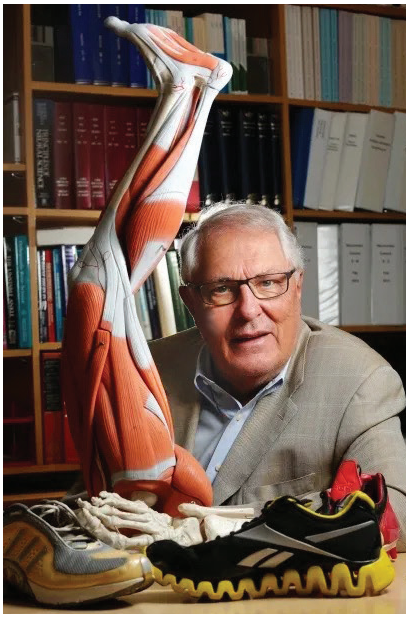

Dr. Benno Nigg

# Up Close and Personal: An Interview with Benno Nigg

A biomechanics legend espouses his wisdom.

**BY BEN PEARL, DPM**

*Benno Nigg, Dr.Sc.Natis (European PhD) is an icon in lower extremity biomechanics research and theory. He has authored and co-authored hundreds of articles, written nearly a dozen books, and he has been cited over 30,000 times. He shows no sign of slowing up, having published almost a dozen articles in the last year.*

*This interview demonstrated his knowledge and experience in conceiving and producing a vast amount of research on biomechanics, footwear, sports injury treatment and prevention, kinesthetics, strength training, orthotics, gait analysis, and other related areas. It also reflected the admirably careful manner in which he perceives and provides information: that is, regarding the differences between what he knows to be scientific fact versus what he sees the evidence pointing to, versus what he sees as lacking in evidence. Such honesty and clarity are the hallmark of the best scientists.*

***Ben Pearl:*** *Dr. Nigg, what do you think about the condition of the Olympic tracks in Japan this past summer? What advantages, if any, did you see?*

**Benno Nigg:** In Japan, the tracks are influenced by the fact that most of these stadiums are used for big concerts. Therefore, they have to be built to allow big cars and trucks to drive over them. This doesn't result in a significant effect on times; perhaps only one percent. However, a much greater gain can be made in shoe design. This creates a much larger magnitude and you may easily have an impact of four to five percent.

***Pearl:*** *Simon Bartold opined, after talking with some people at Nike, that perhaps the shape of the rocker accounted for several percent; secondly, the carbon plate maybe for a percent or two, and that there was a third factor also—you mentioned that you have contributed a paper on the teeter-totter effect. Do you think that plays a role also? And what would you define as the greatest biomechanical factors in performance with reference to the "super shoes?"*

**Nigg:** Nobody knows which claims are true. Nothing has been proven. A study was performed in which they cut the plates of the shoe. They saw the same effect and benefit as with the non-cut plates. So perhaps the plates are functioning in a different manner. They claim that the material has an impact of about two percent. However, no one has done an experiment that demonstrates that.

**"In our lab, the work we do is to try to understand which factors in these shoes play a role in performance."**

In our lab, the work we do is to try to understand which factors in these shoes play a role in performance. No one knows what these factors are but the international track and field body (the IWAF) have made these rules without understanding which factors play a role in performance.

***Pearl:*** *Let's go back to some of your seminal work with changing paradigms. Perhaps you're best known for your theories on muscle tuning, the effect this may play in injury rates, and also the concept of the preferred movement pathway. We have a*

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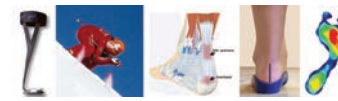

*Dr. Nigg* *(from page 121)*

*mix of readers here from new students to the very experienced. Could you share your pillar theories that you felt changed from the old view of skeletal alignment dogma to the new paradigms you've brought forward?*

**Nigg:** When I was a young biomechanist, I thought that impact and pronation were the two factors for the development of injuries. I wanted to go out and prove that this is true. When we first researched impact, it came to the point where I had to say that I did not find the result I expected. If you look at everything that has been published in the literature about impact forces and injuries, the sum seems to be that impact forces are not the reason for injuries. From a purely statistical point of view there is no evidence that impact forces during running are the reason for injuries.

Functional thinking leads to the concept of internal forces created by moments. If you have a force which acts on the forefoot, then that force produces a big moment with respect to the ankle joint which must be countered by some structures behind the ankle joint. This would be the triceps surae. There is a large distance (lever arm) from the forces in the front (to the ankle) which results in a big moment that has to be countered by the triceps surae. The forces in the triceps surae are huge. When you have a force close to the ankle joint, that force has a small lever arm, and therefore the forces are small. And small doesn't mean 10% less. The internal forces due to active function are five to ten times higher than the internal forces produced by impact. So, functionally, there is no reason why we should think that the impact forces produce high internal forces, which are the reason for injuries.

**"If you have a force which acts on the forefoot, then that force produces a big moment with respect to the ankle joint which must be countered by some structures behind the ankle joint."**

***Pearl:*** *This makes perfect sense with respect to the longer lever arm of the action of the forefoot being a key component and something we may want to look at further. Perhaps we should explore this in respect to the valgus wedges Kogler described for plantar fasciitis. Expound on that and give us an example of what happens.*

**Nigg:** That refers to what occurs when you land on the forefoot and produce those high forces which must be countered in the Achilles tendon. And if you land on the forefoot in an asymmetrical way, then these forces in the Achilles tendon are even higher. So you may want to make the landing more symmetrical. That's an example of how you can reduce the local loading in these structures.

***Pearl:*** *Can you address the implications for injury and asymmetry? Let's say I have a deficient ACL on my left knee which is going to affect my gait and other things. How does that then translate with what you just said? And is this something we might need to consider with your preferred movement path theory which is that we're going to move towards the most efficient injury-free pathway? I think you relate it mainly to running, but I think it might even apply to other sports, including ice skating and skiing, perhaps. I'd like your thoughts on injury and asymmetry, and then how that intersects the preferred motion pathway theory that you've developed.*

**Nigg:** Let's assume with reference to injuries related to loading: if you have high internal forces you will get injuries sooner or later. Let's assume that is true. Now we have two possibilities:

1) We can reduce the forces in the structure that we look at—for instance, the Achilles tendon.

2) We reduce the asymmetry.

Now, these are two different things. If I take off very symmetrically, I will have a high force in the Achilles tendon. In sprinting, it will be somewhere between five and ten times body weight. So the forces are high. But the Achilles tendon is made for that. Now, let's assume I take off on the outside or on the inside of the foot. And being asymmetrical, that means a load increase in the already high forces in the Achilles tendon. That increase is something like 2 to 10 times. Of course if that continues step by step, then that may be a reason for injury.

**"When you put an insole in and then make a medial or lateral adjustment, make sure that what you do makes the whole movement more symmetrical."**

So, the first thing to do is make sure that you get rid of the asymmetry. Your walking or running should be very symmetrical. The second thing to work on is to make sure that the forces in general are not so high .The first you can achieve by altering the insole to make the loading better distributed—the reduction of the total force by taking shorter steps. When you take shorter steps, there are lower forces developed in the Achilles tendon or less total forces in the internal structures. That of course is an advantage.

***Pearl:*** *Can you reiterate what is the single most important function of an insole or orthotic that you think will have the most tangible effect from the studies and research that you've done.*

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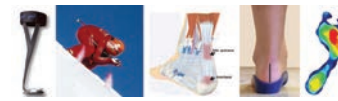

*Dr. Nigg* *(from page 122)*

**Nigg:** My suggestion is to make sure that the loading is symmetrical. So, when you put an insole in and then make a medial or lateral adjustment, make sure that what you do makes the whole movement more symmetrical.

***Pearl:*** *So, always have that as your center line. You mentioned offloading for both injuries and for a diabetic ulcer. You mentioned a term called ride, which is the heel to toe progression. Can you explain the importance of ride and how that plays out? What can be done to help someone with problems of loading?*

**Nigg:** Ride is primarily related to comfort. Ride is defined as the forward rolling of the center of pressure in the shoe. When you land on the heel, you slap down and the forward rolling would be fast at the beginning and slower at the end. First you will have a slapping down of the midfoot and then a slapping down of the toes. You then have two peaks of force from that ride. But you don't want that. You want to have a ride that is of an essentially constant velocity rolling forwards. That seems related to high comfort.

***Pearl:*** *Can you talk about how you came to that sort of epiphany about the importance of tuning muscles? What are some of the applications that you've worked on to prevent injury in view of your muscle tuning theories to try to prevent injuries?*

**Nigg:** You don't land the same way on sand as you do on asphalt. The question then is why do we do that differently?

One of the possible explanations we found was that when you land, your soft tissue starts to vibrate; it doesn't feel pleasant, so you try to avoid that. You can avoid that by changing the landing style or by pre-tuning the muscles differently so that they don't vibrate as much. It's like a car that has a damper. When you drive that car over a bump, the vibrations are dampened. We do something similar like that when we run. So, we can adjust the landing or we can adjust the muscle activity. Adjusting of the muscle activity we call pre-tuning. We have some evidence that this takes place. No one has shown evidence that this is not the case.

***Pearl:*** *You wrote an important paper in which you discuss the importance of muscles crossing the ankle joint and their relevance to injury prevention. Which muscles in particular do you think are the most fruitful to work towards that goal.?Then, as a quick follow-up, what are the roles of the intrinsic muscles such as the interossei and the lumbricals?. How important are these intrinsic muscles that don't cross the ankle joint?*

**"We have done some studies to prove that having strong, small muscles is beneficial."**

**Nigg:** Let's go first to the muscles crossing the ankle joint. One of the problems that we often have is that we use the triceps surae to adjust the geometry of the joint. This is an expensive strategy, because that costs a lot of energy, since the triceps surae always work with big forces and large amounts of muscle activity. Our thought process was that if we could replace the function of the triceps surae with other muscles crossing the ankle joint, then that would be an advantage.

The condition in which you could do this would be if the other muscles were strong. So, we did a study with the MBT shoe, known as the Masai barefoot technology shoe, which makes the whole system unstable and basically strengthens those small muscles. The results we saw indicated that those muscles were used more for stabilizing the joints. So, the Achilles tendon was unloaded. The load was shifted to the small muscles earlier. Because the small muscles don't need much force earlier in the process, it was an advantage with respect to the loading of the whole muscle system.

We have done some studies to prove that having strong, small muscles is beneficial. We are just now doing a three-center study together with colleagues in Finland and Canada. In the study, we have about 600 people employing different forms of training for the small muscles. The initial results are very promising. The idea, basically, is that you strengthen the small muscles and by doing that, you change the function of these muscles, making them act more as a stabilizer and reducing the internal forces. You then see that many of the problems in the foot and knee can be solved by this strategy.

***Pearl:*** *How much benefit will we achieve for injury prevention by using some of the common things that we instruct our patients to do, such as resistance bands for the posterior tibialis and peroneal muscle groups? Do you think that these movement patterns are helpful for prevention of injuries?*

**Nigg:** That's a good exercise. The important thing is to do it in all directions. The exercises should be done in three directions: forward, sideways, and upwards. Also perform rotation exercises by adding in adduction-abduction, inversion-eversion, and plantar flexion-dorsiflexion. You have to do all of these consistently in all directions.

The problem when you exercise with a rubber band is that it encourages you to focus on just one direction. However, all directions are important. What I do each morning is to stand on one leg while I brush my teeth. I lift myself a little bit up and down by perhaps no more than about five centimeters. Brushing the teeth adds instability to my posture; by doing that, I strengthen those important stability muscles. But whatever you do, you can do it isometrically or dynamically; it doesn't matter as long as you do it in all directions.

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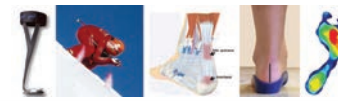

*Dr. Nigg* *(from page 124)*

***Pearl:*** *That's a good sort of benchmark. Has there been an over-emphasis on things like box jumps for power sports and sprinters? Box jumping got very big in the Crossfit community. I do know that you work with the Cirque du Soleil. Tell us about those types of higher impact and potentially more detrimental activities for the purposes of developing explosive strength.*

**Nigg:** I can tell you the Cirque du Soleil had a lot of injuries. One reason for the injuries seemed to be because the surface was not uniform. If the surface is not uniform, you are prone to have injuries. So we began with a surface that was kind of irregularly hard and then soft. We replaced that surface with one that was completely hard and the injuries disappeared.

***Pearl:*** *Was that because of the pre-tuning phenomena that you mentioned?*

**Nigg:** Yes.

***Pearl:*** *You also mentioned that most of the injury occurs in the propulsive phase when the muscle is most vulnerable to injury.*

**Nigg:** Yes. During the propulsive phase the forces are high, but nobody has data for that. So, there's no publication that shows that active injuries are more common than impact injuries. However, that is theoretical thinking that is right.

***Pearl:*** *One of the big things that you debunked is this idea that we knew what was happening in the subtalar joint. Simon Bartold told me that once you exposed what was happening inside the shoe where you windowed out the back of the shoe, you could then see the movement rather than just measuring the external axis of the shoe. There are controversies that persist regarding the subtalar joint and the mid-tarsal joint axes. Can you comment briefly on what your thoughts are?*

**Nigg:** These joints are very important, but no one in the world has been able to determine the axes. We don't know how to. Sometimes, we can determine the position of the subtalar joint axis in very isolated situations. But you cannot use that data for walking or running.

So what we do is use "clinical axes''. We may use an A-P axis which is not a functional axis since there is no joint corresponding to that. The movement. Though. really happens in the real joint axis which is the ankle joint axis and the subtalar joint axis. We are not able to quantify that. This is apparent movement along an axis and not the actual movement along the axes.

***Pearl:*** *Can tuning vibration and kinesthetic feel when people use compression sleeves affect the tuning vibrations in the muscle or is it more of just a kinesthetic effect?*

**Nigg:** Theoretically, I would predict that they have an effect on the vibrations; practically, we haven't seen that. We have done some experiments with some sprinters with some compression pants in addition to the compression socks. We have measured the vibrations during sprinting and we didn't observe any difference. So theoretically, I would expect there should be a difference; but practically, I was not able to experimentally demonstrate a difference.

***Pearl:*** *Are carbon plates helpful?*

**Nigg:** We are working on whether or not they are helpful. In the meantime, shoes can mimic the impact of the carbon plate.

**"Strength training to me is the most important thing for aging people."**

**"There's no publication that shows that active injuries are more common than impact injuries."**

***Pearl:*** *What would you recommend for students wanting to learn more about biomechanics?*

**Nigg:** I'd recommend that they learn to think functionally. For example, with some thought you can see that the small intrinsic muscles may offer a more efficient effect than the triceps surae on stabilization. Remember functional thinking!

***Pearl:*** *What exercise do you like to do personally?*

**Nigg:** Strength training to me is the most important thing for aging people. I like to do strength training in 6 directions: 3 translational and 3 rotational. Unfortunately the pandemic has interfered significantly with this kind of exercise. **PM**

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