

# ATHLETIC FOOTWEAR AND RUNNING INJURIES

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## **Essay on the harmful effects of modern running shoes.**

( Written a number of years ago, this piece was published in part in the German ultra magazine *Spiridon*.)

### **PART 1 - INTRODUCTION AND HISTORY**

Look, if anyone displayed brand-loyalty, it was me. I LOVED my NIKE AIR MAX Triax™ runners. I wouldn't buy anything else. Why? Because they felt good. I liked the cushioning. I liked the ride. I also felt they protected me from the hard road by interposing a layer of air between the sole of my foot and the pavement. So why was I sidelined with a heel injury for over two months? I listened to the manufacturer and changed my runners every 400 miles. Come to think of it, why do I see so many runners with lower extremity injuries in my office? The traditional answer to these questions has always been overuse often compounded by an underlying mechanical abnormality such as over-pronation or flat-feet.

The treatment, along with modification of training, physiotherapy, stretching etc. has always included a close look at the runner's footwear, often with recommendations about motion control, stability, cushioning, orthotics or custom molded insoles. A growing body of literature in the field of sports medicine, however, is causing a bit of a stir...no, call it PANIC in the running world. Everything you and I always believed about running shoes and running injuries may be wrong! Here's the scoop: The modern running shoe itself may be the major cause of running injuries! Stated another way, the modern running shoe, presently thought of a protective device, should be reclassified as a "health hazard". (NIKE, please tell me it ain't so!!!)

Now relax, get back on your chair and take a deep breath. We'll take this one step at a time and since we're going to be talking about shoes and feet, I may as well start at the beginning...the very beginning. Until quite recently in our history, most humans lived out their lives unshod. S.F.Stewart in his "Footgear - It's History, Uses and Abuses" states that "...all writers who have reported their observations of barefoot peoples agree that the untrammelled feet of natural men are free from the disabilities commonly noted among shod people - hallux valgus, bunions, hammer toe and painful feet." So why was footgear developed? One of the earliest examples of footgear known to us takes the form of sagebrush bark sandals found in caves and rock shelters near Fort Rock, Oregon under a layer of volcanic ash dating back 10,000 years. The foot surface is smooth and they were held on by bast straps over the instep. Similar sandals were used throughout the volcanic cordilleras of Meso and South America and the volcanic islands of the South Pacific. The early Polynesians used sandals to cross old lava flows and when fishing on the razor-sharp coral. It seems, therefore, that the prime function of the earliest sandals was protection of the sole.

Although the early Pharaohs are all represented as barefoot, by the first millennium BC sandals in Egypt were common in court and were worn by soldiers. In Mesopotamian kingdoms sandals were evidently a status symbol with the king known to have worn a wedged sandal in contrast to his flat-soled courtiers. Very thick-soled low boots are known to have been worn by Greek tragedians to increase their height. Comedians wore socks or *soccus* - hence the expression "high tragedy and low comedy". Thus, the secondary function of footwear appears to have been symbolic.

From the time of the Greeks, footwear gradually evolved to meet both symbolic and functional needs. For example, tradition tells us that about the beginning of the present millennium Count Fulk of Anjou introduced long pointed toes to cover up some deformity of his feet, and courtiers quickly adopted the fashion. The Mongols, who on horseback ravaged the Middle East between Damascus and Moscow from the 12th-14th centuries, are credited for the introduction of the block heel presumably developed to better grip the stirrup plate. But in the French court of Louis XIV, the rugged Mongolian heel underwent a radical cosmetic transformation eventually leading to the ultimate idiotic expression of modern fashion - the stiletto heel.

European peasants wore clogs carved from a block of wood. Mass production seems to have begun prior to the 14th century, for Edward II in 1342 decreed that shoes should be sized. Their length was measured in barleycorns, 3 to an inch. This is still the basis of shoe measurements, 1/3 inch to a size in length. We start sizing from a baseline of 3" in children and 7" in adults. Widths vary with length; in a given size the widths vary by 1 1/2 inch. Unpaired shoes were introduced in England in the 15th century when gout became common and these shoes had broad square toes to relieve pressure. The most recent innovation seems to have been the hard box toe to preserve the appearance of the shoe.

Now, let's focus-in on the running shoe. It seems that the earliest sports shoes were developed in the 1830's by the Liverpool rubber company owned by John Boyd Dunlop. Although they were first called sand shoes because they were worn on the beach by the Victorian middle classes, they eventually became known as plimsolls because the lines formed by the rubber and canvas bond looked similar to the Plimsoll line on a ship's hull. In 1933, Dunlop launched its Green Flash range of trainers. Adi Dassler (and his brother Rudolf) started making sports shoes in Herzogenaurach, Germany in 1920 and in 1936 Jesse Owens wore a pair of them when he won four Olympic gold medals in Berlin. ADIDAS (Adi Dassler) was formed in 1948 with the now famous three stripes logo developing from three support leather bands used to bolster the sides. By the 1956 Olympics, dozens of competitors were wearing ADIDAS shoes. Rudolf Dassler broke away to form PUMA. Amidst the first rumblings of the jogging-boom, NIKE (after the Greek goddess of victory) was launched by American Phil Knight, a former track star at the University of Oregon, and his waffle-making coach Bill Bowerman in 1971 (Surely you remember the NIKE Waffle Trainer!). The NIKE 'Swoosh' is arguably the most successful logo in the world and was conceived for Phil Knight by a local Oregon graphic design student, Carolyn Davidson, for a total fee of \$35. (But don't worry about the graphic designer. In September 1983, NIKE presented Carolyn Davidson with a rather substantial share package as a way of saying "Thank-you.") ASICS (acronym for *Animus Sanus In Corpore Sano*, Latin for A Sound Mind In A Sound Body) first introduced its shoes in North America in 1977 while REEBOK (named after a species of an African gazelle) entered the US Market in 1979 as the

running shoe was slowly transforming into a fashion item. 1987 was declared the Year of the Running Shoe by the clothing industry, the same year NIKE launched the 'cross-trainer' and it's flagship running-shoe, the Air Max. After 16 years of research, NIKE introduced its SHOX line of runners in 2000, arguably the first athletic shoe on springs (foam)!

## **PART 2 - SHOES AND INJURIES**

For the last fifteen years or so, buying a pair of runners has always been accompanied by a warm fuzzy feeling inside, a feeling that comes from the certain knowledge that you're investing in a high-tech device purpose-designed to protect you from injury and improve your performance. You can just see all those smart dedicated NIKE mechanical engineers hard at work developing and testing newer and better space-age materials to shield you from the terrible pounding you submit yourself to in order to "Just do it!" Gel, air, channels, honeycomb, microspheres, super-light materials, foam springs and soon...yes, you guessed it, micro-chips in the soles of your shoes (better than diamonds, I suppose). New round laces and ribbon eyelets result in that custom-fitted feel supplemented by molded sorbothane insoles or special orthotics from your local prosthetist and you're ready to tackle any distance.

Now here's the catch. If all this high-tech stuff is supposed to be preventing running injuries by shielding us from impact, why is it that two out of every three runners are sidelined every year because of a running injury? Why is it that since the great jogging boom of the mid-seventies, there has been no decrease in the incidence (some authors say there has been an increase) of running injuries in spite of yearly 'improvements' in running-shoe technology? Why is my office filled with runners who have injured knees (26% of running injuries), tibias (13%), Achilles tendons (6%) and plantar fascias (5%)? The cause of all these injuries is quite evident: cumulative micro-trauma caused by repetitive impact experienced during running. The heel of a runner upon striking the ground generates a force that can equal 2.5 times body weight at the foot and as much as 7 times body weight at the hip. Repeat this 1000 times per mile and it's easy to appreciate the stress the old bones are under. Add to this the hardness of urban roadways compared to naturally deposited surfaces and eventually, something gives, inflammation sets in and pain results...and you end up working at the finish-line pulling bar-codes off finishers. Now, where's our high-tech shoe in all this? With all the improvements in recent years, you'd think we'd be seeing a marked decrease in running injuries. Just keep reading.

It wasn't till the mid-eighties that some researchers smelled something rotten in the athletic footwear world and it wasn't just dirty socks. Footwear manufacturers were well aware that impact was the cause of running injuries and reasoned that the way to attenuate impact was to interpose a soft impact-absorbing midsole between the foot and the ground. The first major problem was the method used by essentially all the footwear development labs to test the impact absorption of footwear mid-soles. Dr. Benno Nigg from the University of Calgary showed that machine testing of these materials by dropping a 5-kg object onto the shoe-sole and measuring the impact on a pressure-plate did not accurately predict human impact with the same materials. In fact the correlation turned out to be inverse, that is when you drop a 5-kg ball on materials of increasing softness, you measure decreasing impact. However, when the impact from a running human is measured, the result is the reverse, and the impact increases with softer materials!

WHOOOPS! (You'll find out why later.)

Next problem. In 1989, Dr. B. Marti published a paper which still makes the throats of footwear executives go dry. He studied 5,038 runners who participated in a 16km race and had them fill out an extensive questionnaire about their running in the year preceding the race. Here's what he found: The incidence of injuries in runners using shoes costing more than \$95 was more than twice as great as in runners using shoes costing less than \$40. (Note that this result includes correction for other influencing factors such as training mileage and history of previous injury.) In other words, the fancier (high-tech, advanced) the shoe, the more dangerous it is! Now a study of over 5,000 runners is not something to thumb your nose at and you would think the shoe manufacturers would have taken some notice. Not on your life. Yearly athletic shoe sales were in the billions of dollars and this was no time to fiddle with a successful product. In any case, it is felt by many observers that by the mid-eighties researchers, in-house or independent, had effectively been forced out of the loop of new product development and that research and development was now exclusively in the hands of the marketing people. Athletic shoes had become a fashion item and were designed as such, as they are to this day.

The big question: Why are super shock-absorbing athletic shoes causing more running injuries? Dr. Steven Robbins from the Centre for Studies in Aging at McGill University in Montreal is the man who came up with the answer. Dr. Robbins pointed out that the human lower extremity is not a delicate, rigid, passive structure requiring 'packaging' to protect it from impact. This becomes blatantly obvious when one observes the nearly complete absence of foot disorders in unshod populations. People who go around barefoot just don't get plantar fasciitis or any of the other lower extremity injuries so common in shod populations. The lower extremity, he points out, is a rugged, flexible, active, well designed (teleologically) structure. Wire this structure to a spinal cord and a brain and what you've got is a system fully capable of handling the impacts of running. So, how does this system work exactly and why do modern running shoes screw it up?

Allow me for a moment to compare the human locomotor apparatus to a modern luxury car. The bones of the foot, leg, thigh and pelvis act as the frame, linked by joints and all held together by fairly inelastic ligaments and fascia. The bones and joints are surrounded by contracting muscles which act as the suspension system. This is especially evident in the arch of the foot which is formed by both the passive, rigid plantar fascia as well as the active, flexible intrinsic muscles. The bones and muscles are covered by fat and skin within which reside receptors or sensors that send information to both the peripheral computer (the spinal cord) and the central computer (the brain). The skin on the sole of the foot (glabrous skin) is very well suited to its function possessing about 600% of the toughness of hairy skin (the skin everywhere else on our bodies except our palms). The receptors in the foot are specially designed to sense both impact (vertical force) and shear (horizontal force). Add to this information streaming in from pain receptors as well as joint position receptors throughout the lower extremity and you've got a Hummer! (Got carried away a little...sorry.)

During barefoot running, the ball of the foot strikes the ground first and immediately starts sending signals to the spinal cord and brain about the magnitude of impact and shear, getting most of its clues about this from the skin contact with the surface irregularities of the ground.

Take away this contact by adding a cushioned substance and you immediately fool the system into underestimating the impact. Add a raised heel and the shod runner is forced to land on it. Strap the cushioning on tightly with the aid of a sophisticated lacing system and you block out shear as well, throwing the shock-absorption system even further into the dark. The system responds by landing harder in an attempt to compress the cushion and 'feel' the ground. The weight is then transferred to the outside edge of the foot, completely by-passing the skin of the arch. The heel then touches down and the weight is transferred to the ball again with final push-off through the toes. While the weight is being transferred, the arch carries out its function as the suspension system of the foot and flattens under the active control of the intrinsic muscles. The ankle, knee and hip joints flex to absorb impact in response to information flowing in from the foot. The cushioned midsole of the modern running shoe robs the system of important sensory information necessary for ankle, knee and hip response to impact. The arch support (or orthotic) in modern running shoes not only prevents the arch suspension system from absorbing energy by preventing flattening but eventually leads to intrinsic muscle atrophy and complete loss of active muscular control of the arch leaving only the inelastic plantar fascia as a checkrein to flattening. The barefoot runner's 'foot position awareness sense' which relies heavily on sensory input from the sole of the foot minimizes his risk of sustaining an ankle sprain on uneven ground. The shod runner is at marked increased risk of ankle sprains because his 'foot position awareness sense' is handicapped by the paucity of sensations coming from his soles. The barefoot runner is constantly alert scanning the ground before him for irregularities and dangers that might cause him injury. The barefoot runner is a cautious runner and actively changes his landing strategy to prevent injury. He treads lightly. The shod runner is bombarded by convincing advertising stating or implying that the shoe he is wearing will protect him well over any terrain and he becomes a careless runner. He is heavy footed. Finally, certain diseases in humans can cause a gradual destruction of the sensory nerve endings in the foot (and elsewhere) resulting in a significant increase in lower extremity injuries. Diabetes and tertiary syphilis are two. Extremities so affected are termed 'neuropathic'. The shod runner, because of his sensory deprivation and high risk of injury may be termed as having 'pseudo-neuropathic' feet, a term coined by Robbins.

The conclusion that shoes are the primary cause of running injuries is strongly supported by the scientific literature. I've already mentioned Marti's work showing more than twice the incidence of running injuries with expensive shoes compared with cheap ones. Rao and Joseph (1992) examined 2300 Indian children between the ages of 4 and 13 and found that the incidence of flat feet was more than three times greater in those children who used footwear than in those who did not leading them to conclude that shoe-wearing in early childhood is detrimental to the development of a normal arch. In 1988, Hamill and Bates showed that as running shoes lose their cushioning through wear and tear, subjects improve foot control on testing and presumably decrease their risk of injury, i.e. shoes get better with age. Robbins and Gouw showed in 1991 that modern athletic footwear creates a perceptual illusion in subjects whereby they consistently underestimate impact. Simply adding surface irregularities on the insoles (to simulate barefoot like conditions) markedly improves subjects' estimates of impact. Robbins and others (1994) studied the balance ability of men walking along a beam wearing shoes with soles of varying thickness and hardness. Results confirmed that the thinner and harder the soles, the better the balance. In one of their most elegant and widely publicized studies, Robbins and Waked (1997) examined the effect of advertising on landing impact. They asked subjects to step down

barefoot ten times onto four pressure measuring platforms, the first one being bare and the other three covered by identical shoe sole material made to look different by different colored cloth. The subjects were given different messages for each of the covered plates: the message for the first covered plate suggested superior impact absorption and protection (deceptive message), the second suggested poor impact absorption and high injury risk (warning message) and the third suggested unknown impact absorption and safety (neutral message). Results showed that subjects landed with the highest impact when given the deceptive and neutral messages and with the lowest impact when given the warning message or with the bare plate. The authors conclude that running injury rates are greatest in users of the most expensive shoes because advertising has deceived these users into believing that the shoes provide a superior level of safety thereby inducing an attenuation of impact moderating behavior, increasing impact and injury. The authors add that deceptive advertising of protective devices is a public health hazard and should be addressed. Humans are less cautious even when they use truthfully advertised products because of excessively positive attitudes toward new products and wrong impressions of the standards of truth in advertising.

"So," you think, "is this guy telling me that NIKE, REEBOCK and all those big corporations just put this new stuff out on the market without any proof that its safe? Can't be!" Well, that's exactly what I'm telling you. I can be a real pain in the ass when I try, and some years back, I was in the mood. I got on the phone and tried to talk to the directors of research at all the big athletic footwear companies. I tell you, getting to talk to one of these guys is harder than talking to the Pope. I finally got to speak with Mr. Gordon Valiant, then director of research at the NIKE Sports Research Lab in Beaverton, Oregon. JF:" Mr. Valiant. My name is Dr. Froncioni and I'm an orthopedic surgeon. I treat a lot of runners and I was just wondering what your thoughts were on the whole issue of running injuries possibly being caused by your running shoes." ...long pause...GV:"Umm...well...I'm afraid I'm not at liberty to discuss that matter." SAY WHAT!!!!?? JF:"Mr. Valiant, in case you missed it, I'm NOT a reporter. I'm just an orthopedic surgeon who's looking for some answers for his patients. Let me rephrase. Surely you have data to support the injury protection claims you make about your running shoes....surely sir.." GV: "Well...I could refer you to our marketing people and I'm sure they could send you something." Nope. We're not on the same wavelength at all. I'm sure the lawyers have given these guys a gag order. JF: "Mr.Valiant, your marketing people send me stuff all the time; it's all over the Runner's World I get every month. Anyway, nice talking to you."

I've also had a few chats with Dr. Steven Robbins. He feels very strongly that the athletic footwear manufacturers are painting themselves into a very tight corner by not acting on the available information. After all, it is within their power to effect changes in their shoe design based on the available data and in doing so decreasing the running injury rate by up to 55%. By not acting now, Dr. Robbins predicts the footwear manufacturers may end up in the same situation as the tobacco companies with massive class-action lawsuits brought against them.

### **PART 3 - NEW DIRECTIONS**

So, what do we do now? For starters, NO, I do not recommend that you run your next half-marathon barefoot. But certainly, I predict that sooner or later, changes will come about in both

shoe design and training. From the medical establishment's point of view, the prevention and treatment of running injuries must change to incorporate the concepts outlined above. In fact I view the ideas I've presented here as a major paradigm shift in sports medicine, the likes of which I have not seen in the last fifteen years. Of course, the major shoe companies have to own up and start introducing better shoes into their lines. Why not do this gradually and introduce just one shoe that incorporates some of the recommended changes. Dr. Robbins is already testing shoes that use a thinner, less resilient midsole material that provides the comfort but not the impact absorption and of course has no arch support. I'm sure the marketing boys at NIKE could handle it.

Without being too radical, there are some changes that are worth introducing without further delay and they are as follows:

1-Young children should be encouraged to spend as much time as possible barefoot. We know that this is especially important for the proper formation of the foot arch in the first six years of life. So, moms, trash the WEEBOCKS and let your kids develop strong healthy feet just as they were meant to.

2-Runners should consider incorporating sessions of barefoot running into their training. In an article in the October 1997 Runner's World, Adam Bean gives the following advice: "Running barefoot a couple of times per week can decrease your risk of injury and boost your 'push-off' power." You can run on any surface you like as long as you're careful of sharp objects and pebbles. Soft sand is probably the least desirable surface because it is unstable and after your heel has dug-in, you will weight bear on your arch. Paved roads are fine and dangerous objects are easy to spot. But remember, your feet will need to toughen-up so start with small doses. Kick your shoes off as soon as you get home and spend your evenings and weekends barefoot.

Is it possible to rehabilitate the weakened muscles of a normally shod runner? It certainly is according to another excellent study by Dr. Robbins (1987). He asked 17 normally shod recreational runners to gradually increase barefoot activity both at home and outdoors over a period of several weeks and to maintain barefoot activity for about four months. The runners' feet were examined, measured and x-rayed at regular intervals to detect changes. Results showed marked improvement in the anatomy and function of the arch. The authors concluded that the normally shod foot is capable of rehabilitation of foot musculature. Very good news indeed for all of us.

3-Runners may want to consider switching to a lightweight shoe that provides less cushioning and no arch support. The only shoes on the market that come close to these characteristics are racing flats. I use the 6.5 oz. ASICS Gel-Magic Racer. For you diehard NIKE fans, consider the Air Streak II, Air Streak Spectrum Plus or the Air Streak Vapor IV but most shoe manufactures make a flat. A shoe that Nike has just introduced this year, the NIKE FREE also looks like a step in the right direction (I have not actually seen this shoe myself yet). Moreover, a look at the NIKE FREE web page give me a bit of hope that this company may finally have seen the light. If you do change to flats, I recommend you wean into them slowly. Remember that you live in a developed country and that your feet have been shielded from

natural stresses your entire life, i.e. you've got wimpy feet, buddy. The intrinsic muscles of your feet are asleep and need to wake up slowly. The first thing that will strike you in a racing flat is the lightness of the shoe (Most runners today run in shoes that weigh as much as 14 oz.) Then, you will quickly realize that for the first time, you start to feel the ground you are walking on. Oh...and one more thing: don't listen to the guy at the running store. He's there to sell shoes and is under the spell of the powerful shoe industry advertising machine. He has become well and truly brainwashed with the traditional concepts that we all need cushioning and arch support. He will try to dissuade you from buying a racing flat and he may even go as far as telling you that they are for elite runners and are meant to be used for one marathon only. Don't believe him. I keep my flats for at least 400 – 500 miles with no problem.

Finally, some radicals among you may wish to become full-time barefoot runners. Barefoot running clubs are springing-up all over America and Europe. Point your search engine to 'barefoot running' or go to [www.runningbarefoot.org](http://www.runningbarefoot.org) to get more information. I also welcome anyone who wishes more information on any of the quoted materials to contact me and it would be my pleasure to provide you with copies ([froncioni@ibl.bm](mailto:froncioni@ibl.bm)).

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## READING LIST

1. BEAN, A. "Expert Advice". *Runner's World*, Oct 1997; 100-101.
2. BENSON, R. "Trainerspotting". *Electronic Telegraph*, 6th December 1997.
3. BRUNET, M.E., COOK, S.D., BRINKER, M.R., DICKINSON, J.A. "A survey of running injuries in 1505 competitive and recreational runners". *Journal of Sports Medicine and Physical Fitness*, Sept.1990; Vol 30, No 3, 307-315.
4. CLEMENT, D.B., TAUNTON, J.E., SMART, G.W., McNICOL, K.L. "A Survey of Overuse Running Injuries". *The Physician and Sportsmedicine*, May 81; Vol 9, No 5, 47-58.
5. CUDICIO, R., "L'étude Qui Fait Peur Aux Géants". *Sport et Vie*, Jan Feb 1998, No 46.
6. D'ASSCHE, G. "History of the trainer". *Electronic Telegraph*, 6th December, 1997.
7. GREGORIADIS, X. "Will this one run and run?" *The Independent* on Sunday 1st February 1998.
8. GWYTHER, M. "Smelly old trainers, £300". *Electronic Telegraph*, 15th February, 1997.
9. HAMILL, J., BATES, B.T. "A Kinetic Evaluation of the Effects of In Vivo Loading on Running Shoes". *Journal of Orthopaedic and Sports Physical Therapy*, 1988, Vol 10, No 2, 47-53.

10. LEBOW, F., AVERBUEN, G., AND FRIENDS. "The New York Road Runners Club Complete Book of Running (Updated Edition)". New York Road Runners Club, 1994.
11. MARTI, B. "Relationships Between Running Injuries and Running Shoes – Results of a Study of 5,000 Participants of a 16-km Run – The May 1984 Berne 'Grand Prix'". In: Segesser B., Pforringer W., eds. The shoe in sport. Chicago: Year Book Medical Publishers, 1989: 256-265.
12. McNITT-GRAY, J.L., TAKASHI, Y., MILLWARD, C. "Landing Strategy Adjustments Made by Female Gymnasts in Response to Drop Height and Mat Composition". Journal of Applied Biomechanics, 1993, 9, 173-190 by Human Kinetics Publishers.
13. RAO, U.B., JOSEPH, B. "The Influence of Footwear on the Prevalence of Flat Foot, a Survey of 2300 Children". The Journal of Bone and Joint Surgery, July 1992, Vol 74-B; No. 4, 525-527.
14. ROBBINS, S.E., GOUW, G.J. "Athletic Footwear and Chronic Overloading A Brief Review". Sports Medicine 1990, 9 (2): 76-85.
15. ROBBINS, S.E., GOUW, G.J. "Athletic footwear: unsafe due to perceptual illusions". Medicine and Science in Sports and Exercise, 1991, Vol 23, No2, 217-224.
16. ROBBINS, S.E., GOUW, G.J., HANNA, A.M. "Running-related injury prevention through innate impact-moderating behaviour". Medicine and Science in Sports and Exercise. 1989, Vol 21, No2, 130-139.
17. ROBBINS, S., GOUW, G.J., McCLARAN, J., WAKED, E. "Protective Sensation of the Plantar Aspect of the Foot". Foot & Ankle, July/August 1993, Vol 14, No 6, 347-352.
18. ROBBINS, S., HANNA, A.M. "Running- related injury prevention through barefoot adaptations". Medicine and Science in Sports and Exercise. 1987, Vol 19, No 2, 148-156. American College of Sports Medicine©.
19. ROBBINS, S.E., HANNA, A.M., GOUW, G.J. "Overload protection: avoidance response to heavy plantar surface loading". Medicine and Science in Sports and Exercise. 1988, Vol 20, No 1, 85-92. American College of Sports Medicine©.
20. ROBBINS, HANNA, A., JONES, L.A. "Sensory Attenuation Induced by Modern Athletic Footwear". Journal of Testing and Evaluation. 1988, Vol 16, 412-416. American Society for Test and Materials©.
21. ROBBINS, S., WAKED, E. "Balance and Vertical Impact in Sports: Role of Shoe Sole Materials". Arch Phys Med Rehabil May 1997, Vol 78, 463-467.
22. ROBBINS, S., WAKED, E. "Factors Associated with Ankle Injuries Preventative Measures"

Sports Med. 1998 Jan; 25 (1): 63-72.

23. ROBBINS, S., WAKED, E. "Foot Position Awareness: The Effect of Footwear on Instability, Excessive Impact, and Ankle Spraining". *Critical Reviews in Physical and Rehabilitation Medicine*, 1997, 9 (1):53-74.

24. ROBBINS, S., WAKED, E. "Hazard of deceptive advertising of athletic footwear". *Br. J. Sports Med* 1997; 31:299-303.

25. ROBBINS, S., WAKED, E., GOUW, G.J. McCLARAN, J. "Athletic footwear affects balance in men". *British Journal of Sports Medicine* 1994; 28(2) 117-123.

26. STEWART, S.F. "Footgear – Its History, Uses and Abuses". *Clinical Orthopaedics and Related Research*. Oct 1972, No 88, 119-130.

27. WARBURTON, M. "Barefoot Running", *Sportscience* 5(3), [sportsci.org/jour/0103/mw.htm](http://sportsci.org/jour/0103/mw.htm), 2002