Does Barefoot Running Minimize Injury Compared To Running With Shoes?

To this day, jogging is thought to be the convenient leisure activity for many active individuals. “The more vigorous the activity is, the better is for the body” – this is a common misconception in the fields of sports medicine. Simple activities such as running had been over-shadowed, however, rapid advancement in research in the past couple of decades concluded aerobic exercise - the closest form to a miracle drug to extend life span, which lead to increased popularity in the art of running. Recent studies points at high beneficial effects of barefoot running in minimization of injuries through intrinsic, physiological training of the ECM (extracellular matrix), joints, muscles and nerves. However, in order achieve a state of barefoot running, the individual needs to properly progress through appropriate sets of footwear modifications. Otherwise, sudden transition into barefoot running can increase injury burdens instead.

The early works of biomechanics in the motions of running originated in the late 20th century from Novacheck, (1) where he formulated the running gait cycle. The gait cycle illustrates repeated series of patterns on the lower extremities during a run. One complete gait cycle is marked when one foot strikes the ground and terminates when the same foot strikes the ground again. During this time, the subject’s legs undergo a period of swing and stance phases (40% stance, 60% swing). With correct articulations of joint - muscle activities, and the elasticity in the body, proper gait cycle can occur. A common misinterpretation in differentiating running and walking is thought to be the speed of motion, this is untrue. While running, an individual experience a “float period” where both feet of an individual are in the air. On the other hand for walking, one foot is always on the ground, no matter how fast the speed is.

The stance period of the running gait cycle is divided into three portions, an initial contact, midstance and toe off segments. Initial contact to midstance phase is illustrated by the deceleration of forward-swing motion of the leg. At the same time, passive shock absorber in the foot lightens the impact stress when the heel strikes the ground. Midstance to toe-off phase is signified by concentric contractions of the lower extremities (hip and knee regions) in preparation for toe-off. The stance phase act as a spring-mass system, where energy absorption is stored passively and converted quickly to energy generation, as recoil of the spring. The swing phase occurs in three phases as well, initial and mid-swing propels the legs forward, and terminal swing occurs when the heel strikes the ground.

In coordination of joint activities, muscles from the lower extremities facilitates proper movement of the ligaments during gait cycle. Tibialis anterior muscles is most active during a jog, it functions as the primary dorsiflexor of the ankle, and causes adduction of the foot. Gluteus maximum, gluteus Medius and TFL are active during the beginning of stance/end of swing phase to decelerate and stabilize the leg. Quadriceps controls knee flexion/extension when heel strike occurs. Medial Hamstrings are active during the beginning of stance phase, and the majority of swing phase, where it prepares the hip and controls knee extension in late swing.

Joanne Elphinstone proposed an elastic support strategy that the body incorporates as an individual run. Elphinstone’s theory describes a mechanism of force transfer between upper and lower body. As a result, runners who utilizes a diagonal elastic support mechanics produces a diagonal stretch that allows counter-rotation in the body. A flow of forces alternates up and down evenly, minimizing focal stress of forces, allowing an even distribution of forces throughout the body, therefore, reducing the chances at injury.

Running is a high impactful activity that generates large forces on the body, through the means of kinetic chain. If repetitive forces are not resolved properly by the body, it leads to micro-traumatic injuries through overuse. As running became more popularized amongst both the general population and athletic performers, researchers observed an increase in minimalist shoe wearers/barefoot runners. Heel striking pattern varies between barefoot/minimalist to conventional shoe wearers. Minimalists shoes reflect correspondingly to barefoot running with minor differences. The (minimalists) shoes themselves are constructed using reduced materials and cushioning compared with conventional shoes, which allows greater amount of sensory stimulations between the foot and the environments. Further research studies were determined to uncover pros and cons to the three “states” of shoe-wearing: conventional shoes, minimalist shoes, and barefoot runners.

Difference in force generation between walking and running from a biomechanical view noted impact stress from heel striking can generate up to five times as much force as to walking, because of the unsupported transition from a float phase. Minimalist shoes are thought to act as a transitional state between shoe wearing runners to barefoot runners. Barefoot runners incorporate a mid to forefoot initial contact. Whereas, shod runners initial contact with rearfoot. Forefoot striking in turn, have a faster natural cadence/stride rhythm than rearfoot striking. A study noted minimalist shoe wearers emulates the forefoot striking patterns as seen in barefoot runners (2). The authors used a treadmill to record interval differences between the three different types of shoe wearing. The result states that participants who were barefooted or minimalists, landed with faster cadences than those who wore conventional shoes. Barefooted participants landed in a plantar flexion manner, which increased the frequency of strides, leading to reduced forces in stride kinematics in terms of shorter stride length. Additionally, pre-activation of plantar flexor, lowered the torque around the hip, knee and ankle regions. Neural anticipation also preactivated the soleus and gastrocnemius, which decreased the stress on striking. The composers concluded that, people who are more experienced in running (barefoot runners), run with a “five fingered technique” such that these individuals tend to land forefoot, and are more protected against injuries. This paper did not clearly state the cons of minimalist shoe wear. However, another article was able to bridge the gap in knowledge (3). While minimalists’ shoes drive injury reduction by mimicking fast cadences, it cannot fully replicate the intrinsic stabilization effects of a barefoot runner. Barefoot running allows activation of glabrous epithelium, and its ECM through the plantar surface to minimize force transmissions via direct contact to the ground (3). Glabrous epithelium then activates a series of muscles by proprioceptive feedbacks to function as natural shock absorbers, therefore, impact transmission decreases and reduces the chances at injury. In minimalist shoes, this phenomenal cannot occur, because contact is mediated through a layer of shoe-covering, therefore the glabrous epithelium does not activate. Both authors were able to agree that barefoot runners are more protected from injuries through neural innervation and physiological adaptations by cellular constructs.

As new knowledge unveils in the field of sport medicine, accompanying advancement in technology to make shoes also follows. Another study conducted by Sun X, et al (4), showed the pros and cons in shoe modifications considering physiological biomechanics experienced by the body during a run. Four main points were stablished by this study: increasing stiffness of the forefoot can increase performance, softer midsoles attenuates loading stresses, thicker midsole provides higher resistances to sudden shocks, and minimalists shoes increases the cross sectional area of the Achilles tendon, induces greater loading pressure at the ankles and the metatarsophalangeal joints.

The effects of forefoot bending stiffness influences lower joint kinematic and kinetics. Increasing the bending stiffness of the forefoot can be done through two distinct ways, inserting a foot plate (5) or craft a harder midsole (6). Tuning forefoot stiffness enables higher performances in sports that involves the needs to accelerate and jump. Additionally, there’s evidence supporting minimization of negative joint power generation at the metatarsophalangeal joint, leading to higher performance by bending stiffness (7). On the contrary, there have been conflicting data showing the cons of bending the stiffness. Overbending leads to an increase in discomfort and a reduction in physical performance in runners (8). Optimal bending remains an enigma due to the unequilibrated units of measure across different studies.

Softer midsole can reduce the loading forces on the runner’s feet. The harder the midsole, there’s less energy loss upon impact, therefore, focal force on impact remains high, causing elevated chances at injury. A midsole with higher content of cushion can decrease shock factors by increasing collision time, likewise, release higher amount of energy during impact, which reduces the chances at injuries. Studies found the peak forces on impact are significantly higher with increased hardness on the midsole (9). Chambon et al, 2014 (9), separated subjects into two groups, a soft midsole shoe group, or hard midsole shoe group, and asks the participants to carry out their training. The results show larger peak knee adduction moment and higher peak forces in loading, leading to increased risk to injury in the hard midsole group.

Minimalist shoes claim to have minimal design, bigger room for the toes, which ultimately delivers a more “natural forefoot-first stride” than conventional shoes (motion-controlled shoes). Regarding to the use of minimalist shoes, there are positive effects of tissue-ligament of the lower extremities, specifically, the changes in the Achilles tendon. One article reported an increase the cross-sectional area of the Achilles tendon (an increase in stiffness) by wearing minimalist shoes (10). Random assignments from Fuller et al, 2017(11), study shown improvement in running economy when compared with motion-controlled footwear. On the other hand, there’s been past studies displaying consistent forefoot fractures with the usage of minimalist shoe wear (12). Minimalist footwears are highly associated with metatarsophalangeal joint fractures when compared with conventional shoes due to the reduction in cushioning. The reduction in support increases peak stresses on the forefoot. Fractures were measured through edema leakage of the bone marrow after transition from conventional to minimalist footwear in the participants. Progressive transition between the footwears is the key to proper barefoot running.

Furthermore, supplementary researches had been done on the subjective usage of shoe in terms of stability and comfort levels in relation to injury while jogging. Varying shoe tightness and lacing seems to impact peak pressure and pronation for the wearer. (13), shown that the highest tightness and lacing reduces loading pronation (degrees of arching as the foot collapses) in the rearfoot (14). High lacing patterns correlates with lower pressure in the heel and midfoot. Moreover, lacing patterns and its tightness tend to associate with experience (15). Perhaps through classification of experience level, future manufactures can aid runner’s performance by producing optimal lacing and tightness for different levels to minimize injury.

Barefoot running offers additional prevention to injuries than conventional shod running, when preparations are done correctly. Throughout past decades, studies had been made comparing the different biomechanics the human body experiences while using conventional, minimalist, or barefoot running. (16) Each “style” (conventional, minimalist, or barefoot) of running correlates with its own risk and benefits with recent data showing higher benefits to shift to a barefoot/minimalist style of running, which allows intrinsic fortification effects between joints, muscles and ECM to the “natural” rhythm of running. Active runners should shift from conventional footwear usage (inexperienced runners) to barefoot running (experienced runner) progressively to minimize injuries. Nevertheless, as running propelled in fame across populations through its effective, yet convenient form of physical activity. Many manufactures and researchers strive to promote safe running through minimalizing the chances of injuries through modifications of footwears. There are limitations in the fields that are profoundly present. Subjective misinterpretation of an individual’s level can result in higher chances of lower extremity injuries through improper equipment(footwear) decisions. Future goals in the should aim to fabricate a clear progression guideline in shoe wear choices to lessens injury burden relative to runner’s experience.

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