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Barefoot Running

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Running barefoot is associated with a substantially lower prevalence of acute injuries of the ankle and chronic injuries of the lower leg in developing countries, but well-designed studies of the effects of barefoot and shod running on injury are lacking. Laboratory studies show that the energy cost of running is reduced by about 4% when the feet are not shod. In spite of these apparent benefits, barefoot running is rare in competition, and there are no published controlled trials of the effects of running barefoot on simulated or real competitive performance. Reprint pdf · Reprint doc

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Reviewer's Comment

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Introduction

Well-known international athletes have successfully competed barefoot, most notably Zola Budd-Pieterse from South Africa and the late Abebe Bikila from Ethiopia. Running in bare feet in long distance events is evidently not a barrier to performance at the highest levels. Indeed, in this review I will show that wearing running shoes probably reduces performance and increases the risk of injury.

I became interested in research on barefoot running when I noticed that a reasonably high proportion of runners compete in bare feet during cross-country races in Queensland, Australia. I have based the review on articles I found containing the words *barefoot* and *running* in Medline, SportDiscus, and in Web publications. I found several original research reports on the occurrence and mechanisms of acute and chronic injuries in unshod and shod populations, and a few reports on the energy cost of running with and without shoes (including an unpublished thesis). Two authors provided recommendations for adapting to barefoot running. I also found informal websites devoted to barefoot running and barefoot living. There are apparently no published controlled trials of the effects of running in bare feet on simulated or real competitive performance, nor any surveys on the reasons why people do not compete barefoot.

Injuries

Where barefoot and shod populations co-exist, as in Haiti, injury rates of the lower extremity are substantially higher in the shod population (Robbins and Hanna, 1987). Furthermore, running-related chronic injuries to bone and connective tissue in the legs are rare in developing countries, where most people are habitually barefooted (Robbins and Hanna, 1987). This association between injury and wearing shoes is consistent with the possibility that wearing shoes increases the risk of injury, but other explanations for the association are possible; for example, in developing countries barefoot runners may be too poor to seek medical attention, shod runners may wear shoes because they have problems running barefoot, and shod runners may wear bad shoes, wear shoes incorrectly, and cover more miles. Prospective studies and randomized controlled trials of barefoot and shod running would resolve this uncertainty.

Studies of rates of injury in barefoot and shod runners in developed countries are non-existent, presumably because barefoot runners are a rarity. However, there have been several studies implicating footwear in the etiology of injuries in runners. I have grouped these as studies of acute injuries (resulting from an accident during running) and chronic injuries (resulting from continual exposure to running).

Acute Injuries

Ankle sprains are the most frequently reported acute sports injury, and 90-95% of these are inversion injuries causing partial or complete rupture of the anterior talofibular ligament and occasionally of the calcaneofibular ligament (Robbins et al., 1995; Stacoff et al., 1996). It is claimed that footwear increases the risk of such sprains, either by decreasing awareness of foot position provided by feedback from plantar cutaneous mechanoreceptors in direct contact with the ground (Robbins et al., 1995), or by increasing the leverage arm and consequently the twisting torque around the sub-talar joint during a stumble (Stacoff et al., 1996). Siff and Verkhoshansky (1999, p.452) reported that running shoes always reduce proprioceptive and tactile sensitivity, and that using bare feet on the high-density chip-foam mats in gyms preserves proprioceptive sensitivity. Robbins et al. (1989) considered that behaviors induced by plantar tactile sensations offer improved balance during movement, which may explain the preference of many gymnasts and dancers for performing barefoot.

The skin on the plantar surface (sole) of the foot is more resistant to the inflammatory effects of abrasion than skin on other parts of the body (Robbins et al., 1993), but stones, glass, nails or needles can still cause bruising or puncture wounds even when the plantar skin is thickened by adaptation to barefoot running. Extremes in temperature can also cause discomfort, blistering or chill blains. Running shoes therefore will play an important role in protection on some courses and in some weather conditions.

Chronic Injuries

One of the most common chronic injuries in runners is planter fasciitis, or an inflammation of the ligament running along the sole of the foot. There is some evidence that the normally unyielding plantar fascia acts as the support for the medial longitudinal arch, and that strain on the proximal fascial attachment during foot strike leads to plantar fasciitis (Robbins and Hanna, 1987). Barefoot running may induce an adaptation that transfers the impact to the yielding musculature, thus sparing the fascia and accounting for the low incidence of plantar fasciitis in barefoot populations (Robbins and Hanna, 1987).

Chronic ailments such as shin splints, ilio-tibial band syndrome and peri-patellar pain are attributed variously to excessive pronation, supination, and shock loading of the limbs (Siff and Verkhoshansky, 1999, p.451). When running barefoot on hard surfaces, the runner compensates for the lack of cushioning underfoot by plantar-flexing the foot at contact, thus giving a softer landing (Frederick, 1986). Barefoot runners also land mid-foot, increasing the work of the foot's soft tissue support structures, thereby increasing their strength and possibly reducing the risk of injury (Yessis 2000, p.124).

Wearers of expensive running shoes that were promoted as correcting pronation or providing more cushioning experienced a greater prevalence of these running-related injuries than wearers of less expensive shoes (Robbins and Gouw, 1991). In another study, expensive athletic shoes accounted for more than twice as many injuries as cheaper shoes, a fact that prompted Robbins and Waked (1997) to suggest that deceptive advertising of athletic footwear (e.g., "cushioning impact") may represent a public health hazard. Anthony (1987) reported that running shoes should be considered protective devices (from dangerous or painful objects) rather than corrective devices, as their capacity for shock absorption and control of over-pronation is limited. The modern running shoe and footwear generally reduce sensory feedback, apparently without diminishing injury-inducing impact–a process Robbins and Gouw (1991)—described as the "perceptual illusion" of athletic footwear. A resulting false sense of security may contribute to the risk of injury (Robbins and Gouw, 1991). Yessis (2000, p.122) reasoned that once the natural foot structures are weakened by long-term footwear use, people have to rely on the external support of the footwear, but the support does not match that provided by a well functioning foot.

Measurements of the vertical component of ground-reaction force during running provide no support for the notion that running shoes reduce shock. Robbins and Gouw (1990) reported that running shoes did not reduce shock during running at 14 km/h on a treadmill. Bergmann et al. (1995) found that the forces acting on the hip joint were lower for barefoot jogging than for jogging in various kinds of shoe. Clarke et al. (1983) observed no substantial change in impact force when they increased the amount of heel cushioning by 50% in the shoes of well-trained runners. Robbins and Gouw (1990) argued that plantar sensation induces a plantar surface protective response whereby runners alter their behavior to reduce shock. The less-cushioned shoe permitted increases in plantar discomfort to be sensed and moderated, a phenomenon that they termed "shock setting". Footwear with greater cushioning apparently provokes a sharp reduction in shock-moderating behaviour, thus increasing impact force (Robbins and Hanna, 1987; Robbins et al., 1989; Robbins and Gouw, 1990). However, in these studies the subjects ran on treadmills or force platforms. Further studies are needed to establish how shoes affect impact force and shock-moderating behavior on natural surfaces such as road or grass.

Other features of footwear, such as arch supports and orthotics, may interfere with shock-moderating behavior and probably hinder the shock-absorbing downward deflection of the medial arch on landing (Robbins and Hanna, 1987). These features reportedly reduce pronation and supination or offer the wearer lateral and arch support. They may help some people with foot pathologies, but their benefit is uncertain for runners with healthy feet (Yessis, 2000, p.121).

Runners with diminished or absent sensation in the soles of the feet are particularly vulnerable to damage or infection when barefoot. Peripheral neuropathy is a common complication of diabetes mellitus and may result in the loss of protective sensations in the feet. Barefoot locomotion is therefore not recommended in this population (Hafner

and Burg, 1999). Indeed, proper footwear is essential and should be emphasized for individuals with peripheral neuropathy (ACSM/ADA, 1999; ACSM, 2000).

Economy

Wearing shoes increases the energy cost of running. Burkett et al. (1985) found that oxygen consumption during running increased as the amount of mass they added to the foot increased; shoes and orthotics representing 1% of body mass increased oxygen consumption by 3.1%. Flaherty (1994) found that oxygen consumption during running at 12 km/h was 4.7% higher in shoes of mass ~700 g per pair than in bare feet. An increase in oxygen consumption of ~4% is of little importance to the recreational runner, but the competitive athlete would notice a major effect on running speed.

The increase in oxygen consumption with running shoes could have several causes. An obvious possibility is the energy cost of continually accelerating and decelerating the mass of the shoe with each stride. Another possibility is the external work done in compressing and flexing the sole and in rotating the sole against the ground--up to 13% of the work done in walking, according to Webb et al. (1988). Frederick (1986) reported that oxygen consumption increased substantially with thicker shoe inserts during treadmill running. Not surprisingly, materials used for cushioning in shoes absorb energy, and stiff midsoles should produce a 2% saving of energy compared with standard midsoles (Stefanyshyn and Nigg, 2000). Finally, shoes probably compromise the ability of the lower limb to act like a spring. With bare feet, the limb returns ~70% of the energy stored in it, but with running shoes the return is considerably less (Yessis, 2000, p.123).

Adapting to Barefoot Running

Thirty minutes of daily barefoot locomotion is a recommended starting point to allow thickening of the sole of the foot and adaptation of muscles and ligaments (Robbins et al., 1993). Begin by walking barefoot at every reasonable opportunity then progress to jogging, gradually increasing the intensity and duration (Yessis 2000, p.124). After 3-4 weeks, the plantar skin eventually becomes robust and allows longer periods of barefoot running at higher average velocities (Robbins et al., 1993). To facilitate adaptation, perform progressive strengthening exercises for the foot and ankle, including foot inversion, toe flexion, and walking on the balls of the feet. Barefoot locomotion on uneven surfaces will also help stimulate the plantar surface and provide increased sensory feedback (Yessis 2000, p.125).

Conclusions

- Running in shoes appears to increase the risk of ankle sprains, either by decreasing awareness of foot position or by increasing the twisting torque on the ankle during a stumble.
- Running in shoes appears to increase the risk of plantar fasciitis and other chronic injuries of the lower limb by modifying the transfer of shock to muscles and supporting structures.
- Running in bare feet reduces oxygen consumption by a few percent. Competitive running performance should therefore improve by a similar amount, but there has been no published research comparing the effect of barefoot and shod running on simulated or real competitive running performance.
- Research is needed to establish why runners choose not to run barefoot. Concern about puncture wounds, bruising, thermal injury, and overuse injury during the adaptation period are possibilities.

- Running shoes play an important protective role on some courses, in extreme weather conditions, and with certain pathologies of the lower limb.

Reviewer's Comment

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