the ball. So you clean missed it. Try to do that and you'll make contact, solid contact.

PLAYER Sounds strange, first of all cause you know you're always taught to hit the ball in the center of the ball, and to actually sit there and to try to actually miss the ball, knowing that your mind's thinking it's going to miss, is something new.

ALAN ALDA (NARRATION) All the players are skeptical. But having hit so poorly when they aimed to hit, now they try aiming to miss.

JOHN GARVER Hot dig. That's the first time for one of those, eh?

ALAN ALDA (NARRATION) On the replay, the bat makes solid contact with the center of the ball - even though the batter was aiming below it. Next, a high ball.

JOHN GARVER Where are you gonna hit?

PLAYER When I swing I'm going to be aiming somewhere about right in there.

JOHN GARVER Pretty good connection there. A little adjustment on this one, a little bit lower, lower. There you are.

ALAN ALDA (NARRATION) The players are impressed.

PLAYER Definitely makes a difference, just by hitting the ball on a line drive, instead of popping it up or hitting it down in the ground.

JOHN GARVER Look at that sucker go. I'm applying science to what's going on, not happenstance observation, and if we can't establish that the thing we are seeing is true and repeatable then I'm just a baloney guy, not worth listening to. If we can establish it, then the science tells us you better pay attention.

ALAN ALDA (NARRATION) Now it's time for Garver to demonstrate another embarrassing weakness of the average batter.., how their judgement is confused when pitchers change pitches on them.

JOHN GARVER Ready. Where is his hand and where is the ball?

ALAN ALDA (NARRATION) Batters must point to where they think the ball has hit the canvas.

JOHN GARVER Ready? Ready?

ALAN ALDA (NARRATION) They're only allowed to see the ball up to the halfway point - which is when they'd have to commit to a swing if they were actually hitting.

JOHN GARVER O.K. Ready.

ALAN ALDA (NARRATION) This player judged a fastball right on the money. But watch what happens when Garver quickly switches to a curveball.

JOHN GARVER Ready? Was he really fooled with that one?

ALAN ALDA (NARRATION) On the replay, the error is dramatic.

JOHN GARVER He just missed a curveball by over a foot. But he had seen fast balls before hand. That set him up not to be able to identify it. It always does that. Whatever the changed pitch is causes you to miss identifying the new pitch. And seriously makes you misjudge it.

STADULIS You were twenty eight milliseconds late.

ALAN ALDA (NARRATION) Garver believes the misjudgment can be minimized by pausing between pitches - an idea being tested on a simulator, where the light is the ball, the slider the bat.

STADULIS You were late...

ALAN ALDA (NARRATION) As the pitch flashes down the track, the bat should pass the white mark just as the last bulb lights up.

STADULIS Late by a hundred five milliseconds.

ALAN ALDA (NARRATION) Both the speed of the pitch and the interval between pitches can be changed.

STADULIS Very good. Seventeen milliseconds late.

ALAN ALDA (NARRATION) When the interval between pitches is only around 11 seconds, the batter's accuracy is poor.

STADULIS You were early by one hundred and sixty seven milliseconds.

ALAN ALDA (NARRATION) But with nearly every batter tested, when the time between pitches is greater than 15 seconds, judgement improves.

STADULIS You were early by one millisecond. You hit that one out of the park. If batters are facing a pitcher who is throwing quickly between pitches, in other words not taking very much time, and there are some major league pitchers who

are well known for that, the batter would be wise to call time out, step out of the box. Delay probably somewhere on the order of fifteen seconds at least, in terms of the time between the pitches to lessen the potential effect of the pitcher changing speeds.

ALAN ALDA (NARRATION) After two days of training in Garver's ideas, it's time to try them out in a practice game.

ALAN ALDA (NARRATION): What about the old notion of aiming to miss? Player #9 went through Garver's class and today, at least, aiming below low balls and above high balls seems to be working.

PLATER #9 Sometimes it's hard to like, think about it as you are doing it, but on a couple of 'em I did think about it and I actually swung harder and I hit the ball well.

ALAN ALDA (NARRATION): And #22 after missing a ball, takes advantage of Garver's research and tries a 15 second breather. This helps him erase from his mind any memory of the previous pitch. He'll face the pitch with a new eye. By the end of the two days, most of the players are convinced, at least for now, that Garver's ideas are working.

JOHN GARVER In the system we have been studying, we notice we get twice as many contacts and if that were translated into the ballgame, if you can make a guy make twice as many contacts, you can possibly double his batting average.

PLAYER You know, if you can make a hit 3 out of 10 times, you can make the hall of fame, so, if you can get that up to four, even then that would be a good improvement.

ALAN ALDA (NARRATION) But the real test of Garver's claim to be applying science to the art of hitting will take more than a practice game. Keep an eye on Kent State next season.

back to top

HIGH ANXIETY

ALAN ALDA (NARRATION) The Alps. Beautiful. Enticing. And all too often, deadly. Hardly able to move, this climber is a victim of mountain sickness. Here at 15,000 feet, thin air is starving her body of oxygen. She could become one of the one-in-ten climbers who get so sick their lives are in danger. It's an all too common sight for the mountain guides.

SWISS GUIDE It's mostly from the high altitude, why they get very tired. Sometimes they vomit in the snow. They walk like drunken people. But mostly they don't like any help, but they don't like to go down also. Strange. It's difficult to say why they don't go back.

ALAN ALDA (NARRATION) Like most new climbers, she probably had no reason to suppose that she'd be especially vulnerable to the altitude. Which is why there's a research program at the University of Heidelberg in Germany to try to predict who's most susceptible to mountain sickness. This young man, named

ARNDT, is one of a group of volunteers willing to push their bodies to the limit to help find a test that will tell people before they climb if they're likely to get sick. Arndt's testing begins by finding out how fit he is. As he works harder, his body responds by increasing his heart rate, pumping more blood to his muscles and so supplying them with more oxygen to burn.

SYNC (Yelling in German)

ALAN ALDA (NARRATION) To get that extra oxygen into his blood, he breathes faster and more deeply. Now the real test begins. Arndt's oxygen is cut back, simulating high altitude. The idea is to see how he responds when there is less oxygen available. Again his heart rate increases - and again his breathing gets faster and deeper. At the equivalent of 15,000 feet, Arndt is breathing five times more air than usual, even at rest. This is Michael, another of the volunteers for the test. On the fitness test, he's as good as Arndt. But when Michael's oxygen is reduced, there's a curious difference. At a simulated 15,000 feet, Michael's breathing is little different from what it was at normal altitude. Even during moderate exercise, his body - unlike Arndt's - seems to be ignoring the fact that his oxygen supply is dropping. The Heidelberg researchers wondered if people like Michael, whose bodies don't seem to recognize they're getting into trouble when oxygen is scarce, might be the ones most susceptible to mountain sickness. There was one way to find out - and perched at 15,000 feet on the Italian-Swiss border is the perfect laboratory - a 100-year old mountain hut, the highest building in Europe. Peter Bartsch, the leader of the Heidelberg team, is heading there now. He's taking it slowly, giving his body time to acclimate. But the subjects in his experiment don't have that luxury. They climb fast, rising two miles in elevation in just over a day. The experiment is designed so that neither Bartsch nor his subjects know how they performed in their tests. So Arndt, for instance, doesn't know his test suggested he'd cope with the mountain air by breathing much harder.

ARNDT I feel good, very good. Good air.

ALAN ALDA (NARRATION) Michael, who didn't breathe harder in the test, is finding the going rough. As the test predicted, his body just isn't getting the message that the air up here is thinner. But then there's a third subject, Udo, who like Arndt breathed harder in the lab - but may be having the first hint of a problem.

UDO I've just a little bit of a headache, very little bit. Except for this I'm feeling really good, and I'm lucky to do this now.

ALAN ALDA (NARRATION) We are going to see what happens to Arndt, Michael and Udo once they reach Peter Bartsch's mountain top laboratory. Night falls - the most dangerous time for those vulnerable to mountain sickness. During the shallow breathing of sleep, blood oxygen levels can drop steeply. Six hours after arriving, Arndt - whose test suggested he'd do well at high altitude - is absorbed in a murder mystery. But Udo, whose test results also suggested he'd cope by breathing harder, is in trouble.

UDO And when I came up I was feeling quite good. But then it was developing a big headache. And it was a stomach ache and wasn't good. I had to vomit.

ALAN ALDA (NARRATION) All he wants to do now is rest.

UDO My body is exhausted and I have to sleep. So I hope that I will have a good night.

ALAN ALDA (NARRATION) Knowing the dangers of the night, Bartsch makes regular checks. At 5:30 am, the only one complaining is Udo.

DR. PETER BARTSCH Udo has a lot of problems. He was vomiting once at night and he had headache. I gave him some drugs. His symptoms went away. He didn't feel nauseated anymore but he couldn't sleep.

ALAN ALDA (NARRATION) Neither Udo nor Bartsch knows that his test predicted his breathing should adjust to the altitude. But if it has adjusted, it hasn't been enough to prevent his worsening symptoms. Arndt, meanwhile, as predicted, is still doing fine. His balance is good, his blood oxygen normal.

ARNDT Now I feel me good. Only muda, in German, tired.

DR. PETER BARTSCH He would love to climb the Dufourspitze or any other mountain here. I actually think he's enjoying himself here, that's my impression.

ALAN ALDA (NARRATION) Which leaves Michael - who is definitely not enjoying himself. His pre-climb test suggested he wouldn't adjust his breathing to high altitude - and he is now very sick.

DR. PETER BARTSCH The problem with him was he didn't call us last night. When he went to bed he already realized that something was wrong and no one called us. And when I saw him this morning he was really in a severe condition. I think if we had caught him earlier we could have stopped the process at an early level.

ALAN ALDA (NARRATION) Michael's decision to tough out the night could have been a fatal error.

MICHAEL I didn't quite notice that I was getting worse and worse. So just this morning at half past five they wake me up and I couldn't do anything. I couldn't breath and I couldn't stand on my feet. It was an extremely bad feeling.

ALAN ALDA (NARRATION) X-rays show Michael has advanced pulmonary edema. The lace-like pattern in his lungs, especially the right, means they are filling with fluid.

DR. PETER BARTSCH This means that we have a very severe illness. If we do not treat Michael he's most likely going to die. Fluid will accumulate in all his lung and he will eventually drown. And we have to immediately install treatment by giving oxygen now and fly him down as soon as possible.

ALAN ALDA (NARRATION) The oxygen will stabilize Michael's condition for a while - but the only way to clear the fluid from his lungs is to get him off the mountain - fast. A rescue helicopter is called in from Zermatt, Switzerland. Once he gets to a lower altitude, Michael will be fine. It turned out that Peter Bartsch's pre-climb test correctly predicted his sickness and Arndt's health, but missed Udo's vulnerability. So the mystery of mountain sickness isn't solved yet. Meanwhile, Michael's experience dramatically demonstrated why being able to predict the effect of extreme altitude could potentially save so many climbers' lives.

back to top

FASTER THAN THE WIND

ALAN ALDA (NARRATION) Tarifa, Spain. It's windy, but when the wind blows off the land, the seas are relatively calm - ideal conditions for speed-sailing. Wind surfers come here every year, looking to break records - without, they hope, breaking anything else. The most recent champion was Frenchman Thierry

Bielak, who amazed the crowd by doing 45.3 knots - more than 52 miles an hour. In fact, Bielak was the world record holder as we started producing this story. Although more traditional sailboats once held the speed record, in recent years windsurfers have been out ahead. Here's why. This is Thierry Bielak again. His lightweight board almost completely leaves the water during a run. That's called planing. Unlike heavy conventional sailboats, which plow through the water, a planing windsurfer just skips across the surface. That's why most people are convinced windsurfers will always be the fastest sail-powered water craft. But Greg Ketterman, of Long Beach, California, thinks windsurfers have had their day.

GREG KETTERMAN Well, the windsurfers have been going up steadily since '86, just bit by bit. Little tiny refinements. So it doesn't seem likely that they're all of a sudden going to go considerably faster.

ALAN ALDA (NARRATION) Greg is sailing his Trifoiler, a radical hydrofoil boat he designed himself with one goal in mind: to snatch the speed record away from the windsurfers. And Greg isn't the only one with this goal. On the other side of the world, Australian

LINDSEY CUNNINGHAM is after Bielak's record too. He's also come up with a radically different design. His boat, Endeavor, uses a solid wing sail mounted on three small, planing hulls. Lindsey and Greg are arch rivals in the world of speed sailing. Both want Bielak's record. And both think that their sailing technology can prevail over the windsurfer's physical advantages. Greg has pinned his hopes on hydrofoils-small wings that work like airplane wings.

GREG KETTERMAN Everything that the airplane designers do, we do just about the exact same thing. The big difference is, water is about 700 times more dense than air, so our wings are 700 times smaller than the airplane wing.

ALAN ALDA (NARRATION) As the boat speeds up, the foils produce lift, just like an airplane wing, raising the hulls off the surface. With only the streamlined foils slicing through the water, Greg's Trifoiler should be as efficient as a planing windsurfer. The major drawback of hydrofoils is that it's hard to keep the boat at a constant height above the water. But here's where Greg has made a breakthrough. He's found a way to keep his hydrofoils stable. It works like this. The two skis extending from the outside hulls act like feelers, sensing the boat's height above the water. If a hull lifts up, the ski drops, pivoting the hull downward. This automatically tips the foil downward. Now the water is pushing down on the angled foil, forcing the hull down with it. On the other hand, if a hull drops down the foil tips upward. This time the water pushes up on the angled foil, lifting the hull back up. The two skis work together to constantly - and automatically - keep

the boat rock-steady. Greg's system seems to be working. But down in Australia, Lindsey Cunningham decided hydrofoils were too risky.

LINDSEY CUNNINGHAM We knew planing worked on the sailboards, and we knew that hydrofoils were still having a lot of control problems and while they're efficient in themselves, their overall efficiency still wasn't that good.

ALAN ALDA (NARRATION) Taking his cue from windsurfers, Lindsey made Endeavor's pontoon-like hulls flat on the bottom, so they can plane easily. And to reduce drag even further, Lindsey designed the boat to sail on only two of the three hulls. The crew sits in a capsule on the longest arm of the tripod. Helmsman, Simon McKeon faces forward to steer. Facing sideways, Tim Daddo works the sail. Tim has to tighten the sail just enough for the crew pod to lift free of the water. It's a delicate balancing act. Tightening too much may drive the boat faster - but could flip it over. Too little, and the pod drops in the water. But with the pod flying and the other two hulls planing, Endeavor, like Greg's Trifoiler, can match a windsurfer's performance. Still, no design's perfect. The drawback of Lindsey's solution is the terrific strain created as the weight of the crew fights the force of the wind. Last year in the middle of a run, that strain resulted in disaster.

SIMON McKEON (ON CAMERA) Well, we think what happened was a wire has let go at the wrong moment and caused the boat to basically fall apart. We hit the water at quite a high speed, but fortunately the cockpit is designed to let us out when a disaster like that happens, and we just somersaulted over the water a few times.

ALAN ALDA (NARRATION) While Lindsey Cunningham's boat was out of action for repairs, Greg Ketterman was hard at work. During these speed trials off the coast of Africa, he came tantalizingly close to Bielak's record. Close, but not quite.

GREG KETTERMAN Right now we seem to be hitting a wall right at 50 miles per hour.

ALAN ALDA (NARRATION) The faster the boat goes, the harder it is to drive it, and then it reaches a limit regardless of how hard the wind blows.

GREG KETTERMAN I suspect our efficiency's probably dropping off around 43 or 45 miles per hour, but then at 50 we just can't go any faster.

ALAN ALDA (NARRATION) Greg suspects a problem with the foils. But with the boat rocketing along at 50 miles an hour it's impossible to know. If there were some way to look at his foils at high speed, he might be able to find a way to

break though the wall. It's with just this hope that Greg has come here, to MIT. Greg and research engineer

CHARLIE MAZEL are setting up a rare device: a water tunnel. Right now the tunnel is drained of water so that one of Greg's foils can be mounted in the see-through test section. With the foil in place, the tunnel is filled. I caught up with Greg and Charlie just as they were beginning their first tests.

ALAN ALDA (ON CAMERA) Is this your foil? Or is it something you just...

GREG KETTERMAN That's our foil...

ALAN ALDA So that's what you're going to be riding on.

GREG KETTERMAN Yeah.

ALAN ALDA Could I see what happens when the water starts to go past it?

GREG KETTERMAN Sure. Charlie, if you could speed it up.

ALAN ALDA (NARRATION) The tunnel should show what's going on with Greg's foil as the water speed approaches the mysterious wall.

CHARLIE MAZEL ...okay, speed's coming up a little more...

ALAN ALDA (NARRATION) As we passed through 40 miles an hour, we saw what Greg had long suspected.

GREG KETTERMAN There's some cavitation...

ALAN ALDA (ON CAMERA) There it is.

GREG KETTERMAN Just starting.

ALAN ALDA (NARRATION) Streams of bubbles began to appear under the foil - it's called cavitation.

ALAN ALDA (ON CAMERA) What's the speed?

CHARLIE MAZEL 43 miles an hour

ALAN ALDA You want to inch up closer to the speed at which you experience your wall?

GREG KETTERMAN Yeah, let's bring it up slowly...

ALAN ALDA (NARRATION) As we approached 50 miles an hour, the foil became covered in a sheet of foam. This is what Greg's boat has to pull along with it.

ALAN ALDA (ON CAMERA) How does it form? What makes it happen?

GREG KETTERMAN Well the pressure goes so low that the water vaporizes, or boils.

ALAN ALDA So you're looking at a kind of boiling there now.

ALAN ALDA (NARRATION) Cavitation creates a lot of drag. It's like a big underwater brake. Greg had suspected it might be happening but until now hadn't known for sure.

GREG KETTERMAN Well, that seems to explain exactly what our problem is.

ALAN ALDA So that confirms your hypothesis that cavitation is the source of the drag.

GREG KETTERMAN Yes.

ALAN ALDA You're out there on the water going as fast as you can, you hit that wall at 50 some miles an hour, and you're thinking that under the water this is happening. Now you've seen it for the first time. That must be an interesting experience.

GREG KETTERMAN Yeah, it's super exciting. This is what I wanted to see, because we want the record, and to simply change the shape is a real simple fix. So it's wonderfully exalting.

ALAN ALDA (NARRATION) Now Greg can concentrate on redesigning his foils, rather than tinkering with other elements like the sails, which are probably working fine. But in the very week Greg and I were at MIT, Greg's big rivals down under were waiting for the wind in this bay south of Melbourne. Lindsey Cunningham's Endeavor is fully repaired and back in action. Perfect weather is forecast, with high winds sweeping down the wide beach onto the bay. The 500-meter course is set up close to the beach where the smoothest water will be. In the blue wind shelters are cameras and official timers. Simon and Tim make several runs, but the wind is gusty. You can see Tim struggling here to keep the pod flying. Suddenly a gust slams the boat sideways. It swerves dangerously, almost out of control. Tim frantically loosens the sail to abort the run. It was a close call, but no damage was done. Since the boat can only sail in one direction,

Endeavor is dragged back to the start. It's another in a long line of frustrating runs. And now the wind is rising ominously with an approaching storm. Nobody wants a repeat of last year's disaster.

LINDSEY CUNNINGHAM ...no, I just don't like the looks...looks dangerous. Well, I guess it'll be alright...

ALAN ALDA (NARRATION) Lindsey decides they can get in one more run. This time the wind is steady. Tim keeps the pod dead level. Even before the official time is announced, the crew knows it was a great run.

TIM DADDO This is the best we've had in a year. If the boat doesn't go close to 50, I'm going home.

TIMER Yes, it's a world record. 46.2.

CREW Hurray!

ALAN ALDA (NARRATION) 46.2 knots - over 53 miles an hour. Not the 50 knots they were hoping for, but enough to steal the world speed-sailing record from Thierry Bielak's wind surfer. And enough to give Greg Ketterman a slightly harder target.

GREG KETTERMAN The record is here, I've been coming up and the record's been going up and I can't quite get there. That's the way it's been going for the last five years.

ALAN ALDA (NARRATION) He'll be ready for another attempt soon - and this time he might make it - assuming nobody comes along and moves the target again.

back to top