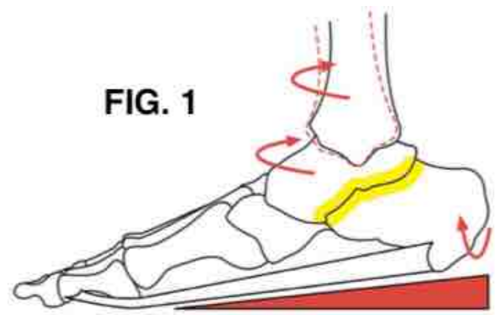
FIRST DRAFT 8/9/22

UNNATURAL MISALIGNMENT & DEFORMITY: An Unprecedented Medical Catastrophe Hidden In Plain Sight For Centuries

OVERLOOKED EVIDENCE AND CONFIRMATION OF AN UNEXPECTED DISCOVERY

Elevated shoe heels automatically tilt down a wearer's foot, thereby plantarflexing the wearer's ankle joint. Based on the work of J. H. Hicks and a multitude of other leading researchers – all unchallenged – plantarflexion supinates the **subtalar joint** (the joint connecting the ankle and heel bones). It therefore follows directly and inexorably that **elevated shoe heels must supinate the subtalar joint**, since a raised heel (in **red**) automatically plantarflexes the ankle joint, as illustrated in **FIGURE 1**.

FIG. 1

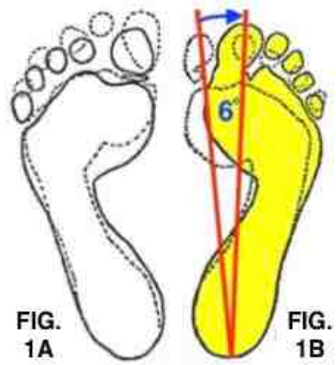


Nevertheless, that artificial coupling between elevated shoe heel and subtalar joint supination has been entirely overlooked in biomechanical research, including by the scientists of the most elite athletic footwear companies. I first described the then unknown coupling in 2015 in Web-based publications and in 2019 my discovery was summarized in peer-reviewed research published in ***Footwear Science*** titled "**Shoe heels cause the subtalar joint to supinate, inverting the calcaneus and ankle joint**."

Because that shoe heel-induced supination had previously remained unnoticed for hundreds of years, the probable direct effects on modern human anatomy of its unnatural inversion and external rotation of the ankle joint also had not been explored until I published my initial research on those probable effects in 2015. As a first step in correcting that previous oversight in research, I undertook a detailed investigation into the effects that were biomechanically required in human anatomy under the relatively simple operations of Wolff's and Davis's Laws by the heretofore unexamined artificial coupling biomechanism, the elevated shoe heel-induced supination of the subtalar joint. This article is a very brief summary of that initial investigation.

In an unexpected way, my investigation of the artificial shoe heel biomechanism uncovered compelling evidence for overturning the centuries-old basic understanding of human anatomy. Much of what has heretofore been defined as normal human anatomy and what is abnormal (or arrogantly presumed to be less highly evolved) are completely reversed. In fact, much of what we think of as normal is actually abnormal, and much of what was considered primitive is in fact normal. The implications of this new basic distinction are profound, since effective modern medical care is based on correctly identifying the abnormal and understanding its cause in order to treat it effectively or to prevent it.

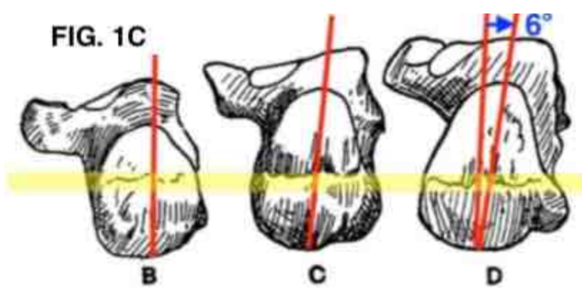
THE OVERLOOKED EARLY EVIDENCE SHOWS MODERN FOOT SUPINATION IS ARTIFICIAL, NOT GENETIC



A probable direct effect of modern shoes with elevated shoe heels on the modern human foot was published in 1939 in ***The Lancet***, which reported that exemplary footprints are the same among racially different individuals (shown in dotted and solid lines) who have never worn shoes despite their significant genetic differences **(FIGURE 1A).**

In contrast, ***The Lancet*** reported that an exemplary modern human foot (in yellow) subjected to the everyday use of modern shoes is externally rotated about **6°** into a **supination** position **(FIGURE 1B)** compared to a never shod foot. The conclusion is inescapable that the difference is artificially-induced by modern shoe use, not a genetically-based racial difference.

Further support from other racial groups comes from a 1931 physical anthropology study, which indicated that an exemplary modern European calcaneus is inverted about **6°** compared to those of two "primitive" barefoot populations (**FIGURE 1C**). Note particularly the level lines of the Achilles tendon attachment to the heel bone on all three samples. That attachment line shows the characteristic supination-based structural tilt to the outside in (**D**) European on the right and not in barefoot Africans (**B & C**) on the left. Again, this difference must be artificial, not racial, given the critical insight provided by the later study from ***The Lancet***.

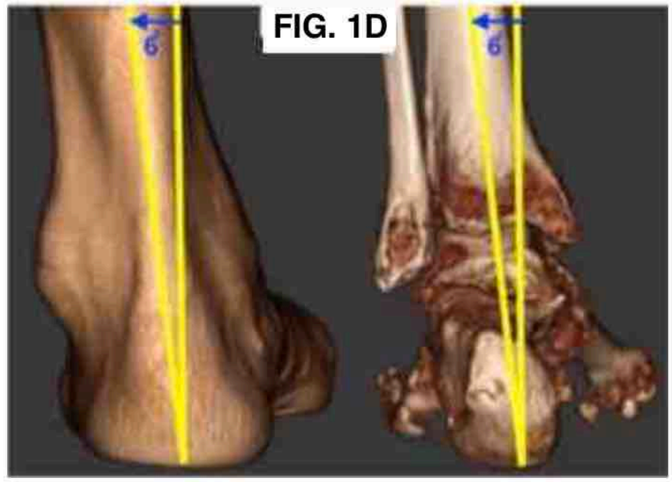


All of this evidence and a great deal more on significant anatomical differences between habitually shod modern and never shod barefoot populations has been entirely ignored by the footwear industry.

LATER AND RECENT EVIDENCE SUPPORTS FOOT AND SUBTALAR SUPINATION

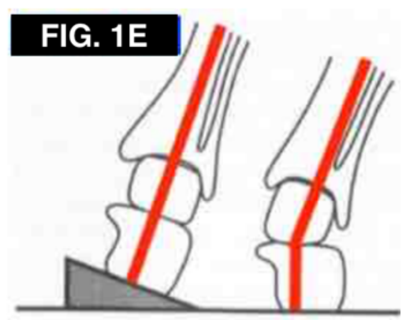
These long overlooked effects of the coupling biomechanism strongly suggest that the modern shoes and their most unnatural feature – elevated shoe heels – cause an actual physical deviation in the modern foot. Using a large variety of measurement techniques, many subsequent studies, including the most recent, have provided general support for ankle inversion of **4° – 8°**, and crucially but incorrectly have assumed the inversion to be natural.

For example, roughly **6°** of calcaneal and rearfoot inversion of the calcaneus and foot is observable in a 2019 study using weightbearing cone beam computed tomography in current symptomatic National Basketball Association players. This heel inversion position is so commonly seen at the **Hospital for Special Surgery** in New York that it is officially characterized there as **'… a neutrally aligned hindfoot** and slightly increased foot arch,' shown in **FIGURE 1D**.



The **4°-8°** of ankle inversion has been so well known for so long that in 1976 Dr. Steven Subotnick convinced the **Brooks** Shoe Company to use a **4°** varus wedge in what became for many years its top-rated Brooks Vantage running shoe (and still in widespread industry use today in the equivalent form of midsole density variations).

As illustrated (with exaggerated angle) on the left in **FIGURE 1E**, the varus wedge puts the subtalar joint into a neutral position so that the calcaneus is aligned with the talus and tibia. Without the varus wedge, as shown on the right in FIGURE 1E, the subtalar joint is forced to pronate **4°** unnaturally in order for the calcaneus to align with the level supporting surface below it, and the subtalar joint is thereby left in the inherently unstable position, subject to unnaturally excessive pronation because of the **4°** angle of the bodyweight load acting on it.



Unfortunately, the varus wedge maintains the heel, ankle, and lower leg in an artificial varus position caused by elevated shoe heels, instead of in a naturally stable vertical position, which is the leg position of barefoot runners who have never worn shoes, as we shall soon see.

Ironically, the varus wedge approach has always been used as an add-on with conventional modern athletic shoes together with elevated heels. So, both the wedge treatment and its immediate heel cause are combined into the same basic shoe design! The standard varus wedge is therefore a classic example of treating the symptom – ankle inversion – instead of its actual cause – the elevated shoe heel – which results in a treatment that does not work well.

Besides the **4°-8°** ankle inversion, other studies have noted a correlation between shoe heel height and ankle joint inversion (and/or foot supination). However, they have completely missed the pivotal role of unsuspected shoe heel-induced subtalar joint supination as the cause of the observed ankle inversion, principally because the motion of the subtalar joint during locomotion has been invisible, especially in running, until now.

POWERFUL CONFIRMING EVIDENCE FOR SUBTALAR SUPINATION FROM A NEW GOLD STANDARD IN JOINT MOTION MEASUREMENT

Now, for the first time, truly accurate measurements of the subtalar and ankle joints during running have been made in a study **(Peltz et al., 2014**) that used new gold standard 3D radiographic and computer modeling techniques. The new measurements make all previous measurements using older, less precise techniques obsolete due to their relative inaccuracy, so grossly wrong as to be grossly misleading, particularly relative to the subtalar joint. What has long been thought to be a subtalar joint pronation problem is actually a supination problem.

The new results are startlingly unexpected, essentially the opposite of the previous scientific understanding, which was that pronation of the subtalar joint and eversion of the ankle joint predominated at peak load during running midstance. Instead, **both subtalar and ankle joints were found to be substantially supinated at midstance during running, with an extraordinary combined total of about 8° of inversion and 18° of external rotation at a peak repetitive load of 3 times bodyweight. The subtalar joint provides about 5° of the inversion and the ankle joint provides about 10° of the external rotation.** (See **ENDNOTE 1**)

In the first half of the Peltz-reported stance phase (which was from footstrike to heel-off) there is a reduction in subtalar joint inversion of about 7° and an increase in tibial inversion at the ankle joint of about 1°. That is a net reduction of about 6° inversion of the ankle joint complex, comparing calcaneal motion to tibial motion. In the past this motion has been misinterpreted to be ankle joint eversion or pronation caused mostly by subtalar joint eversion or pronation.

The new more accurate Peltz data does indicate that the observed joint motion is in a pronation and eversion direction, and therefore a motion that can properly be called pronation and eversion. However, **it is actually only a reduction in continuous subtalar joint supination and inversion**, which remains substantial throughout the stance phase of running, including at peak repetitive loads of 3 G's.

Moreover, the pronation motion occurs only in **artificial reaction** to the shoe heel-induced supination in order to reduce its abnormal tilting-out effect, allowing the foot, ankle, and leg to become more vertical. Nevertheless, such pronation motion is itself unnatural and is not reported to exist in the feet or ankles of barefoot runners who have never worn shoes.

To summarize, the subtalar and ankle joints are artificially supinated by elevated shoe heels, and any pronation motion that occurs is unnatural and occurs only in reaction to the artificial supination, its sole biomechanical function being to reduce the artificial supination. This explanation contradicts the previously known science regarding pronation, but must be now accepted as the correct understanding of the actual biomechanics revealed in the Peltz data.

To put this in proper context, prior to this evidence being uncovered in the ground-breaking Peltz study, few if any biomechanics scientists with running research experience would have believed it. But given this apparently irrefutable evidence firmly based on a new gold standard peer-reviewed study, funded and directed by Nike, confirming the biomechanical coupling of elevated shoe heels and subtalar joint supination, the likelihood of human anatomical effects as a consequence cannot be overlooked.

The probable effects of the artificially realigned talus and tibia with a large 8° outward tilt away from vertical and larger 18° outward twist away from straight ahead <u>in opposite directions</u> occurring at peak repetitive loads of about three times bodyweight on the structure of the modern human body have never been explored until now. However, my initial research that follows indicates the direct anatomical effects on the modern human body is to extensively deform it gradually over time, as would be expected under the simple and direct operation of Wolff's and Davis's Laws.

The best way to investigate those effects is first to look more closely at the elevated shoe heel-induced supination of the subtalar joint and how it operates biomechanically.

ELEVATED SHOE HEEL-INDUCED SUBTALAR SUPINATION: HOW IT OPERATES

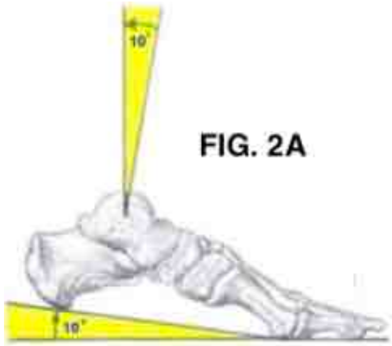
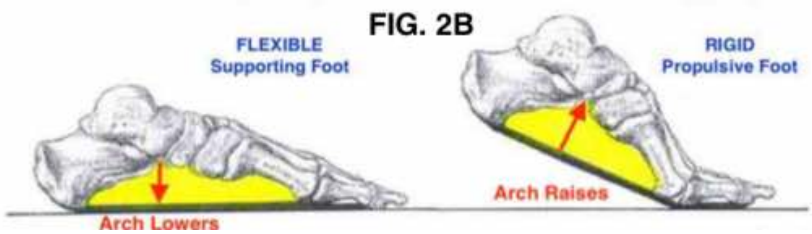


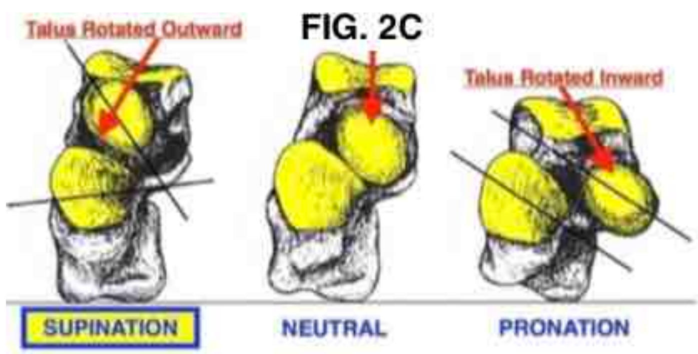
FIG. 2A

It is obvious, of course, if the shoe heel moves the foot heel up by, say 10°, the front of the foot is tilted down automatically by 10° into what is called technically a plantarflexed position of the ankle joint **(FIGURE 2A)**.

The hidden effect of the abnormal plantarflexed position is that it activates a well-known **windlass mechanism** of the foot, which normally converts the flexible supporting position of the foot on the ground into a rigid lever to propel the body forward in locomotion **(FIGURE 2B)**. The windlass mechanism automatically rotates the position of the ankle bone (talus) on top of the calcaneus (heel) in an external direction, so that the ankle bone points to the outside.

FIG. 2B


The elevated shoe heel artificially forces the foot into the unnatural **supinated position** (front view of ankle and heel bone in (**FIGURE 2C**) when it naturally should be flexibly supportive on the ground. That is an unfortunate and critical change. The automatic shoe heel-induced mechanism unnaturally points both the ankle joint and the lower leg to the outside, instead of straight ahead.

FIG. 2C


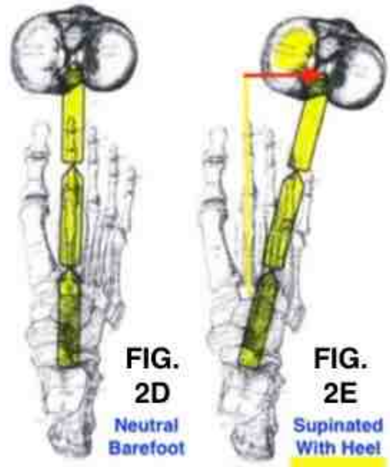
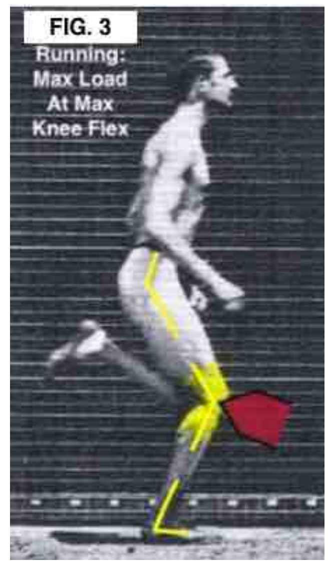


FIGURE 2D shows an overhead view of natural, unshod right foot bones and the natural, non-twisted right knee bone position pointed straight ahead in the flexed-knee midstance running position. The ankle joint is pointed straight ahead and the knee joint is flexed to absorb the maximum repetitive load of 3 times bodyweight, at the maximally loaded midstance position of **FIGURE 3**.

FIGURE 2E, in contrast, shows the unnatural, maximally loaded, twisted out right knee position caused by an elevated shoe heel when walking and especially running, at the same maximally loaded position of 3 times bodyweight shown in **FIGURE 3**. Note that all the leg joints are significantly flexed in running, not neutral as in walking, in which the entire leg is relatively straight at peak load.



The outwardly rotated ankle joint forces the knee to twist to the outside, as shown by **Fisher** et al. (2018). **FIGURE 2E** also shows that the inside (medial) half of the knee joint abnormally carries most of that maximal load, an amount as great as 80-90% for some individuals, due to the tilting-out of the knee to the side.

That hidden effect is relatively inconsequential when standing or walking, but, when running, the hidden effect is severely deformative. The reason the hidden shoe heel effect is so consequential when running is that the peak load of about 3 times bodyweight occurs at exactly the worst possible time: when knee, hip, and ankle joints are substantially flexed. **(FIGURE 3)**

MODERN RUNNERS' TWISTED AND TILTED-OUT LEGS ARE ARTIFICIALLY UNSTABLE

FIGS. 4A & 4B

FIGURE 4A shows a front prospective view of the tilted-out runner's leg. Whereas the leg would be naturally stable if vertical, it is unavoidably unstable in the twisted and tilted-out position forced by an **elevated shoe heel**.

In terms of simple classical physics, this angled force vector of body weight carried by the runner's leg resolves into a vertical component vector and a horizontal component vector, as shown in **FIGURE 4B**. The horizontal component is critical, since it unnaturally forces the subtalar joint inward, thereby causing the foot to pronate inward unnaturally. If the runner's leg remained naturally vertical, there would be only a vertical force vector, with <u>no</u> horizontal component vector.

Remarkably, evidence indicates that **never-shod barefoot runners <u>do not pronate</u>** with each running stride because they have untilted, vertical legs, as shown later in a Bushman and in Kim Phuc and Zola Budd when young (**FIGURES 7A, 8B & 8C, and 8E**), as well as the Bantus of South Africa in **FIGURE 1C**. Only runners exposed to longtime use of elevated shoe heels are forced to pronate unnaturally with every running stride!

A natural, vertical leg is inherently in equilibrium. The downward body weight force is balanced by a matching upward ground reaction force. In contrast, the unnatural shoe heel sets up a fundamental structural instability, as shown above in **FIGURES 4A & 4B**.

The lower leg shown in **Figures 8A & 8B** has about an 8° varus position that is almost constant throughout the stance phase of running. It creates an artificial horizontal force vector component of the ground reaction force (GRF) in the medial direction that powers compensating rearfoot eversion that would not be present in a vertical leg. This medial horizontal force component has been measured recently with a magnitude of slightly more than 2% of the GRF for 25 male runners (**Zifchock**, Parker, Wan, Neary, Song, and Hillstrom, 2019). The same study includes extraordinary evidence of a lateral horizontal force component with a magnitude of almost 4% of GRF, which is almost twice the magnitude of the medial force component.

That evidence appears therefore to provide additional empirical confirmation of the shoe heel-induced coupling. Moreover, there is no alternative explanation for the cause of such a lateral horizontal force component except as a direct effect of artificial subtalar supination.

The artificial cause: supination. In summary, as shown in **FIGURE 2B**, the elevated shoe heel unnaturally forces the knee to tilt <u>outward</u> in the frontal plane into an abnormal bow-legged position. As a result, the ankle joint is unnaturally de-stabilized. The full body weight load acting on the ankle joint is tilted into an unnatural angle, rather than remaining vertical, which would be naturally stable. This is the primary **action**.

The unnatural effect: pronation. Simultaneously, in compensation to the abnormal bow-legged position, the ankle is unnaturally forced <u>inward</u> by an unstable horizontal force vector resulting from the tilted lower leg, resulting in unnatural pronation, as shown in **FIGURES 4A & 4B**. This is the secondary **reaction**.

Simply put, **the artificially supinated foot creates an unnatural horizontal force on the subtalar joint that causes the foot to pronate artificially in reaction.**

Where the action and reaction forces balance in equilibrium for each leg of any given individual is dependent on that individual's sex and personal history of shoe heel use, as well as subtalar joint genetics. Some individuals become supinators, others find a more neutral equilibrium, and others become pronators. The simultaneous dual interaction of action and reaction is **strictly biomechanical**. It is an automatic and unavoidable action and reaction, both unnatural and artificially caused by elevated shoe heels.

The repetitive peak joint loading of 3 times bodyweight occurs when running just when the maximal abnormal knee, hip and ankle joint bending shown in **FIGURE 3** occurs, while also unnaturally rotated to the outside by elevated shoe heels. That directly results in a closed chain of structural misalignments throughout the modern human body, artificially deforming all of it from natural to abnormal.

Bone structure is totally dynamic, always changing based on the loads to which it is subjected. When broken, it heals without a scar uniquely in the human body, just remodeling constantly to load. The unnatural deforming occurs as prescribed by **Wolff's Law**, which requires that bone is remodeled by the maximum loads to which it is subjected. Similarly, the soft tissues of all of the joints – the ligaments, cartilage, tendons, and fascia – also are remodeled by the maximum stresses to which they are subjected according to **Davis' Law**.

THE EFFECT OF UNNATURAL SUBTALAR SUPINATION ON THE ANKLE JOINT

The shoe heel-induced inversion of **8°** and external rotation of **18°** the modern ankle joint automatically twists the ankle bone (the bottom of the ankle joint) against the tibia/fibula combination (the top of the ankle joint) . The modern (left) ankle bone shown in **FIGURE 5B** shows an enlargement caused by the unnatural rotary motion, as well as a resulting lateral side angled enlargement, when compared to a natural ancient barefoot Egyptian (left) ankle bone **FIGURE 5A.** The barefoot ankle operates like a section of a pulley or wheel to efficiently perform its basic simple hinge function.

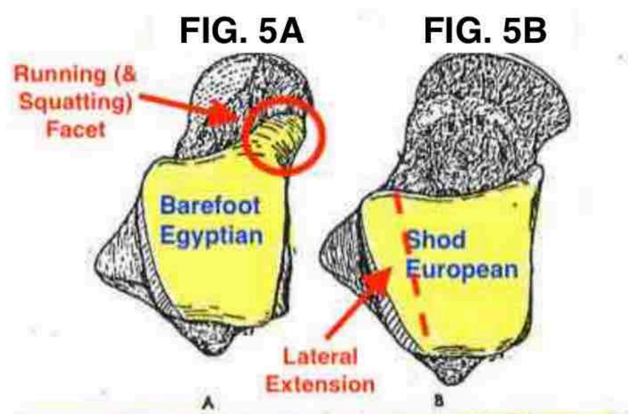
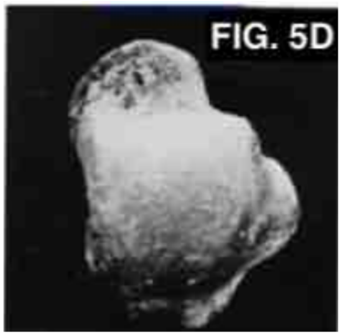


Fig. 61.—Upper surface of the talus. A. of an Egyptian. B. of a European. In A. the surface of the neck is articular and the facet for the tibial malleolus extends far forwards on the neck.

FIGURE 5C shows more definitively the well-known but unnatural rotary structure built into the **modern elevated shoe heel wearing Englishman**'s (left) ankle joint (ankle joint trochlear surface highlighted in yellow). The **8°** outward tilted tibia causes the modern (left) ankle's ligaments to loosen on one side of the joint, allowing motion, and tighten on the other side, creating a relatively fixed center of rotation. Based on the governing simple geometry, the lateral side on the modern ankle joint become looser and the medial side becomes more fixed, resulting in the rotary joint structure shown in **FIGURE 5C.**

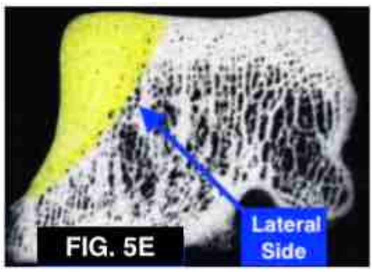
That rotary joint structure is also formed by the primary supination action to the outside – the cause – followed gradually by a secondary pronation reaction to the inside – the effect at peak load and peak dorsiflexion. The overall effect is to carve the shape of the trochlear surface

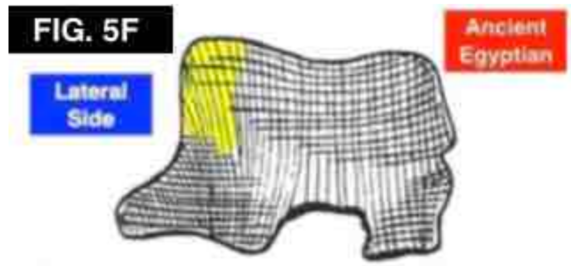


of the talus into a semicircle.

In marked contrast, the trochlear surface of the natural (right) ankle joint of an **ancient barefoot Anglo-Saxon** of **FIGURE 5D** shows no rotary structure, with a medial side that is just as long as the lateral side.

As a result, the anterior **lateral** side of the (left) **modern talus**' trochlear joint surface develops a far denser network of underlying trabeculae, shown highlighted in yellow in **FIGURE 5E**, in a coronal plane cross-section of the anterior joint surface that is load-bearing in the dorsiflexed ankle joint under peak load during running, as shown in **FIGURE 3.**





Showing the arrangement of the lamellæ in a trans-section through the corpus.

In contrast, as shown highlighted in **FIGURE 5F**, the (left) **ancient Egyptian talus shows the opposite structure** – a far less dense trabecular network on the same lateral side. In fact, the much greater density in the trabecular network of the **medial** side indicates that the medial side is the dominant load-bearing side of the natural Egyptian talus.

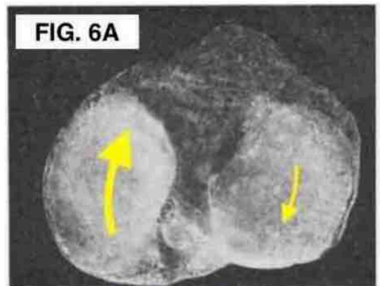
Those significant bone and ligament changes can be remodeled only slowly over a considerable period of time, if at all, and therefore are likely to be the underlying physical structure which determines the '**preferred movement path**,' a concept developed by eminent biomechanics scientist Dr. Benno **Nigg**. That path may be structurally locked-in by bone remodeling over a lifetime, so that, for example, the typical shod tibia is externally rotated about 20° relative to the calcaneus throughout running stance, as observed in the Peltz study. That would also explain why in the Peltz study running barefoot and in minimalist and structured shoes all produced roughly the same subtalar and ankle joint measurements, with the exception of the ankle joint at footstrike, when elevated shoe heels have their greatest unnatural effect. However, there was also a lack of any adaptation period between the three trials, which would tend to merge the results.

If so, this would largely explain why the popular conversion to barefoot running and minimalist shoes during the past decade has not apparently produced the performance and injury-avoidance advantages expected by most of the runners who experimented with conversion. It would also largely explain the current success of Kenyan and Ethiopian runners who grew up running barefoot throughout childhood and adolescence, and therefore probably would have much less bone remodeling even after converting later in life to running in modern athletic shoes, as do all elite runners today. Their feet and ankles, as well as the rest of their bodies, are less deformed than runners who have been subjected to elevated shoe heels from early childhood.

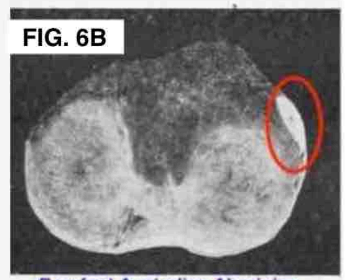
THE EFFECT OF THE UNNATURAL SUBTALAR SUPINATION ON THE KNEE JOINT

Since their motion is coupled, the shoe heel-induced inversion of **8°** and external rotation of **20°** the modern ankle joint automatically twists the tibia, which forms the lower surface of the knee joint, unnaturally to the outside about **18°** during running.

The shoe heel-induced **18°** outward twisting of the **modern knee joint** creates an unnatural rotary torsion that is built directly into the abnormal bone structure of the upper articular surface of the modern tibia **(FIGURE 6A)**, enlarging and weakening either or both knees, promoting arthritis and otherwise avoidable patellar, ligament and meniscus damage.

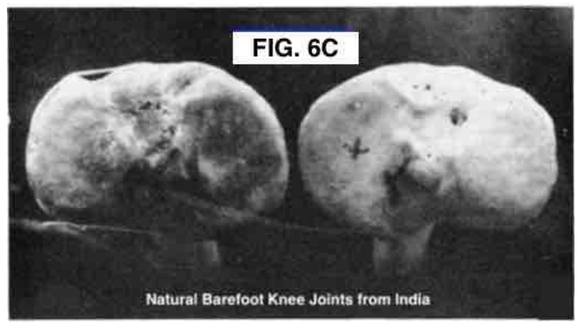


Shoe-Wearing European



Barefoot Australian Aborigine

In contrast, the rarely injured **natural barefoot knee (FIGURE 6B)** of non-shoe wearers, regardless of their genetic background, has a smaller, simpler structure, with no abnormal rotary motion built into it and with much stronger ligament attachments (such as for iliotibial tract, circled in **red**).



Natural Barefoot Knee Joints from India

Similar tibia samples from **barefoot Caucasian populations in India (FIGURE 6C)**, show the same simple, non-rotary articular surface structure as the barefoot Australian Aborigine of **FIGURE 6B**.

In addition, an **ancient Roman** tibia **(FIGURE 6D)** shows an equivalently simple, non-rotary surface structure as the barefoot Australian and Indians.

The asymmetrically twisted and malformed menisci highlight the abnormality of the modern knee and its cartilage. The medial meniscus is pushed far forward and the lateral meniscus backward **(FIGURE 6E)**. The outward tilted tibia causes the knee ligaments to loosen on the inside, medial side of the joint, allowing motion, and tighten on the outside, lateral side, creating a relatively fixed center of rotation on the lateral side. The result is unnaturally common knee ligament ruptures such as the ACL and meniscus damage.

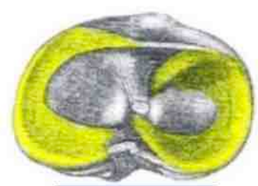


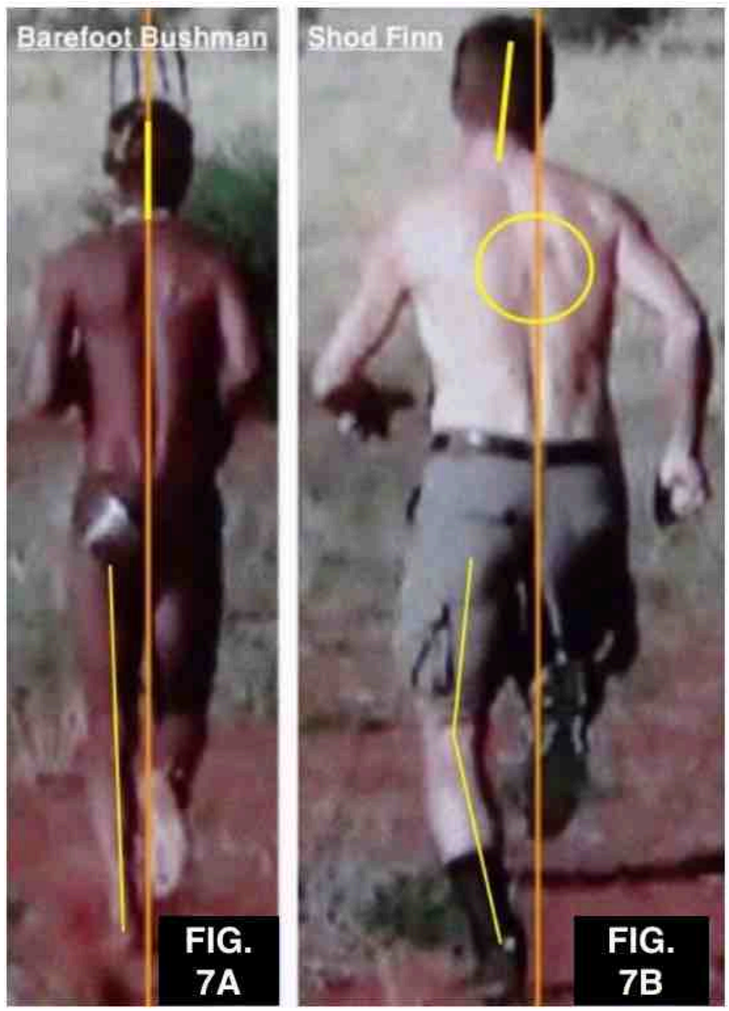
FIG. 6E
Modern Knee Joint

THE OVERALL EFFECT OF THE UNNATURAL SUPINATION ON THE HUMAN BODY

It is already well-established in evolutionary terms that the human body was born to run. In terms of the evolution-in-reverse in operation today, the artificial conversion of the modern human body from natural to abnormal, with a twisted and deformed bone structure built by aberrant rotary torsion, occurs during running with elevated shoe heels. Astonishingly, the effect of the **8°** outward tilt and **18°** outward twist of the ankle cascades throughout the entire modern human body, slowly deforming and destabilizing every part of it.

As previously noted, that is because the artificial tilt and twist occurs during running, when the highest repetitive forces in the human body are experienced. That pounding, highly repetitive load of about 3 times bodyweight controls bone growth and joint formation during the critical childhood and adolescence growth phases, a time when running occurs frequently – all as dictated by Wolff's Law on bone growth.

An **African Bushman (FIGURE 7A)** who grew up barefoot has a typical **natural body structure**: symmetrical with straight legs and level pelvis when running, with no leg crossover and well-defined spine, as well as minimal foot supination or pronation. Other photographic evidence indicates that **Asians** and **Caucasians** who had not worn conventional modern shoes have the same typical natural body structure**,** such as **Kim Phuc,** the well-known "napalm girl" of the Vietnam War **(FIGURE 8B & 8C),** and **Zola Budd**, a world record 5000m runner as a teenager **(FIGURE 8E)**.



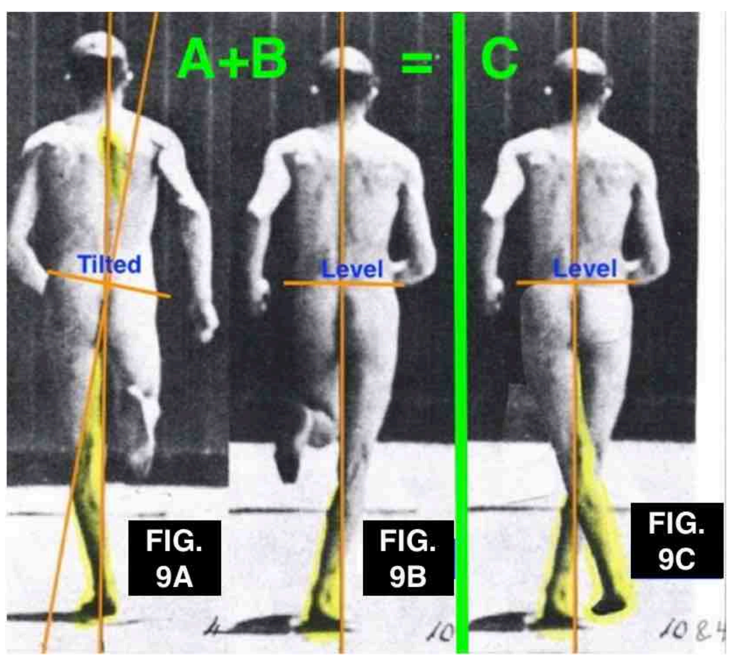
In contrast, the typical modern body of a relatively elite **shod Finnish marathoner (FIGURE 7B)**, who doubtless grew up wearing modern shoes, is **unnaturally deformed: his legs and torso are both tilted and twisted away from a vertical centerline in the frontal or coronal plane.** His support leg is bent-out into a bow-legged position by his shoe heel-induced supinated feet, and he has a twisted pelvis and bent-out spine with shallow definition, with unnatural thoracic torsion abnormally distorting the chest and subjecting the heart to unusual repetitive pressure, thereby potentially promoting heart disease. The neck and head of the **Finn** are tilted-**in** to counterbalance his tilted-**out** spine, so it is even reasonable to expect that, like the modern knee, the modern human brain within the tilted and twisted skull is itself tilted and twisted in an artificial reaction to unnatural lower body alignment caused by shoe heels, as we shall see.

Even the most elite modern athletes, like **Roger Bannister** breaking the 4-minute mile barrier **(FIGURE 8A)**, demonstrate the same misaligned and deformed body structure under the duress of maximum effort, in contrast to upright and aligned structure of the **barefoot Bushman** of **FIGURE 7A** and of **Kim Phuc (FIGURE 8B & 8C)** or **Zola Budd (FIGURE 8E)** (both shown beside modern Western shoe-wearing female runners).

THE EFFECT OF ARTIFICIAL SUBTALAR JOINT SUPPINATION ON THE HIP JOINT

During running, at the point of maximum load of about 3 times body weight, the effect of modern shoe-supinated feet is to automatically tilt both left and right legs unnaturally inward, crossing over the centerline of the body. **(FIGURES 9A+B)**

Consequently, **a modern runner's pelvis is forced to <u>tilt down</u> abnormally (FIGURE 9A)** on at least one side to prevent the feet and legs from crossing over the body's centerline and thereby colliding directly into each other. Otherwise, if a modern runner's **pelvis is <u>artificially kept leveled</u> (FIGURE 9C), instead of tilted**, his maximally flexed and loaded legs become so criss-crossed that running would be impossible.



That theoretical level pelvis position **(FIGURE 9C)** shows the true relative position of the hip joints between both the pelvis and the legs at peak load when running, the position in which those lower extremity joints are all unnaturally deformed by that peak load.

The absurdly unnatural crossed-leg position deforms the bone structure of the hip joints, bending them into an abnormally adducted positions, which weakens the hip and restricts its natural range of motion, promoting fractures. The neck of the femur is also unnaturally deformed and weakened, bent into an abnormal position in both the frontal and transverse planes. The pelvis itself is deformed because of the unnatural outward horizontal force component at the hip joint created by the abnormal bent-in position of the legs, as shown above in a frontal or coronal plane, remodeling the pelvis and birth canal, making both wider and flatter.

Again, supporting evidence comes from published and unpublished data from a prize-winning study by Dr. Steven **Willwacher**. The standing hip angle for 222 test male and female test subjects was **2° to 3° of outward tilt** (abduction) of the leg.

However, at the very beginning of the stance phase of running, the initial hip angle immediately became **8° to 10° of inward tilt** (adduction). This is an amazing change, the total hip angle increasing by a full **11° to 12° of inward tilt**, a dramatically abrupt difference in the transition from standing to running on the support leg.

Even more extraordinary is the fact that **at peak load midstance, the hip inward tilt (adduction) angle for females climbed to 17° and to 14° for males.** In remarkably stark contrast, for the typical never-shod barefoot runners shown previously in **FIGURES 3A, 18C and 20A**, the support leg at peak load is **vertical!**

From standing still to the peak load position when running, **the total increase of inward tilt (adduction) of the hip when running is 19° for modern females and 17° for modern males**. The huge angular difference would seem to indicate that modern hips are abnormally structured, which would thereby explain why hip fractures and osteoarthritis are so common.

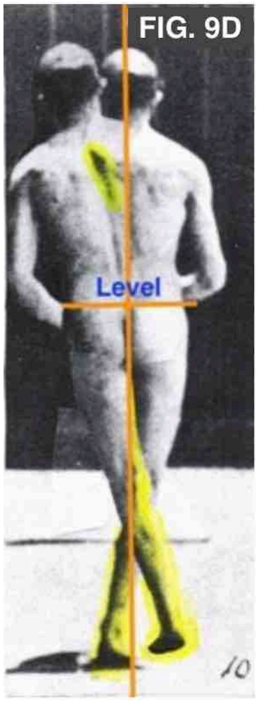
An obvious question arises. What causes both legs to be bent-**in** so far from their natural vertical position? The answer, which at first sounds more confusing than helpful, is that both legs actually are being bent-**out** unnaturally by both ankle joints, as we have seen earlier.

The observed bent-**in** position of both legs is because both legs are anchored to the body at the hip joint, but obviously are not anchored at the ground, so the counterintuitive answer is: the legs – that are abnormally bent-**out** by the moveable ankles – are **in direct reaction** forcibly bent-**in** by the relatively unmovable hip joints (which are fixed in the frontal plane by the inertia of the torso's mass).

It should be noted that about **7-8°** of tibial inversion or bent-in position of the lower leg was assumed to be normal by Drs. Cavanagh, Frederick, and Subotnick beginning in the 1970's and at least through the 1990's, since it was what was typically observed in running studies. However, in light of the extraordinarily high **18°** of average hip adduction noted above, and the inherent crossover problem caused by that excessive adduction shown in **FIGURES 5C & 26D**, together with new knowledge now of the shoe heel-induced supination of the subtalar and ankle joints, that old assumption of normalcy seems highly unlikely.

THE EXTREME RIGHT/LEFT ASYMMETRY OF THE MODERN HUMAN BODY

FIGURE 9C & **FIGURE 9D** show the asymmetrical position of the right and left legs in the **FIGURE 3** position of peak load of 3 times bodyweight at midstance. Virtually all biomechanical running studies of the lower extremity measure only one leg (and usually only one or two parts of the leg), but a precedent-breaking 2017 study by **Radzak** et al. specifically collected data on both right and left legs to evaluate asymmetry during running. The differences found were quite astounding.



The range of motion for the average left ankle of runners was everted (roughly like pronation) about 32° and inverted (like supination) only about 3°. In contrast, the right ankle everted about 16° and inverted about 12°.

Most runners, in other words, when running do nothing except pronate with their left foot, but pronate and supinate almost equally with their right foot. That is an extraordinary imbalance, and yet one that was already evident over three decades ago in a study by Peter Cavanagh, a leading pioneer of modern running research.

Further support comes from a 2019 study by **Tumer** et al. that has identified significant asymmetry between right and left shin bones (tibia and fibula) and ankle bones (calcaneus and talus).

CRITICAL OMISSIONS IN EXISTING PEER-REVIEWED RUNNING STUDIES

Even so, right/left imbalance is missed in virtually all existing peer-reviewed running studies, even the best, which not only fail to measure simultaneously all the joints of both legs, but also omit all the other major parts of the human body, such as the pelvis, spine (lumbar, thoracic, and cervical), and head, so the obvious structural problems of the Finnish marathoner of **FIGURE 7B** are never measured in a biomechanics lab. The highly interconnected relationship of all the anatomical parts has never been considered based on accurate measurement.

As a result, all existing peer reviewed running studies suffer from the same basic problem described in the parable of the blind men and the elephant, wherein each blind man describes the elephant based on each man separately touching only the elephant's trunk or ear or leg or belly or tail, and thus each blind man having wildly different ideas of what must be an elephant. Such fragmentary knowledge is almost useless, if not wildly misleading.

Moreover, all of the existing studies have ignored the artificial effect of shoe heel-induced subtalar joint supination. Without controlling for that important variable, test results have become incomprehensible, and have resulted in contradictory results that cannot be resolved, for example the unexplained "decoupling" issue of tibia and ankle joint motion during running. However, if the missing effect of artificial subtalar joint supination is taken into account, the decoupling problem can be logically explained.

Unfortunately, neither of these omissions is the greatest problem with existing peer-reviewed running studies. Incredibly, none of them meet the single most basic requirement of scientific validity: randomly selected test subjects. Instead, most select a small number of recreational or competitive runners who have not been injured for a significant period, usually three or six months – which is a highly select group that is not at all characteristic of the general population of active runners. Furthermore, the active runner population, itself, is a highly select group not at all characteristic of the general modern population, the vast majority of which are not active runners.

Worse still, only modern runners who have habitually worn shoes throughout their lives have been tested in modern biomechanical labs, so only human bodies that likely have been permanently affected by shoe heel-induced supination are ever evaluated. Not a single never-shod barefoot runner has ever been measured in the critical frontal and horizontal planes to measure their joint motion, particularly that of subtalar and ankle joints.

In addition to those glaring omissions, most peer-reviewed studies that test runners wearing footwear do not even identify that footwear, which of course varies so widely in sole structure and material that it would be expected to affect test results. In the exceptional cases where the tested footwear is identified, only the shoe model is identified, occasionally with one particular structural or material characteristic identified, but ignoring all others.

So, the critically important testing variables of shoe sole structure and material are entirely overlooked. Given that the foot and ankle form the foundation of the entire human body above it, this is a striking omission! Compare that omission to structural engineering in architecture, where the structure and material of foundations are treated as absolutely critical.

A related comparison is even more glaring. Over 60 architectural programs exist in U. S. universities alone and almost 700 worldwide. There is not a single equivalent academic program on the structural engineering of footwear soles and materials anywhere. Entirely missing also is any footwear sole equivalent to the credentialing, licensing, building codes, and inspections that carefully controls every modern architectural structure, from modest houses to the tallest skyscrapers.

THE FUNDAMENTAL RESEARCH PROBLEM IS EXTREME LACK OF FUNDING

The fundamental issue underlying all of these problems is an appalling lack of biomechanical research funding. Relative to each dollar invested in other important fields of science like astronomy, particle physics or brain research, less than a penny is spent on biomechanics research. That is despite the absence of any tangible or near-term benefit to humanity from existing enormous expenditures on equipment, much less from another giant new particle collider or telescope like the James Webb Space Telescope (costing $10 billion, twenty times its originally estimated cost and fifteen years late).

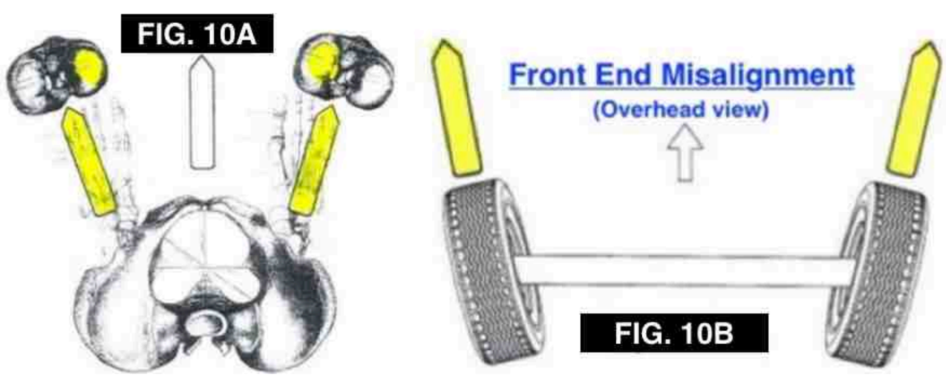
Nevertheless, these costs may be well justified by their non-tangible benefits even if untimely. However, in contrast, the potential health and quality of life benefits of new investment now in biomechanics, anatomy, and related medical research are enormous in a future that may be relatively close. Moreover, the potential savings from reducing existing health care costs currently spent inefficiently to treat the symptoms instead of causes are extraordinarily high.

Nevertheless, currently not a single biomechanics lab exists anywhere (not even in the largest footwear companies) with anything even close what is necessary to produce valid running studies sufficient to take even the first steps necessary to address the anatomical and medical catastrophe caused by elevated shoe heels.

The athletic footwear companies have focused their resources on marketing performance associated with elite athletes, not injury avoidance, and spend relatively nothing on basic research. Moreover, any role they might potentially play directly in basic research is subject to an unavoidable conflict of interest. Almost all of the research they currently do is directly related to commercial product development, not basic research, and is done in-house with publication outside very rare. Only patents eventually become public, but their disclosures are typically as general as possible to obtain the broadest legal coverage..

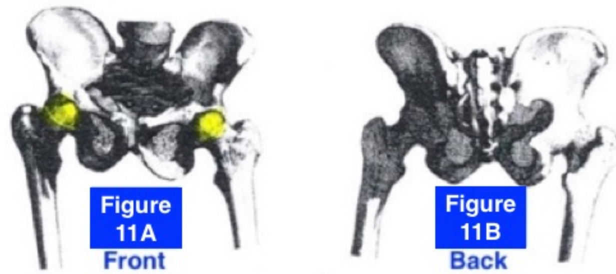
THE UNNATURAL FRONT-END MISALIGNMENT OF THE HIP JOINTS

Besides tilting legs to the outside in the frontal plane, as shown previously in **FIGURES 4A & 7B**, the shoe heel-induced subtalar joint supination externally rotates the ankle bone 20° in the horizontal plane, and that unnatural ankle misalignment causes both legs to be pointed to the outside, inside of straight ahead, as shown in an overhead view in **FIGURE 10A**. The knee of the right leg is at an extraordinary angle of about 40° from the knee of the left leg, instead of being parallel to it.



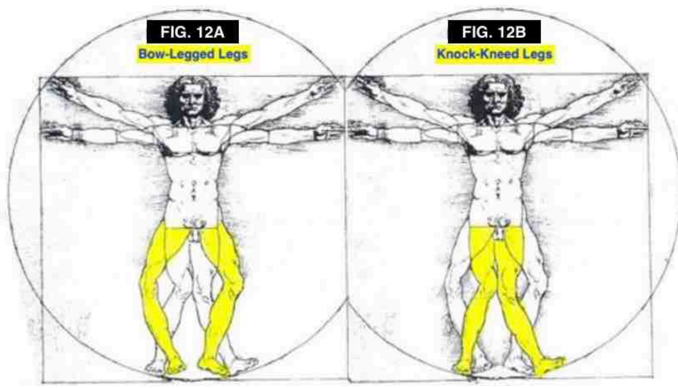
This outward rotation (and an 8° outward tilt) is directly analogous to the frontend misalignment of an automobile (**FIGURE 10B**), which quickly results in breakdown or accident. Only the incredible robustness of the human body, honed by the untold years of evolutionary improvement of bipedal locomotion evident even in the famous 3.2 million-year-old Lucy fossil, is capable of masking the misalignment problem by making the human body breakdown so gradual and spread throughout the entire body that its cause appears to be natural aging.

Nevertheless, the abnormal breakdown is substantial over time, with the worst effect being the drastic increase in right/left asymmetry discussed earlier that is necessary simply to more the human body forward in a relatively straight line, rather than see-sawing left and right like an ice skater. As Cavanagh found, one leg becomes dominantly propulsive, while the other becomes dominantly supportive, each with different ranges of ankle, knee, and hip joint motion.



The effect of the front-end misalignment on the hip joints is seen in the excessive exposure of the femoral heads, which are outwardly rotated almost out of the hip sockets when standing, shown in a front view in **FIGURE 11A**, demonstrating how unnatural their position is relative to the rear view shown in **FIGURE 11B**, where the femoral heads are completely covered and located abnormally deep within the hip sockets. The result is a highly fragile modern hip joint, prone to unnatural fracture and osteoarthritis. It should be noted that the human body is optimized to deal with peak running loads, so in the **FIGURE 3** position, the femoral heads are better seated in their sockets.

UNNATURALLY EXAGGERATED DIFFERENCES BETWEEN MALE AND FEMALE



Modern **male feet tend to become fixed in the supination position** in reaction to elevated shoe heels. Most modern **males tend to become bow-legged**, as shown above in **FIGURE 12A**, often with a noticeable knee bending motion to the outside when flexed during locomotion. This abnormal condition, called varus knee thrust, weakens their legs.

Although females also tend to supinate first in reaction to generally higher heels, modern **female feet are then generally forced into excessive pronation**, in reaction to the greater imbalance of forces generated by the higher elevated shoe heels. Most **females tend to become the opposite, knock-kneed**, as shown in **FIGURE 12B**. Females primarily experience this opposite effect because of their frequent use of much higher heels and their greater joint flexibility as well as their relatively wider pelvis (due to relatively shorter thigh bones) – all of which cause their legs to rotate inward under peak load.

A new study (**Munsch** et al., 2022) of subtalar and knee joints that uses the same new gold standard of joint measurement as Peltz confirms that women's knees are more adversely affected biomechanically by elevated heels than men. At midstance under peak load women are more inverted at the subtalar joint and more externally rotated at the tibiofemoral (knee) joint. During push-off, both sexes underwent subtalar inversion and tibiofemoral internal rotation, but unlike men, women also underwent tibiofemoral (knee) adduction into a knock-kneed position.

It seems likely that the additional unnatural motion of women's knees – the adduction during push-off – must account for the greater incidence of knee-related injuries and osteoarthritis in women. Although not measured in Munsch's study, a relative collapse of the midfoot and forefoot joints of women's feet likely occurred in reaction to the knee adduction. Munsch's study was limited to walking rather than running, so it is reasonable to expect that during running significant knee adduction also occurred at midstance during peak 3 G bodyweight loads.

THE ILLIOTIBIAL TRACT ROTATES THE MALE PELVIS BACKWARDS AND FEMALE PELVIS FORWARDS

The iliotibial tract is a long ligament connecting the iliac crest of the pelvis to the top of the tibia. [**FIGURE 13A**] It plays a little known but critical role in unnaturally exaggerating the difference between male and female body structures. When the foot supinates, the iliotibial tract forces the pelvis to rotate backwards (in the sagittal plane) when the tibia rotates outward in reaction to the foot supination, including the characteristic supinated foot position of modern males caused by moderately elevated shoe heels.

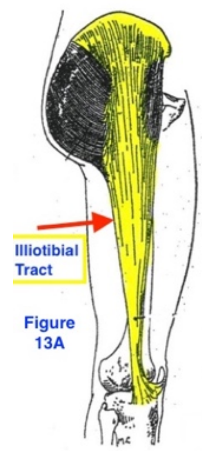
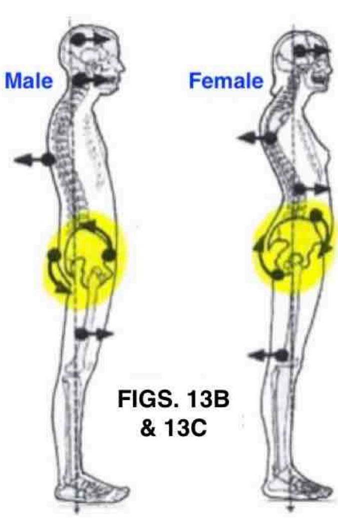


Figure 13A

Conversely, when the foot pronates, the illiotibial tract forces the pelvis to rotate forward (in the sagittal plane) when the tibia rotates inward in reaction to the foot pronation, including the characteristic pronated foot position of modern females caused by higher elevated shoe heels.

The modern **male pelvis** is typically flattened and automatically **rotated backward**, as shown in **FIGURE 13B**, because of its mechanical connection to the outward twisted knee by the critical illiotibial tract. That rotation flattens the male lower back and male butt, and softens the belly, as well as abnormally increasing the thoracic and cervical spinal curves.

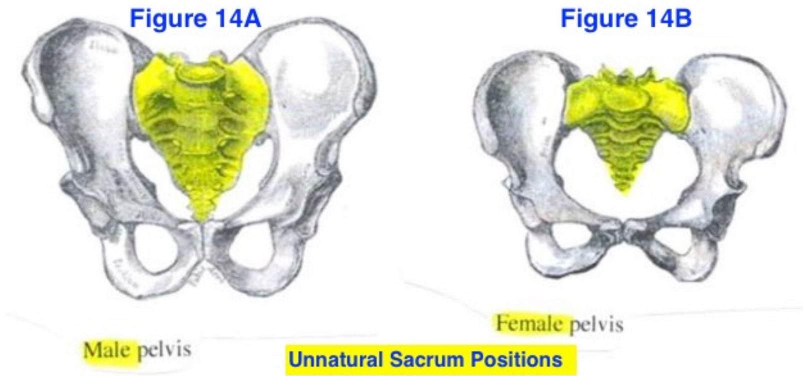


FIGS. 13B & 13C

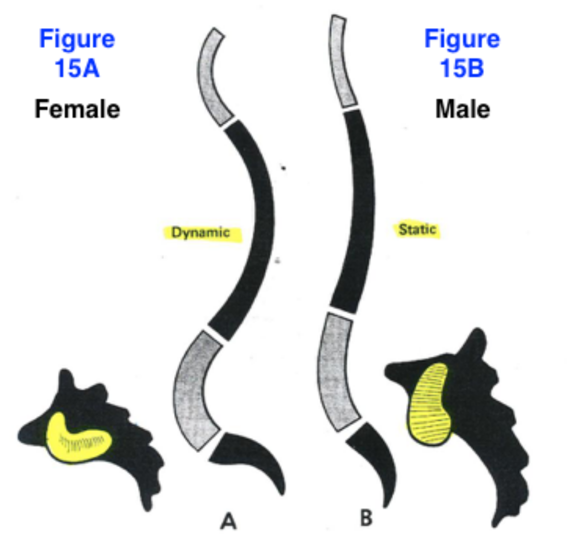
The modern **female pelvis** is also typically first flattened in the same way, but then the female pelvis **rotated forward** in additional compensation, as shown above in **FIGURE 13C**. This rotation results in an excessive rounding of the female lower back and butt, as well as thoracic and cervical spinal curves, making pregnancy and childbirth unnaturally difficult.

THE SACRUM BASE OF THE LUMBAR SPINE IS TILTED UNNATURALLY BACKWARD IN MALES AND FORWARD IN FEMALES

In **FIGURES 14A & 14B**, the sacrum (in yellow) is the base that supports and positions the spine and therefore all parts of the body above the pelvis. The sacrum is rotated abnormally backwards in the modern male figure (on left in **FIGURE 13B**) and abnormally forward in the modern female (on right in **FIGURE 13C**). The sacrum of each sex is in a different and unnatural position to provide direct support to the spine above it. Asymmetrical bilateral tilting shown in **FIGURES 9A-D** also alters the natural structure of the modern pelvis.



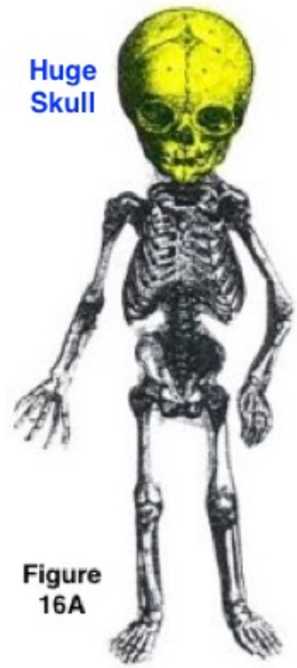
The unnaturally different supporting positions of the sacrum force the curvature of the spine typically to decrease in modern **men**, shown in **FIGURE 15B**, and make the abnormal modern male spine inherently <u>less flexible</u>.



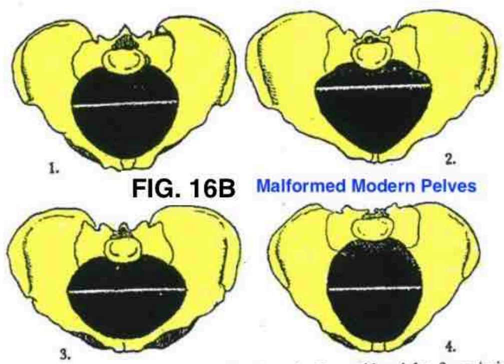
In modern **females**, in contrast, the abnormal curvature of the spine is typically increased, as shown in **FIGURE 15A**, and make it structurally <u>more flexible</u>. Note the drastically different sacroiliac joints (in yellow), which join the sacrum to the ilium of the pelvis. The sacroiliac joints are infamous as sites of intractable (and unnatural) pain.

In addition, the unnatural asymmetrical mismatch in pelvic position and abnormal pelvic functional ability reduce sexual performance, satisfaction, and fertility for both modern males and females. **FIGURE 15C** illustrates an extreme example of the effect of pelvic asymmetry on modern male genitalia. Equivalent female asymmetries exist as well, although in an inherently subtler way, and of course right and left female breasts are often less than perfectly matched.

THE BIRTH CANAL OF THE FEMALE PELVIS IS FLATTENED DANGEROUSLY

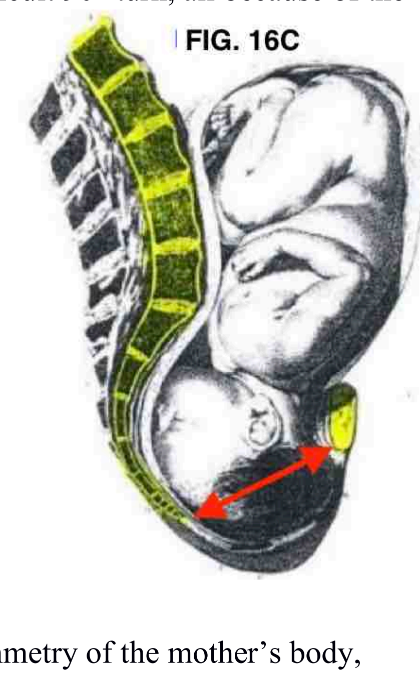


In human childbirth, the primary cause of maternal distress is the size and shape of the baby's head relative to the modern mother’s pelvic opening. The head is huge, twice the size of our closest animal relative, the chimpanzee. The head on the skeleton of a newborn is so large that it makes the skeleton look as if it must belong to a space alien with an enormous brain (**FIGURE 16A**).



—Four main types of pelves. 1. Gynecoid pelvis; 2. android pelvis; 3. platypelloid pelvis; 4. anthropoid pelvis. (From Caldwell and Moloy: Berk's Obstetrical Practice, The Williams and Wilkins Company).

The **female pelvic brim** and the fetus’s relatively huge skull are about the same size. In humans, therefore, the fit is much tighter than in other primates. Mother and fetus are also mismatched in shape. The fetus must enter the birth canal sideways, and then make a difficult 90° turn, all because of the **unnaturally flattened, misshapen brim and pelvis** of the modern mother **(FIGURE 16B).**



The head of the fetus has somewhat flexible sutures within the bone of the skull that help the fetus squeeze through the birth canal, as seen in **FIGURE 16C**. That inherently difficult birth passage, however, exposes the fetus's brain to enormous trauma. The fetus brain is subjected to real danger with potentially permanent consequences.

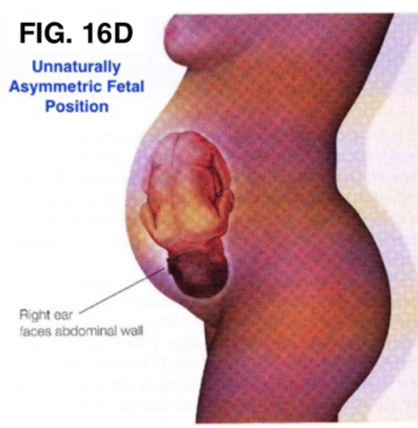
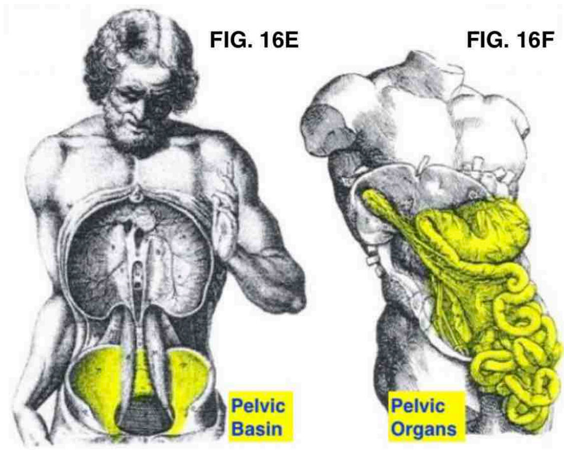


FIGURE 4.36 The womb may affect postnatal manual coordination. According to Fred Previc, functional asymmetries in manual coordination are sometimes attributed to the prenatal environment of the fetus. The position of the fetus in the uterus is thought to influence prenatal vestibular experience. Most fetuses are oriented with the right ear facing outward, resulting in a larger vestibular signal in the right hemisphere. At birth, the left side of the body is more stable, freeing the right hand for exploration.

The unnatural asymmetry of the mother’s body, moreover, can affect the fetus’s placement in the womb during its nine-month development period, as shown in **FIGURE 16D**. The most typical position of the fetus within the womb is unnaturally asymmetrical, for example, abnormally affecting its development, both before and after birth.

The word "pelvis" is Latin for basin, as shown in **FIGURE 16FE**. In the human body, that basin is piled high with our internal organs, as seen in **FIGURE 16GF**.

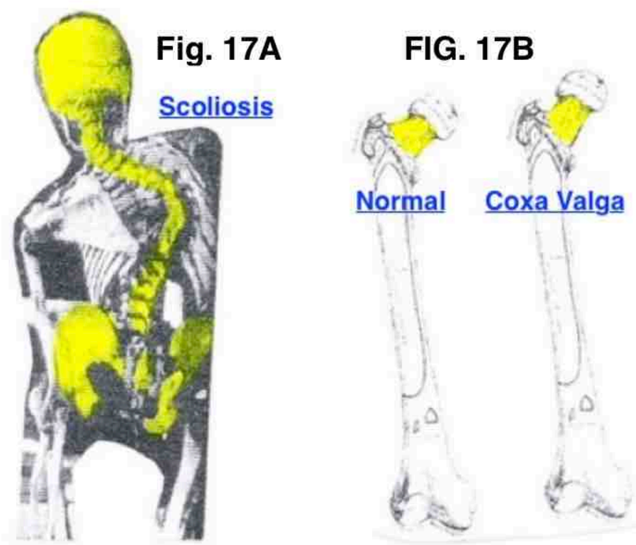


When humans tilt that basin into an abnormal backwards or forwards orientation, it would logically shift our intestines and bladder out of their natural positions, slowing down or even temporarily blocking passage of their contents. Heartburn, indigestion, gas, constipation, diarrhea, hemorrhoids, and incontinence are likely direct effects of the abnormal position of the digestive system. Sexual organs are similarly displaced and thereby subject to unnatural dysfunction.

This unnatural pelvic tilt is likely to affect adversely all of the other internal systems either contained by and/or supported by the pelvis. The other major and minor organs have a multitude of interconnections and interactions that are amazingly complicated and often quite delicate. The function of the interdependent systems of these organs is likely to be degraded in approximate proportion to the degree of abnormal pelvic tilting.

THE TWISTED SPINE OF THE MODERN RUNNER: A MILD VERSION OF SCOLIOSIS

The functionally twisted skeletal structure of the modern runner shown above in **FIGURES 7B, 9C & 9D** shows the early stages of the same kind of structural deformities that are found in a more exaggerated form in a disease called scoliosis, shown in the photograph of **FIGURE 17A**.



Scoliosis, in fact, provides an extreme case for what passes as "normal" in the abnormal modern human body. The twisting effect of shoe heels creates in most modern bodies a moderate version of the unnatural asymmetrical spine twisting seen in scoliois. The twisted spine is so common as to be "normal" in adolescents, with about half having a 5% to 10% thoracic curve even when young. Also, only 19% of non-scoliotic children had level shoulders. The widespread epidemic of back pain is the direct result of an unnaturally asymmetric spine: a condition affecting nearly 30% of all U.S. adults each year

In addition, scoliosis is associated with the femur neck inclination known as coxa valga. Coxa valga is a condition in which the angle of the femur neck is greater than 125 degrees, seen on the coxa valga femur in **FIGURE 17B**. Coxa valga is associated with hip adduction. Scoliosis is linked to hip adduction too, like the abnormally exaggerated hip adduction in running shown in **FIGURES 9A-C**.

UNNATURAL PELVIC TILT IS THE ONLY SOLUTION TO THE IMMOBILITY PROBLEM CAUSED BY SEVERE LEG CROSSOVER

The bizarre X-shaped legs situation shown in the **FIGURES 9C & 9D** photographs directly above is summarized in the drawings of **FIGURE 18A**. The mechanical action of shoe heels tilts inward both legs so acutely that they actually cross over each other (as shown in line drawing on the **left** of **FIGURE 18A**). For the human body to move forward without tripping over its own legs, at least one side of the pelvis must tilt down, so the feet no longer cross over (as shown in line drawing on the **right** of **FIGURE 18A**). The functionally short leg is loadbearing and the longer leg is non-loadbearing. This abnormal pelvic tilting enables forward motion and makes the legs more vertical.

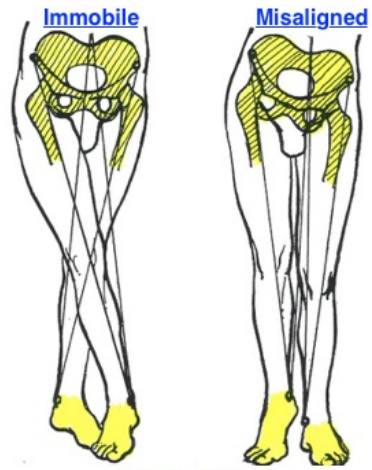


Figure 18A

Adduction deformity at the hip. When the legs are kept parallel as when walking, the pelvis displaces upward on the adducted side and causes apparent shortening. However, measurement of limb length from the anterior superior iliac spine to the medial malleolus of the ankle will reveal no loss of length.

In the photographs of **FIGURES 9A&B**, the running male demonstrates this typical pelvic compensation. To move forward, the runner's left pelvis tilts down, and this pelvic tilt effectively reduces the inward tilt of his left leg. The runner's right leg tilts in more and crosses over, under his center of gravity, while his pelvis remains level. This runner illustrates the most common male resolution to the major structural misalignment.

These correlations suggest the strong possibility that running with shoe heels is the underlying cause of scoliosis for those predisposed to the illness, predominately females, whose hips generally adduct more in conjunction with greater pelvic tilt, as shown in **FIGURE 18B**. The result is abnormal hips more prone to fracture.

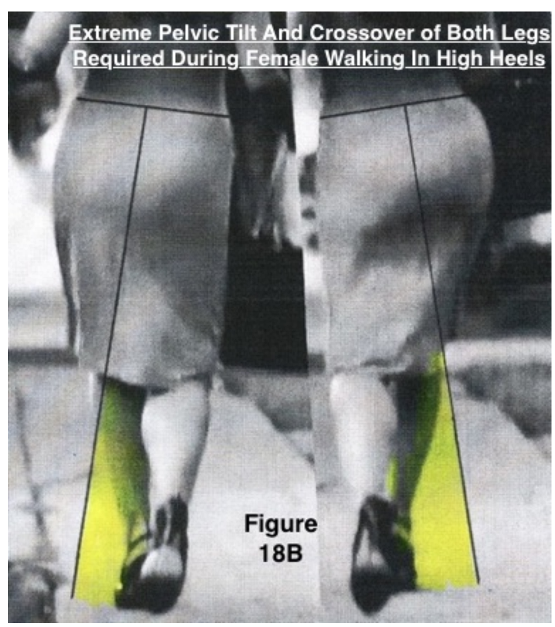
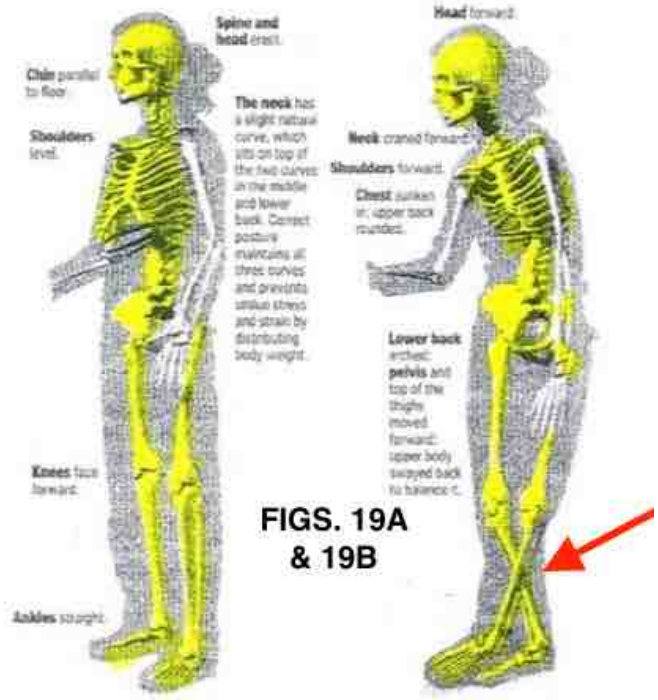


Figure 18B

Finally, the blind are not able to run and do not typically get scoliosis (or at least did not during the period before guide runners became an option).

THE TWISTED POSTURE OF MODERN RUNNERS LOOKS LIKE THE ELDERLY

Although severe scoliosis is relatively rare, aging effects posture in a similar way because of the long-term damaging effects of shoe heels. See **FIGURES 19 A&B** and note particularly the typically crossed legs shown in FIGURES 9C & 9D that are obviously a direct effect of shoe heel-induced supination and the resulting knee cant that was discussed earlier relative to FIGURES 4A & 7B.



FIGS. 19A & 19B

RESULTING ASYMMETICAL DEVELOPMENT OF THE HUMAN PELVIS, HIPS, MUSCLES, AND SOFT TISSUE ORGANS

As shown in prior Figures, the unnatural misalignment of the legs leads directly to severe leg crossover, which in turn frequently resolves itself in the asymmetrical development of the pelvis and the rest of the human body over a lifetime, both its skeletal and musculature structure and the soft tissue organs supported by it.

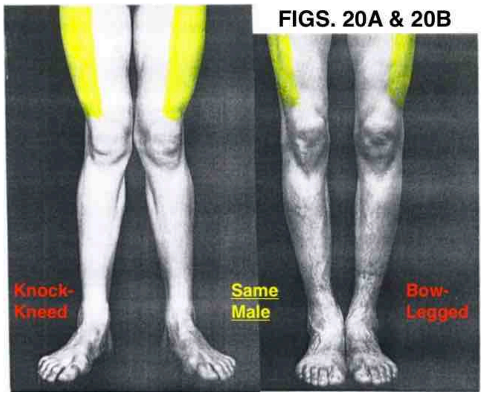
An excellent example of this is **FIGURE 19C**, which shows a pelvic transverse plane cross-section taken at the level of the hip joints of a male, aged 66. Note the severely tilted pelvis and extremely asymmetrical structure of the right and left hip joints (all shown in yellow) and the equally asymmetrical structure of the right and left leg muscles (shown in green on the sides and top of the hip joints), as well as the centrally located prostate gland in pink, with a potentially related cancerous patch in dark green.

A colored magnetic resonance imaging scan of a patient with prostate cancer. The enlarged prostate is visible in pink, and the cancerous tumor is the dark green patch on the prostate.
Science Picture Library/Science Source

MOST GENETIC DIFFERENCES ARE MINOR BUT EXAGGERATED BY SHOE HEELS

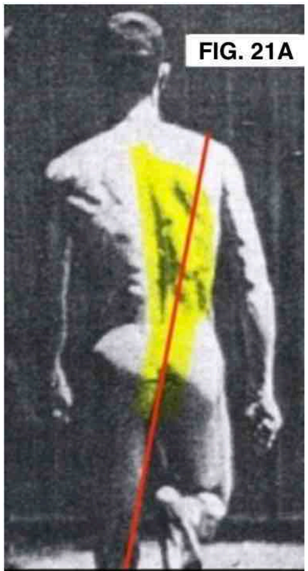
In the unique example below, the same individual Caucasian male demonstrates that a simple surgical **realignment** of his legs from **knock-kneed** with well-developed vastus lateralis thigh muscle **FIGURE 20A** (an alignment more typically found in those of African descent with lower longitudinal foot arches or pronated feet) to **bow-legged** with reliance on vastus medialis thigh muscle **FIGURE 20B** (an alignment more typically found in those of Caucasian descent with higher longitudinal foot arches or supinated feet).

FIGS. 20A & 20B



The only true genetic difference between the two is an otherwise inconsequential difference in foot longitudinal arch height, but that otherwise almost undetectable genetic distinction is made unnaturally exaggerated by elevated shoe heels.

FIG. 21A



Abnormal Chest Distortion Causes Unnatural Pressure on Heart

THE FIRST STAGE OF HEART DISEASE?

Running gives an early start to the misalignment deformities that we develop more fully in old age. The torsional distortions in the chest area are often substantial, as seen in **FIGURE 21A**, and they likely create unnatural pressure on the modern heart and eventually heart disease. Similarly, the stooped chest posture of the elderly, as seen in **FIGURE 19B**, and the increased thoracic spinal curves of males and females, as seen in **FIGURES 13B&C**, also are unnatural distortions that produce abnormally increased pressure on the modern heart.

The distortions in bone and muscle appear to be much greater on the right side. The focus of the distortions on the right side may generally protect the left side-oriented heart. Because the pelvis is tilts down substantially to the right, the spine is actually curved far to the left side relative to the pelvis, as seen in **FIGURE 21A**. Previous **FIGURES 7B & 9A** show the same unnatural chest distortion and pelvic tilt. These three figures all demonstrate substantial pelvic tilt, which increases the extent of overall structural abnormality, particularly in the thoracic region.

FIG. 21B

Heart

That abnormal torque and excessive pressure may focus directly on the modern heart, creating abnormally high pressure on the heart, with its highly complex and delicate plumbing network of valves and arteries, as seen in **FIGURE 21B**. That pressure unnaturally distorts and stresses the modern heart, especially at the midstance in the running stride when the body is subjected to a peak load that is a multiple of bodyweight.

A recent study has indicated that men who can do many pushups are protected against heart disease, apparently because the well-developed chest muscles required to do so counteract the asymmetrical breakdown seen in **FIGURE 21A**.

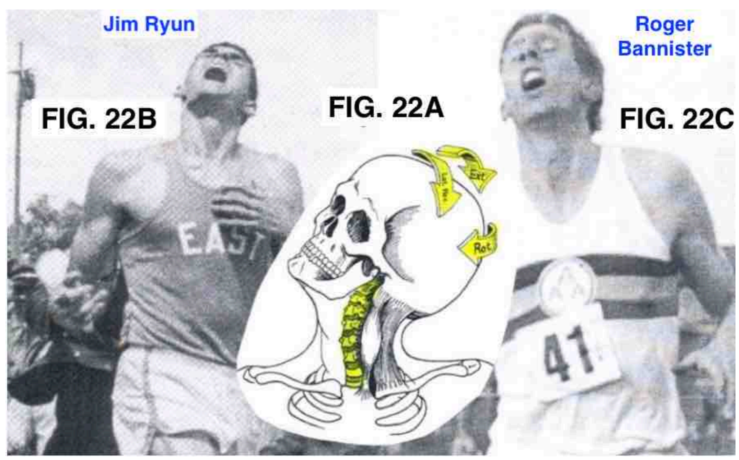
THE TILTED AND TWISTED MODERN HEAD

The human body part most unexpectedly affected by elevated shoe heels could be the part farthest away from the heels: the human head. The motion of the head while running with shoe heels exaggerates all the abnormally asymmetrical motions of the unnatural body beneath it.

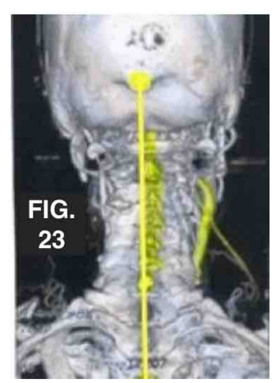
In effect, the skull is the tip of a skeletal whip in which the subtalar joint is the handle controlling abnormal motion. The natural stability system of the human neck – its highly complex structure of muscles, tendons, and ligaments, including its unique nuchal ligament – are overpowered by the excessive instability of the supporting body below it.

Instead of normal jiggling head motion that can be naturally dampened, the modern head is forced into gyrations that cannot be voluntarily controlled. Instead of a natural position, which would be vertical and forward-facing, the modern skull and the brain within it are twisted abnormally even in the most elite modern athletes in all three planes of motion (**FIGURE 22A**).

Famous photos of Jim Ryun (**FIGURE 22B**) and Roger Bannister (**FIGURE 22C**) setting world records in the mile both indicate abnormal, intensely twisted head motion. While these head motions may be extreme and only the occasional result of intense effort, they are actually just exaggerated examples of continuous everyday abnormal motion that has become structurally embedded over time. In somewhat reduced form, the unnatural tilting and twisting motion recurs repetitively on a routine basis throughout modern human life, especially in the early, formative years.



As **FIGURE 23** demonstrates, the asymmetrical position of the modern cervical vertebrae - bowing out to the right to compensate for the leftward tilt of the thoracic spine - becomes quite evident even when the body remains at rest in a stationary position. In addition, there appears to be an arterial aneurysm the right side, an abnormality indicating potential for a future stroke due to atherosclerosis. And **FIGURE 23** is just a typical example taken at random of modern neck structure.

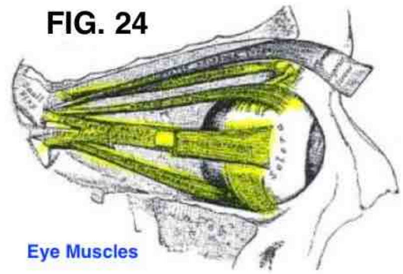


VISION & OTHER PROBLEMS IN THE TILTED AND TWISTED HEAD

Vision issues may help us understand the unnatural deficiencies inside the modern skull. The most common modern vision problem is near-sightedness (myopia), a condition which results from an abnormal elongation of the eye. The modern skull is typically bent backwards by the unnaturally excessive curve of the cervical spine. As a result, the force of gravity is directed more toward the rear of the skull, which will increase pressure on the back of the eye. That unnatural pressure over time gradually tends to lengthen the eye gradually over time, thus moving the retina at the back of the eye backwards and rendering images on it increasingly out of focus.

If the skull is also bent sideways, then that distortion creates asymmetry between the right and left eyes. Any other unnatural twisting motion will create the abnormal skull motion in all three dimensions. The result is asymmetry within either or both eyes (astigmatism), and as well as different levels of myopia in each eye. Note the complex and delicate structural arrangement of the muscles controlling the eye shown in **FIGURE 24**.

FIG. 24



Eye Muscles

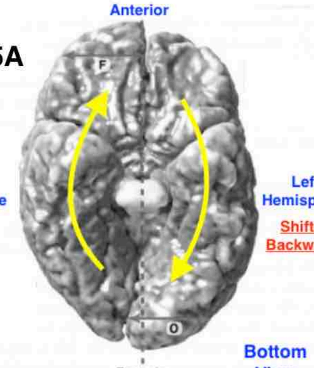
Similar mechanisms underlie all the other deficits inside and outside the skull. These adverse effects may involve the size and shape of the sinuses and associated problems such as a deviated septum, the malalignment of teeth, the malalignment of the jaw with the skull, and various hearing difficulties. There are, of course, no known direct causes for any of these listed head-centric problems. By default, the accepted current wisdom is that these deficiencies just happen; we are told, for example, that excessive reading causes poor eyesight, or that a congenital defect causes the deficiency.

THE MODERN BRAIN IS TWISTED LIKE THE MODERN KNEE

Base on the foregoing, it is even possible to speculate that ordinary elevated shoe heels have created a bilateral asymmetry in the modern brain, despite their location at opposite ends of the human body. Modern neuroscience had firmly established that the modern human brain has a shape and structure that is **<u>asymmetrical</u>, with the right hemisphere shifted forward and the left hemisphere shifted backward**. This modern brain asymmetry is indicative of the very same unnatural rotary torque that is built into the modern knee joint, as previously seen in **FIGURE 6A**.

The well-known structure of the **modern human brain** is shown in **FIGURE 25A**. The modern human brain is twisted, showing an abnormal built-in structural reaction to unnatural rotary torsion in the shifted positions of the

FIG. 25A

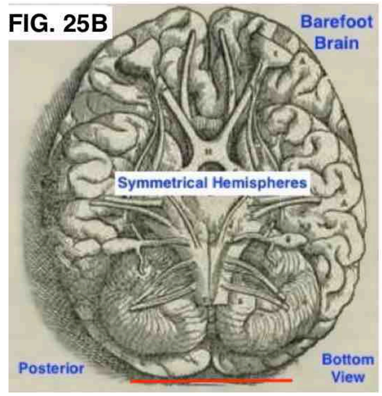


~~FIGURE 4.5~~ **Anatomical asymmetries between the two cerebral hemispheres.**
View looking at the inferior surface of the brain; note that the left hemisphere appears on the right side of the image. <u>In this computer-generated reconstruction, the anatomical asymmetries have been exaggerated.</u>

right and left hemispheres, as shown in a bottom view, with the right hemisphere shifted forward.

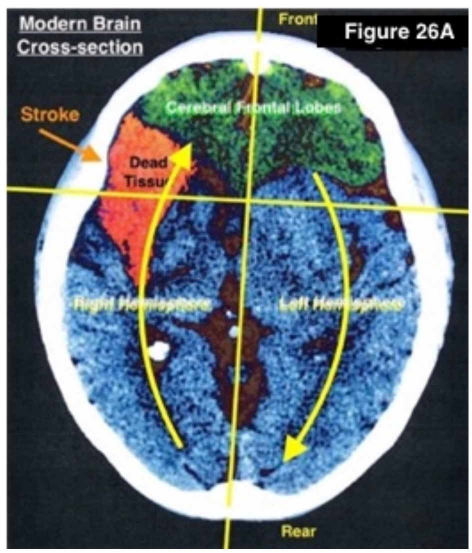
So, it is possible that the right hemisphere brain shift is either caused by elevated shoe heels or the degree of the shift is increased by them. If the shoe heel-based evidence already presented is not considered, it might be reasonable to assume that this brain shift is solely or at least partly due to the predominance of right-handedness. However, the only evidence available now does not support this explanation. Instead, the few pre-modern brain drawings in existence show highly symmetrical brains, albeit with a slight hemispherical shift in the opposite direction from modern brains.

In contrast to the modern brain shown in **FIGURE 25A**, **FIGURE 25B** is a drawing, from 1543 by Andreas **Vesalius**, which shows a bottom view of a **pre-modern, natural brain** that developed before the general use of elevated shoe heels. Unlike the modern human brain, Vesalius' drawing shows a natural barefoot brain with symmetrical hemispheres with no major shifting or rotary torsion, just a tiny, opposite shift forward of the left hemisphere, not the right. Other early brain drawings by Christopher Wren in 1664 and A.L.F. Foville in 1844 (likely without elevated heels) show similar structures.



STOKES OCCUR IN THE COMPRESSED HEMISPHERE

The soft tissue of the modern brain appears to be adversely affected by the abnormal twisting of its hemispheres due to ordinary shoe heels. **Stroke** is characterized by a portion of the brain which has died due to an abnormally reduced blood flow to it. As is evident in **FIGURE 26A** which is a CT scan of a stroke patient, the stroke has occurred in a brain with marked asymmetry between the **frontal lobes** of the right and left cerebral hemispheres (shown in green), in which their twisted positions evidence significant clockwise rotary torsion. The frontal lobes control the most complex intellectual processes of the brain.



Moreover, the portion of the brain tissue that has died (shown in orange/**red** on the left side of **FIGURE 26A**) is in the right hemisphere that has been pushed forward and compressed, probably subject to higher than normal pressure from abnormal clockwise torsion on a repetitive basis. The width of the affected right hemisphere is less than that of the unaffected left hemisphere, again suggestive of regular exposure to higher than natural compressive forces.

It is highly possible, obviously, that increased relative pressure on any portion of the brain would likely have an adverse effect on the flow of blood sufficient to induce brain stroke. The higher than natural compressive forces that are present in brains with asymmetrical hemispheres would produce that increased relative pressure. It is therefore reasonable to speculate that elevated shoe heels increase the occurrence and severity of brain strokes by increasing brain hemispheric asymmetry, as demonstrated previously.

DEMENTIA IS ANOTHER EFFECT OF ABNORMAL BRAIN ASYMMETRY

Artificially twisted brain hemispheres appear to play a major role in causing chronic traumatic encephalopathy (CTE) caused by repeated concussions (such as in American football). Strong evidence now indicates CTE is likely due to the sudden impact causing extreme tissue stretch by up to 50% of its normal volume on the principal network connection between the hemispheres, the corpus callosum (shown in **red** in **FIGURE 26B**). As a result, the corpus callosum is likely steadily weakened and deteriorates over time by this repetitive abnormal twisting of the hemispheres under sudden high forces.

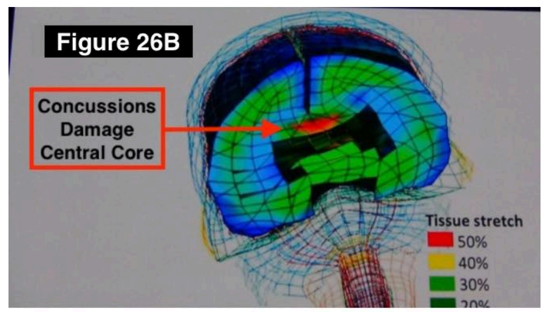


Figure 26B

The upper cross-section of **FIGURE 26C** shows a robust corpus callosum in a normal human brain. In contrast, the lower cross-section shows the severely damaged corpus callosum of a retired NFL football player with CTE. His corpus callosum shows more deterioration than any other portion of his brain.

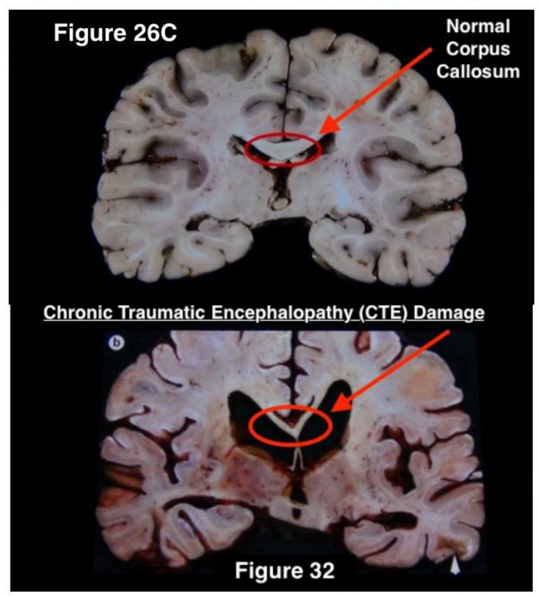


Figure 26C

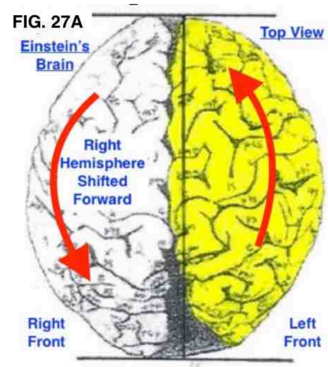
Figure 32

Other mental diseases, such as dementia, including Alzheimer's Disease and schizophrenia, addiction, anxiety, depression, obsession, multiple sclerosis, and Parkinson's disease, all may be worsened or even caused by the artificial twisting of the modern brain due to ordinary elevated heels. Perhaps even the Yips.

Other mental diseases, such as dementia, including Alzheimer's Disease and schizophrenia, addiction, anxiety, depression, obsession, multiple sclerosis, and Parkinson's disease, all may be worsened or even caused by the artificial twisting of the modern brain due to ordinary elevated heels. Perhaps even the Yips.

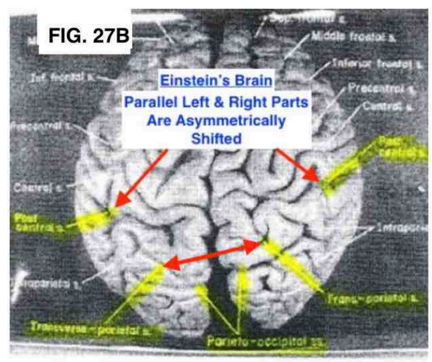
ALBERT EINSTEIN'S ASYMMETRICALLY BRILLIANT BRAIN

At least in some individuals, the possibility exists that this unnatural twisted asymmetrical structure of the modern brain inadvertently enhanced its highest level of mental functions, language and logic. The evidence suggests that the asymmetrical brain change includes an important increase in the size of the **left hemisphere's dorsolateral prefrontal cortex**, the specific part of the brain that handles its most complex mental functions.



The brain of Albert Einstein provides an extraordinary example of the possible value of brain bilateral asymmetry. As shown in a top view in **FIGURE 27A**, **Einstein's brain was bilaterally asymmetrical**, with unnatural counterclockwise rotary torque squeezing the right hemisphere forward and compressing it relative to the wider left hemisphere (in yellow).

The left hemisphere has expanded into a greater maximum diameter (crossing over brain centerline), allowing for an increase in size of the left hemisphere's critical dorsolateral prefrontal cortex – again, the location of the brain's highest intellectual functions.



Of course, the accuracy of any of the previously referenced centuries-old brain drawings remains unknown. However, Einstein's modern brain is carefully drawn from the published photograph shown in **FIGURE 27B** and is highly accurate. As is clear in the photograph, even component parts of his brain (in yellow) are substantially shifted between right and left hemispheres.

However, unlike the Einstein brain, there are no conclusive photographic or physical anatomical evidence for the pre-modern, natural brain. Therefore, the definitive anatomical structure on the symmetry or asymmetry of the pre-modern, natural human brain remains uncertain. However, modern technology, including MRI and other scanning techniques, as well as standard gross anatomy lab techniques, could easily be used to obtain such evidence by examining living and deceased members of the few remaining "barefoot" populations that have never worn shoes or elevated shoe heels.

IS IT POSSIBLE THAT ELEVATED SHOE HEELS IGNITED THE RENAISSANCE AND REFORMATION, AS WELL AS THE RISE OF MODERN SCIENCE AND TECHNOLOGY?

The substantial physical asymmetries of Einstein (and Steven Hawkings) suggest a possible correlation between modern brain asymmetry and exceptional intellectual ability, at least in some outstanding individuals. Remarkably, the historical period during which elevated shoe heels were introduced into use in Western Europe is the same period in which arose the beginning of modern science and technology that created the modern world. This might not be a coincidence.

Elevated shoe heels may have - in a totally inadvertent way - provided a brain enhancement to at least some individual modern humans that ignited the revolutionary explosion of technological invention and progress that occurred then. It is possible that it did so by enlarging the dominant left hemisphere, allowing for the accidental development of it as a more powerful and specialized uniprocessor instead of a parallel processing twin of the right hemisphere. Although the direct causation seems almost unimaginable, a logical possibility of it clearly exists, given the timing correlation. Sir Isaac Newton, for example, is shown wearing elevated shoe heels, but that could well be an anachronism. Clear evidence is lacking for now. Nevertheless, it remains possible that elevated shoe heels gave birth long ago to what has evolved into the modern geek.

THE LIMITING FACTOR IN MODERN MEDICINE: TREATING SYMPTOMS INSTEAD OF PROVIDING PREVENTION OR CURES

As I have already shown in detail, the elevated shoe heel bio-mechanism has degraded the structure and function of every part of the modern human body. The mechanism has changed the body from natural to abnormal, and from strong to weak. As a result, adverse health effects logically should occur throughout the modern human body, so it is difficult to imagine any human medical problem that the elevated shoe heel has not at least made worse.

The shoe heel's effect, however, may be even greater than we know. From arthritis to back pain, from heart disease to sexual dysfunction, even from cancer to constipation – in fact, with almost every non-infectious disease occurring throughout the human body – every one of these disorders represents a disconnected effect with no known direct cause.

The consensus of expert opinion is generally that these diseases just happen, many due to weakness in the basic design of the human body as it evolved haphazardly with a biologically unusual bipedal upright stance in locomotion, and therefore nothing more can be done other than to treat the unavoidable disease as optimally as possible.

In consequence, in the absence of an understanding of specific known causes or underlying aggravating factors, modern medical care must resort to trial and error methods – sophisticated and effective as they certainly are today – to treat the symptoms of disease, instead of directly curing or preventing the disease itself.

Most major human diseases today are not preventable and remain uncured, despite the constant introduction of a vast array of new medical technologies and drugs that do treat their symptoms far more effectively, but often at great expense. Those innovations in health care are very real and continual, and they save or improve countless lives, but they typically emerge as incremental advancements in care, rather than breakthrough cures or prevention.

I believe I have made a strong case here for a single unifying factor that accelerates or even initiates the progression of many of these non-infectious diseases. An unnatural physical weakness that results from the specific debilitating effects of shoe heels is the potential common link for many or even all of these disorders, allowing them to have an unnaturally greater adverse effect on the modern human body.

Even where the biomechanical effect of shoe heels clearly does not directly cause a particular disease, their effect may substantially weaken the body's ability to function naturally to defend itself, such as by degrading the immune system. Such an effect would make the body much more susceptible to infections or communicable diseases and unnaturally less able to fight them effectively.

Finally, elevated shoe heels have rendered the human body more vulnerable to all types of injury, whether from incidental accidents like ankle sprains, as I have shown in my first book, or from long-term overuse injuries, like repetitive stress injuries.

THE MODERN HUMAN BODY IS FRAGILE, BUT THE NATURAL BODY IS ROBUST, HEALTHY AND CAPABLE OF SUPERSTAR PERFORMANCE

Humans evolved barefoot, but in the modern world they are **mismatched** by that evolution with a critical part of their modern physical environment – elevated shoe heels. The result is the physical evolution-in-reverse of modern *Homo Sapiens*.

The few remaining barefoot hunter-gatherers still in existence are almost immune to most of the noninfectious diseases that kill or disable modern humans, as Dr. Daniel **Lieberman** notes in his book, ***The Story of the Human Body***. Liebermann notes that the limited study data available indicates that barefoot middle-aged and elderly hunter-gatherers (who typically live to an age between 68 and 72) remain remarkably healthy:

> ...[they] rarely if ever get type 2 diabetes, coronary heart disease, hypertension, osteoporosis, breast cancer, asthma, and liver disease. They also don't appear to suffer much from gout, myopia, cavities, hearing loss, collapsed arches, and other common ailments. …they are healthy compared to many older Americans today **despite never having received any medical care**. [emphasis added]

This remarkable conclusion echoes that from a study over three decades ago by a Canadian researcher and physician, Dr. Steven **Robbins**, and a colleague. This study surveyed the available literature on the injury history of barefoot populations. What Dr. Robbins found was that those barefoot populations representing genetically diverse human populations had far fewer overuse injuries than were typical of modern shoe-wearing populations. Even more remarkable was that this was far fewer injuries despite far higher activity levels on a routine basis, often including what would be called back-breaking work in the modern world.

It must be conceded that "survival of the fittest" is a selection factor in these barefoot populations that is largely absent in Western populations, due primarily to modern medicine.

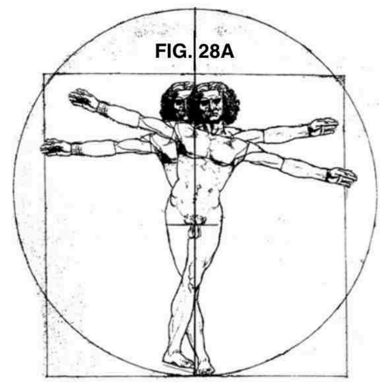
However, obesity plays a leading role in most diseases that are epidemic in modern populations and that obesity may be due mostly to lack of a normal of exercise – exercise in the form of running or walking made painfully difficult or impossible by the unnatural physical deformities caused by elevated shoe heels.

Finally, the difference between modern and never-shod humans is not limited only to health. Today's superstar athletes, who often seem capable of superhuman physical feats, are actually just providing a partial glimpse of what are likely to be the normal capabilities of the natural human body, one that is not artificially deformed by modern footwear. Free of such unnatural deformity, a chimpanzee – which is a 97% genetic match to humans – is more than twice as strong as a trained modern human weightlifter of the same weight, while experiencing substantially less muscle fatigue.

A CORRECTED PARADIGM FOR MODERN HUMAN ANATOMY

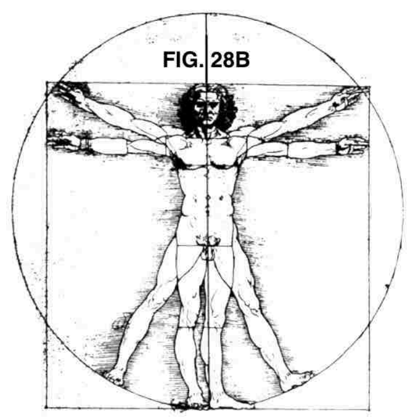
The heel mechanism has fundamentally changed the modern human body from symmetrical and robust to the asymmetrically deformed and fragile body shown in **FIGURE 28A**. The tilted and twisted modern body has abnormally bent-in legs that forcibly tilt an unstable, twisted pelvis. The result is an unnaturally bent-out spine and tilted-in head that is formed in the peak load running position during childhood growth, shown in **FIGURE 9D**, in which the bone and joint structure of the modern human body is deformed unnaturally by elevated shoe heels, in accordance with Wolff's and Davis's Laws.

FIG. 28A



The study of modern human anatomy must adopt a **new paradigm** of the human body. That new paradigm must be based on the understanding that the true natural structure and function of the **barefoot human body** is the natural norm – the bilaterally symmetrical, theoretically ideal body, shown in **FIGURE 28B**, that existed before elevated shoe heels came into widespread use. The existing anatomical paradigm - the modern human body deformed by shoe heels – must be redefined as an abnormal diseased state. The evidence uncovered in this investigation clearly points directly to a completely new and different understanding of what is normal in human anatomy, despite the conventional wisdom that gross human anatomy is the most settled of all the sciences.

FIG. 28B



The entire modern body is structurally destabilized and functionally impaired. Once those asymmetrical deformities are initially developed in childhood and adolescence during running with elevated shoe heels, they become locked into the bone and joint structure of adults, as shown in the modern knee example **(FIGURE 6A)**. These deformities become worse over time with continued running as adults, of course, but also become worse for older adults who only walk, even though walking did not create the original deformities. Once formed, the deformities continue to increase inexorably throughout adult life. They become fully evident in the unnaturally stooped posture of the elderly, for whom walking or standing is often difficult or impossible.

THE MORTALITY AND HEALTH COSTS OF A HUGE UNGUIDED EXPERIMENT INVOLVING BILLIONS OF INVOLUNTARY HUMAN TEST SUBJECTS

The cost of the resulting unnatural human deformity in lives and medical care is so enormous that it must initially seem difficult to believe. For example, since the artificial deformity obviously makes natural physical activity more difficult, it probably causes many, if not most, of the **300,000 deaths in the U.S. each year** that the CDC indicates are due to inadequate physical activity, as well as many if not most of the **5.3 million deaths worldwide each year** due to physical inactivity.

The artificial deformity is also likely to play a role in initiating or increasing the severity of most diseases, including type 2 diabetes, coronary heart disease, hypertension, osteoporosis, breast cancer, asthma, and liver disease. There is no data whatsoever available at this early stage of investigation, but it is not at all unreasonable to estimate that as many as a third of all deaths that occur in the U.S. each year are primarily due to the profound and pervasive effects of the artificial deformity, the total of which would be more than **900,000 deaths annually**.

Since there is also no available cost data, it is impossible to quantify the medical care costs of the artificial deformity with accuracy. But, again, if only a third of **healthcare** in the U.S. is directly or indirectly caused by the ubiquitous deformity, the associated cost would be about $**1.3 trillion each year**. Although it is currently impossible to base these cost and death estimates on actual data, they may be conservative estimates. That is because every part of the modern human body has the potential to be affected adversely, and potentially to a substantial degree, with wide variation among individuals and generally increasing steadily with age.

Although it is obvious that the artificial deformity of the bones, joints, and muscles of the modern human skeleton greatly increase orthopedic costs, it may be much less obvious that other body parts are also directly affected, including for example those farthest away from the foot – the head and its organs. The artificially twisted and unbalanced head substantially creates or increases disorders of the brain and mental health, mouth and dental, ear, nose, and throat and eye, thereby artificially increasing costs in ophthalmology, dentistry, audiology, neurology, and psychology, for example. All of the human body's soft tissues are at risk of some degree of deformity, which is often substantial, and resultant malfunction, often severe, due to unnatural structural support the modern human body caused by elevated shoe heels.

Furthermore, to the estimated medical care cost total should be added a **cost estimate of**

the total work loss (which would be about 20% of the direct medical cost, using as a basis the CDC estimate methodology used on the cost of falls) or about **$300 billion every year**.

The total estimate of the economic cost of the unnatural shoe-heel induced deformity would therefore be an astonishing $1.6 trillion every year in the U.S. alone. To put that in rather stark perspective, the total annual cost of all medical care in the U.S. is estimated to be about $4 trillion in 2021, which is almost a fifth of U.S gross domestic product, according to data from the Centers of Medicare and Medicaid.

Although this enormous estimate of the total economic cost of the unnatural deformity is shocking, and beyond belief due to its sheer magnitude, at least initially, the only available facts clearly support an estimate of that magnitude. In addition, the cumulative effect of elevated shoe heels on our general well-being may be even more costly. In the course of each of our lifetimes – but especially as we age – it seems likely that shoe heels drastically degrade our overall quality of life for many years, if not often for many decades, and that cost is beyond accurate measure, but would likely be in the trillions.

In a realistic sense, the shoe is on the other foot in terms of best estimating the true magnitude of the cost of the artificial deformity, given the total absence of accurate data. The catastrophic annual cost estimate of $1.6 trillion and 900,000 deaths is based simply on the automatic biomechanical interaction between the subtalar joint and elevated shoe heels and the inevitable anatomical effect of that unnatural biomechanism on the structure and function of the human body due to the inexorable operation of Wolff's and Davis's Laws – all of which are unchallenged in well-established empirical studies in the sciences of anatomy and biomechanics.

The real question then is, how can those artificial costs not be enormous even if not accurately known, given the existence of those laws and their well-known operation in the human body? Without doubt, it is a major medical catastrophe whatever its exact magnitude.

CONCLUSION

In summary, there really is no way to describe the untenable situation that all of us, as modern shoe-wearers, are trapped in, except to say that we unknowingly have been little more than **human Guinea Pigs** throughout our lives and remain so today. At least for now, we are all inadvertently trapped, involuntarily enrolled in a huge, unguided experiment in an artificial reverse-evolution that first began for each of us as a fetus in our modern mother's asymmetrical womb (unnaturally formed and functioning), then continued when we took our first infant steps in baby shoes, and continues uninterrupted today and into the future.

Each day our bodies become more deformed and farther away from their true natural state. For now, we know virtually nothing about how to stop or even slow that inexorable progression of deformity in all who have worn modern shoes. All we can do now is to prevent the deformity in our youngest children by avoiding the use of elevated heels in their shoes.

In conclusion, the modern human body has been substantially deformed – artificially by footwear, rather than preordained by genetics – resulting in unnaturally exaggerated anatomic differences between genetically diverse human populations and also between sexes. The cost in medical care and quality of life is enormous and unnecessary. This medical catastrophe apparently happened by happenstance through the routine work of cobblers and their modern equivalent through dozens of generations until today, all entirely ignorant of the enormous anatomical consequences of elevated shoe heels.

Based on the weight of the available evidence, there exists an unknown public health emergency of unprecedented proportions. There is no current understanding or effort whatsoever by any of the parties directly involved in the public health emergency – the footwear companies, the health care industry, and the biomechanics, anatomy, and other research scientists– to meet and overcome the hidden medical crisis that is ongoing every day in modern human populations everywhere in the world.

How the everyday shoe manages to create such widespread deformity in every part of the modern human body is the focus of my new book. What little is known and the research effort urgently needed now are outlined in greater detail there. A first draft of both the abridged book and the complete book are available at my website, **www.AnatomicResearch.com.**

POSTSCRIPT

MY RESEARCH HAS UNAVOIDABLY OCCURRED IN A RELATIVE VACUUM BECAUSE RUNNING RESEARCH AS IT CURRENTLY EXISTS IS FUNDAMENTALLY FLAWED AND INVALID AS SCIENCE

Unfortunately, accurate biomechanical studies of running are critical to understanding this major misalignment/ deformity problem of the modern human body and to develop effective treatments for it. However, every existing running study fails the most fundamental requirement of scientifically valid testing, which is to use only **randomly selected test subjects.**

Instead, all of the human test subjects of existing running studies are in effect cherry-picked from a tiny fraction of the modern human population, that fraction consisting entirely of elite runners or adult runners who are almost never injured while wearing conventional running shoes. Typically, test subjects must have been running injury-free for 3-6 months prior to any study.

With perverse irony, then, only those subjects who are least likely to be adversely affected by modern footwear are selected for testing in formal biomechanical lab studies. This is clearly unacceptable as valid science.

Moreover, none of these running studies attempt to investigate the actual injury biomechanisms that cause the widespread incidence of injuries. Remarkably, no formal peer-reviewed running studies have ever investigated the actual biomechanisms of running injury, the specific causes and effects, instead of merely observing correlations. Consequently, there has been no development of essential safety tests or effective industry standards for running shoes.

Simply put, this is not science. The results of such testing can therefore not properly be used as a valid basis for design of footwear consumer products.

Added to this complete lack of required randomness is another, equally glaring omission. **Pre-modern barefoot populations that have never worn conventional modern shoes also have never been formally tested in a modern biomechanics lab and certainly have not been tested using the latest joint measurement techniques of the Peltz study.**

This is tragic, because testing such barefoot populations using the techniques of the Peltz study would unlock the long hidden knowledge of the true biomechanical performance of the natural human body, with its intact anatomy unaffected by any possible artificial effect of elevated shoe heels.

Moreover, testing such never shod barefoot populations in direct comparison with genetically identical, but habitually shod modern populations would determine without question the reality of important modern human anatomical and biomechanical differences that must be serious abnormalities attributable directly to the elevated heels of modern footwear. The accurate modern testing required with such contrasting populations might be least difficult to accomplish in India.

Instead of this urgently required new testing, today the vast majority of footwear users are never tested in formal lab running studies. Consequently, from earliest childhood throughout adult life, their bodies have been subjected by the footwear industry to uncontrolled and unmonitored experiments using consumer products essentially untested by their actual users instead of grossly unrepresentative test subjects. To this, many other serious methodological problems must be added. As a result, the biomechanical data of existing running studies is without question not scientifically valid, and the conclusions based on that invalid data is seriously misleading, especially with regard to shoe sole design.

The invalidity of the basic scientific methodology used in all formal peer-reviewed running studies is analyzed in greater detail in the attached **APPENDIX**.

NOTE ABOUT THE AUTHOR

In 1988, Frampton Ellis developed the first barefoot-like athletic shoe soles and licensed the U.S. and foreign patents covering that sole technology to Adidas in 1994. Adidas quickly developed commercial versions that were worn by its athletic endorsers like Kobe Bryant and Steffi Graff beginning in 1996 and used it as the core technology in every category of Adidas footwear through the early 2000's. That history is described in greater detail on his company's website: www.AnatomicResearch.com.

In addition, his research, development and patent work in 1988-90 pioneered the use of deep sipes or grooves on the bottom surface of shoe soles to provide barefoot-like flexibility to a shoe sole. That siped sole technology has been used since the early 2000's in the extensive Nike ***Free*** line of athletic shoes, which has been widely copied throughout the footwear industry.

Today, he is the most prolific U.S. inventor of footwear sole technology by a wide margin, with over 50% more U.S. patents in the modern era since 1970 than any other inventor, including those at the largest athletic footwear companies like Nike and Adidas. All of his currently more than seventy-five footwear and footwear-related U. S. patents can be viewed on his website: www.AnatomicResearch.com.

At the same time, he has conducted extensive related research (much of which is summarized in the preceding article) in biomechanics, anatomy, physical anthropology, orthopedics, podiatry, physical therapy, and other fields.

In addition, he has an extensive portfolio of patents on a new basic hardware architecture for secure computers which can be viewed on another of his websites: www.GloNetComp.com.

He has been a member for the past dozen years of the Intellectual Property Committee of the Institute of Electrical and Electronic Engineers (IEEE-USA), a former member of the Board of Directors of the Intellectual Property Owners Association (IPO), and a founding member of the Inventors Network of the Capital Area (INCA).

ENDNOTE

Peltz, C. D., Hakadik, J. A., Hoffman, S. E., McDonald, M., Ramo, N. L., Divine, G., Nurse, M. and Bey, M. J. (2014). Effects of footwear on three-dimensional tibiotalar and subtalar joint motion during running. ***Journal of Biomechanics*** 47, 2647-2653, **Figures 4, 5, 7 & 8**.

Note 1: As noted on page 2648, column 2, of Peltz, 3D rotations shown in the graphs below are of the **ankle or tibiotalar joint** are of the talus (ankle bone) relative to the tibia (shin bone)

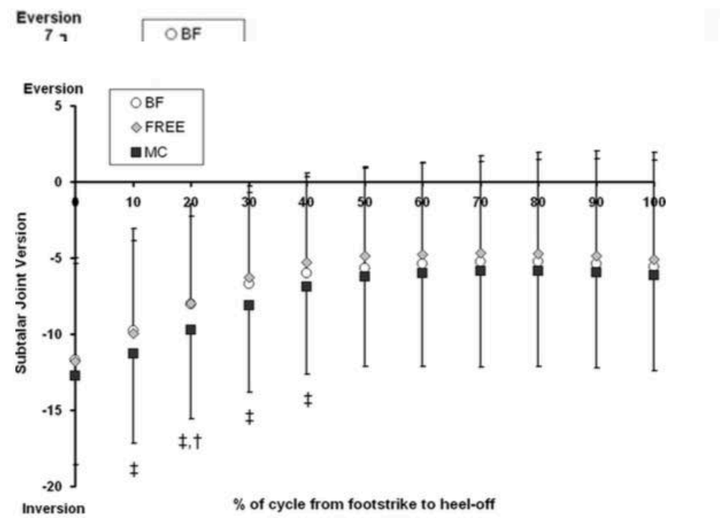


Fig. 7. From 10 to 40% of the early stance phase, the subtalar joint was more inverted in the MC condition than the FREE condition. At 20%, the subtalar joint was also more inverted in the MC condition compared to the BF condition († $p < 0.017$ when BF compared to MC, ‡ $p < 0.017$ when FREE compared to MC).

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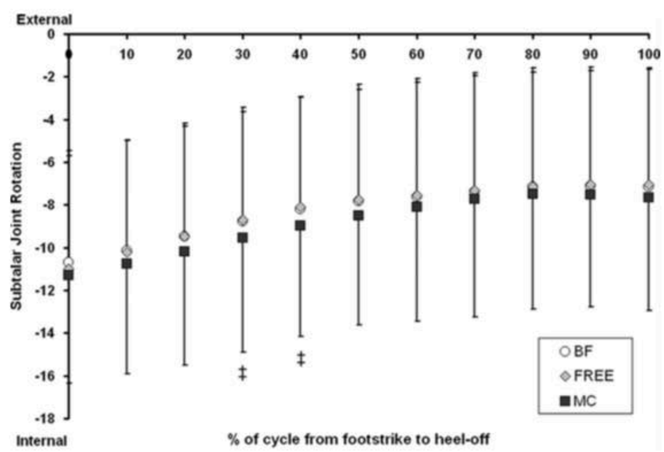

Fig. 8. The only differences in IR/ER at the subtalar joint were at 30–40% of the early stance phase where the MC condition resulted in more internal rotation compared to the FREE condition (‡ $p < 0.017$ between FREE and MC conditions).

Note 2: As noted on page 2648, column 2, of Peltz, 3D rotations shown in the graphs below are of the **talocalcaneal or subtalar joint** are of the calcaneus (heel bone) relative to the talus (ankle bone)

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RESEARCH NOTE:

I should also include here a note about the extent of my research effort related to the heretofore ignored issue of shoe heel-induced subtalar joint supination. I have conducted over a period of many years a comprehensive analysis of all related peer-reviewed research I could locate in many different disciplines like biomechanics, anatomy, orthopedics, podiatry, physical anthropology, archeology, and many other fields, including a number of articles available only at the Library of Congress and the National Library of Medicine, not online. The **Endnotes** of my unabridged book now totals over 75 pages, mostly listing the many peer-reviewed articles I reviewed and concluded were relevant to this investigation, and specifically noting the exact pages and/or specific figures that were considered most relevant. Far more articles were reviewed and deemed not sufficiently relevant to include in the Endnotes.

LIST OF FIGURES:

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Figure 6C Top views of tibial plateaus (middle photos) from India from Figure 2, page 139, from Kate, B. R. & Robert, S. L. (1965). Some observations on the upper end of the tibia in squatters. In the ***Journal of Anatomy***, Lond. 99: 1: 137-141.

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Figure 28A Modified Leonardo De Vinci sketch known as "***The Vitruvian Man***" (c. 1485), showing the *abnormal, unnatural general cross-over structural position of modern legs and hip joints, as well as* showing the effect of the unstable pelvis, which results in a bent-out spine and tilted-in head.

Figure 28B Unmodified copy of Leonardo De Vinci sketch known as "***The Vitruvian Man***" (c. 1485), Accademia, Venice.

APPENDIX

VALID FOOTWEAR RUNNING STUDIES ARE CRITICALLY IMPORTANT FOR A CORRECT UNDERSTANDING OF MODERN HUMAN ANATOMY, A NECESSARY REQUIREMENT FOR EFFECTIVE MEDICAL CARE, BUT ALL EXISTING STUDIES HAVE MULTIPLE FATAL FLAWS IN THEIR MOST BASIC SCIENTIFIC METHODOLOGY

Introduction

Evolutionary biological studies indicate that the human species was "born to run." Human skeletal and joint structures are optimized to run. According to Wolff's and Davis' Laws, those bone, ligament, and cartilage structures are continually remodeled throughout life by the greatest loads to which they are repeatedly subjected. Those maximal loads occur repetitively in every running stride and are about three times body weight. During the critical period of childhood growth, those highest recurring loads occur millions of times.

During that growth, the unnatural joint misalignments caused by elevated shoe heels create bilateral asymmetries throughout the bipedal skeletal and joint structure of the human body and that asymmetrical structure supports all the organs within it, distorting their form and function, and the innumerable connections between them. Over a lifetime, those asymmetries become locked-in and slowly develop into ever increasing abnormal human deformities. Those deformities may be the underlying causes of many serious modern diseases, such as osteoarthritis, osteoporosis, type 2 diabetes, coronary heart disease, strokes, cancer, and many others.

Therefore, accurate biomechanical studies of running are critical to both understanding and alleviating this serious human anatomical misalignment/deformity problem. However, despite being peer-reviewed, **every existing formal running study fails the most fundamental requirement of scientifically valid testing, which is to use <u>randomly selected test subjects</u>.** Instead, all of the test subjects of existing running studies are in effect cherry-picked from a tiny fraction of the modern human population, the fraction consisting entirely of elite runners or adult runners who were not injured before or during the test, and typically were not injured for at least six months prior to testing. Ironically, then, **this obvious <u>selection bias</u> results in only those subjects who are least likely to have been adversely affected by modern footwear defects being selected for testing in formal biomechanical lab studies**.

Putting it in evolutionary terms, only the few surviving healthy runners are tested. Consequently, knowledge about the injuries of the many non-runners – the vast majority of the adult human population – and their biomechanical difficulties when running is non-existent. **Perhaps worse, no formal biomechanical lab study on running has ever used <u>a scientifically valid control group</u>, the use of which is the other most fundamental requirement of the**

modern scientific method. The only valid control group must be drawn from never-shod humans, not from habitually-shod humans, as is the existing standard testing procedure. That is the only way possible to prove the existing convenient but questionable assumption upon which all existing running studies are based.

Suspending Wolff's and Davis' Laws without any basis for doing so, those studies all assume that the artificial structure of conventional shoe soles have no actual effect on the natural development of bones and joints in the modern human body. Instead, there is a substantial evidence (already presented in detail) from a multitude of different sources that the structural and functional anatomy of modern humans has been seriously deformed by elevated shoe heels. This is not poor science, it is not real science at all.

To correct this major scientific oversight, never-shod humans must be formally tested for the first time using the equipment of a modern biomechanical lab, including use of the latest joint measurement techniques demonstrated in the Peltz study. Testing the never-shod would unlock long hidden knowledge of the actual biomechanical performance potential of the natural human body, its intact anatomy unaffected by any possible effect of elevated shoe heels.

In addition, those never-shod humans should be tested in direct comparison with genetically similar habitually-shod populations, the results of which would definitively indicate the biomechanical and anatomical differences attributable to modern footwear with elevated heels. Furthermore, test subjects from both groups should include roughly equal numbers of males and females, and the study results should include a breakout of sex-specific data for never and habitually shod groups.

To these two most basic deficiencies in all existing biomechanical research studies on running – non-random sampling and lack of a valid control group – many other serious methodological problems must be added. The studies are not double-blinded nor placebo-controlled. Studies are rarely replicated to verify their validity. Single-limb testing prevails generally despite the well-documented prevalence of significant bilateral asymmetry. Biomechanics laboratories are too small, poorly equipped, and understaffed due to massive underfunding. Research is narrowly focused on very limited empirical results due to the technical complexity and resultant cost of comprehensive human motion measurement. Absence of comprehensive theoretical research focused on analyzing empirical results. Ignoring the specific effects of footwear sole structure used in testing by failing even to identify the shoe brand and model, much less to define them in a meaningful structural way. Inherent potential conflicts of interest for researchers. Finally, a compartmentalized and insular research culture rigidly resistant to ideas outside the established norms or from different professional specialties.

As a result of this multitude of deficiencies, there can be little doubt that the biomechanical data of existing running studies is not scientifically valid, and any conclusions based on that invalid data is probably misleading. Representative groups of the vast majority of footwear users have never been tested. Consequently, from earliest childhood throughout adult life, the bodies of billions of users worldwide have been blindly subjected by the footwear industry to uncontrolled and unmonitored experiments on a massive population-wide scale using essentially untested footwear products.

In spite of a formal peer-review process, which may only serve to provide the appearance of valid scientific methodology, the existing biomechanical study of running does not meet the most basic standards of valid scientific research, and, as a result, footwear soles worldwide have remained structurally defective with serious health consequences.

An Unusually Large Sample Size, But Highly Selected Instead of Random

One of the best running studies of recent years in technical terms illustrates this fundamental problem. The study led by Steffen Willwacher won the Nike Award for Athletic Footwear Research, the highest award presented in 2015 at the XIIth Footwear Biomechanics Symposium in Liverpool, UK, a biannual conference sponsored by the International Society of Biomechanics.

To its credit, the study's sample size is much larger than a typical biomechanics study, which generally includes only a very small number of test subjects, and it does include nearly equal numbers of both males and females, which is also not a standard protocol.

I must unfortunately also note, however, that the runners studied were all middle-aged. This means that on a de facto basis the subjects are highly selected biomechanically, since it is likely that most of them have remained runners after surviving many years of annual injury rates that reach as high as 70% in the active running population.

The study, moreover, limited its runners to those who had been injury-free for at least the past six months. This prolonged good health renders them highly unique indeed, again given the typical 70% annual injury rates.

The study, in short, failed to randomly select its test subjects. The subjects did not reflect the overall population, even within their age group. The study instead selected highly filtered, elite winners who had triumphed in a lifelong "survival of the fittest" race in an age group in which the majority of runners have become former runners.

A truly random study of subjects in this age group would likely include only a small percentage of active runners among all the test subjects to be studied randomly. That is, of course, why this study and all other running studies are never randomized and therefore cannot at all represent the overall human population.

This problem has serious consequences. Without random test subjects, no existing biomechanical studies on running can possibly examine the progressive effects of elevated shoe heels or other structural problems on the general human population, especially in different age groups from childhood to elderly.

It would be expected with considerable confidence that these effects are generally much more adverse – with much greater abnormal distortion of bone and joint motion and

structure – in the general population than the relatively elite runners invariably used as test subjects.

On the positive side, the unique cross-section of older runners in the Willwacher study does provide a rational guide to interpreting its results. It is reasonable to conclude that the middle-aged runners' relatively straight-to-slightly-valgus legs under maximal load during running midstance enabled them to avoid injury and continue running far longer than typical of active runners.

Even so, Willwacher's data shows the runner's knee torqued into an unnatural varus position. Long-term runners with few injuries have bodies that seem to compensate, however, with a moderate foot pronation that offsets the abnormal knee torque caused by shoe heels. World class running champions demonstrate the same relatively straight-to-slightly-valgus legs.

An informal trip walking around any shopping mall, however, will convince you that the overall population does not enjoy this structural advantage, even under the much lighter maximal load of walking. A large portion of the males are significantly bowlegged when walking (while bearing a bodyweight load only one third of that experienced running), and a similar portion of the walking females are significantly knock-kneed (as I have discussed in detail earlier).

"A Fundamental Breakdown in Biomedical and Biomechanical Research"

A featured article with the above title appeared in ***The Wall Street Journal*** (April 7, 2017). Foremost among the studies it references is a study titled "**Why Most Published Research Findings Are False**," (***PLOS Medicine***, August 30, 2005) by **John Ioannidis**, a renowned epidemiologist and health-policy researcher at Stanford University.

His well-known study notes that, unlike drug studies involving humans, "The problem is especially acute in laboratory studies with animals, in which scientists often *just use a few animals and fail to select them randomly*" (italics added).

Human biomechanical studies on running in shoes have exactly the same problem: the animals are human Guinea Pigs, who have not been selected randomly from the general population. The studies ignore the injured, recently injured (in the past three to six months), or non-active runners, who together comprise the vast majority of the general population. This fatal omission renders their research results inherently suspect and probably misleading.

The adverse biomechanical effects of modern shoes that have made non-runners out of most of the adult human population (and non-walkers out of many), despite evidence that they were born to run, have never been formally researched and therefore remain unknown today.

[For more on the validity problem in modern research, see also Randall, David and Welser, Christopher (2018). **The Irreproducibility Crisis of Modern Science**, National Association of Scholars. April, 2018.
www.nas.org/images/documents/NAS_irreproducibilityReport.pdf.]

The Almost Universal Bilateral Asymmetry of Test Subjects Is Ignored in Studies

In addition, even the prize-winning Willwacher study only tests and provides results for one leg and ignores the other leg on the apparent assumption that both legs are the same. This assumption is almost universally made in human running studies.

That convenient assumption, however, has been highly questionable because even early running studies documented significant bilateral asymmetry, first in the 1970's by Steven Subotnick and then in the 1980's by Peter Cavanagh, both pioneering leaders in the field of running studies. Moreover, that assumption has now been definitively proven wrong. A recent study by K. N. Radzak clearly indicates that the right and left legs and their respective ankle, knee, and hip joints are in fact decidedly asymmetrical in range of motion and apparent function.

Of course, it is easy to understand why most studies have been limited to only one leg: it is difficult enough to evaluate all the data points needed from just one leg in order to adequately measure its function. To assess both legs, and then correlate the differences between them - while optimally also correlating those leg differences with data points from other structurally important parts of the body, like the pelvis connecting them – is a herculean task. However, not doing so leads to the fundamental misunderstanding of research results illustrated by the parable of the blind men and the elephant discussed relative to FIGURE 7B.

As wearable electronic technology with ultrawideband (UWB) wireless network connections continues to evolve between smartphone, sole and body part sensors, configurable sole structures, and/or with smartphone also connected to cloud computer systems employing massive data analytics powered by artificial intelligence, that complexity problem will become much easier to solve. The necessary technology has continued to evolve at a high rate steadily over decades. Until now, though, the complexity has been overwhelming and attempting to overcome it too costly to be economically feasible.

Missing Running Injury Studies: None Have Ever Looked for The Actual Biomechanisms That Cause The Widespread Injuries

Existing running studies do not attempt to investigate the actual injury biomechanisms that cause the very high incidence of injuries that has existed since at least the 1970's. Remarkably, no formal peer-reviewed running studies have ever investigated the actual biomechanisms of running injury; that is, the specific causes and effects, not just observations of correlations. As ludicrous as it may sound, these formal lab studies only ever test runners who have remained uninjured at least for a significant period of time and are therefore unlikely to be injured during the study.

Moreover, many moderately injured runners could still run with little or no pain in controlled test conditions. It is reasonable to expect that doing so would be useful in diagnosing the special biomechanical problem underlying the injury, but that never happens either. It follows that there has been no development of important safety tests or basic industry standards for running shoes.

It is difficult not to conclude from the published record that apparently neither the footwear industry nor academic researchers have any real interest in investigating running injuries to find their true causes. I say this having reviewed thousands of running studies over the many decades. Certainly, there have been no important injuries studies that have had tangible impact on the footwear designs of the industry.

Underfunding of Biomechanics Makes Its Basic Mission Impossible to Achieve

That brings up another fundamental scientific deficiency in biomechanics research, which is that it is so drastically underfunded that it is impossible to accomplish its basic scientific mission. There is not a single biomechanics laboratory in the world, including at any of the shoe companies, sufficiently equipped and staffed to investigate the level of complexity of critically important data, so much of it is being ignored in current studies.

Neuroscience and astronomy, for two examples, receive vastly more research funding today than gross human anatomy or the biomechanical study of the human body in motion, particularly the science of running, despite the need for reliable answers to the urgent questions raised in this analysis.

Until a few decades ago, ***Business Week*** reported annually on the relative level of R&D performed by major companies. The dominant footwear companies were always at the bottom of the list at about 0.3% of revenues compared to U.S. industry average of about 3.6%. Moreover, virtually all of that extremely low level of footwear in-house R&D was dedicated to the development of commercial products, not to research, and certainly not to basic research. In contrast, at the same time the footwear industry spent about 40 times more on marketing than on R&D.

I included the issue of this gross R&D imbalance in an analysis of the lateral instability of footwear sole structures that I distributed to with many officials in the footwear industry in 1992, following up on an article on my footwear research and development that appeared in **The Wall Street Journal**.

Unfortunately, ***Business Week*** stopped publishing its R&D summary a few decades ago. The largest company in the footwear industry, Nike, did not publicly discloses its R&D or its marketing expenses in its online 2020 annual financial report. The second largest company, Adidas, has disclosed R&D expenses in 2020 of about 0.6% but what it counts as R&D is not disclosed and probably includes no real basic research, since there is little evidence if any of it in publicly published studies.

This consistent lack of interest in in-house basic research carries over to the industry's lack of funding for basic research done either by academia or independent consultants. Instead, all of the industry's funding apparently is focused on commercial product development. The footwear industry's R&D appears to be almost all commercial Development and no basic Research.

The important Peltz et al. study, funded and led by Nike, is itself a prime example of this laser focus on development over research. The running study compares barefoot and conventional motion control running shoe to a new flexible minimalist running shoe, both shoes being commercial products of the shoe company that sponsored the study. Based on the stated hypothesis, the study was undertaken in the expectation that it would show that joint motion data for the minimalist shoe and barefoot conditions would be similar and both would be different from the motion control shoe. However, the study's data indicated similar results for all three conditions, thereby failing to support the commercially-based hypothesis. The was what the Peltz study reported as its principal finding.

At the same time, the Peltz et al study completely overlooked the amazing basic research data made available by its use of the new gold standard joint measurement technology. The data included the first unequivocal evidence that, for habitual shoe-wearing populations, the subtalar joint was substantially supinated throughout the landing and midstance phases of running, even at peak load – not pronated as all previous studies inaccurately indicated.

Summarizing the current situation, formal basic research on the biomechanics of footwear, and specifically on engineering the basic architectural structure and biomechanical function of shoe soles, is essentially non-existent. Despite the enormous growth of the footwear industry and its development of high technology in every other aspect of its commercial footwear products, its basic architecture of its sole is astonishingly ancient, but universally accepted without question.

Of the two most fundamental structural features of modern shoe sole design, one is at least two thousand years old and the other is about five hundred years old. However, unlike the wheel, based on the theoretical concept of perfect roundness, the basic design of footwear soles is so flawed as to be biomechanically inexcusable under the most cursory of examination techniques, much less with the sophisticated testing technology that should be used, but has not been, except in the 2014 Peltz study.

Inherent Potential Conflicts of Interest

Biomechanical research is heavily dependent on the footwear industry for funding. Although most published research is done at academic institutions, with the facility and staffing funded at a basic level by the institution, virtually all discretionary funding for researchers comes from the footwear industry.

The most senior academic researchers, who control the basic direction of all biomechanical academic research, receive a substantial part of their personal income directly from the industry as consultants and as expert witnesses for the industry in costly litigation. In addition, many former footwear industry senior researchers work as independent consultants to the industry, as expert witnesses in industry litigation, and in other roles where they are obviously dependent on the industry for continued employment.

As a result, despite many exceptions, there is an inherent bias for many senior researchers in biomechanics to be reluctant to take their research in directions that might be regarded by the footwear industry as confrontational to its interests. This is a classic example of an inherent potential conflict of interest. It seems unavoidable in the strictly limited funding situation of footwear biomechanical research, as now controlled and structured by the footwear industry.

Max Planck's Identification of the Main Hurdle to Acceptance of New Scientific Paradigms

It is commonly accepted that new scientific theories which challenge the existing paradigm are generally not accepted by the old guard of scientists. The general problem was described by Machiavelli in ***The Prince*** (1513).

> There is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things. For the reformer has enemies in all who profit by the old order, and only lukewarm defenders in all those who would profit by the new order. This luke-warmness arises partly from fear of their adversaries who have the law in their favor; and partly from the incredulity of mankind who do not truly believe in anything new until they have had actual experience of it.

I have vetted my work at the various stages of development for the past six years with many of the leading biomechanical scientists, most of whom I have had working relationships at various times over the past three decades. This vetting has been done both formally and informally.

Their reactions have been uniformly negative, but only on a general, overall basis. When pressed for specific objections that are based on peer-reviewed study evidence, they have produced nothing. To date, absolutely nothing. (In contrast, all of my investigative work includes a very large number of the peer reviewed studies, which are all laboriously cited, including an extra, non-standard step of also citing particularly relevant pages and figures in the studies.)

On the other hand, when I have presented my work to mid-level or young researchers, they are mostly positive. I think the glaring difference between reactions may have been explained previously by Max Planck, the originator of the quantum theory, whose own struggles with the acceptance of his theory seem to describe a similar situation:

> A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it.

However, in comparison to the quantum theory, my work presents far less of an intellectual challenge to anyone, so I remain optimistic that it will not be necessary for these elder statesmen of biomechanics to actually die for their obsolete perspective to be replaced by a more accurate one. I remain hopeful for their eventual conversion, since my work is certainly far less incomprehensible than quantum mechanics.

Their initial reluctance may derive from the fact that, in hindsight, I think my work is fairly simple and obvious. It is therefore inherently embarrassing for them as the premier experts in biomechanics to have missed the obvious (especially since I am not even a trained biomechanics scientist, yet somehow as an outsider I did not miss it).

But in their defense, it is a well-established truism in science that what is obvious in hindsight is all too typically impossible to see before it is discovered and described, especially for those in whom the existing paradigm is embedded all too well. Their oversight is a classic case of not being able to see the forest for all the trees. Whereas, as a relative outsider without the formal biomechanical training necessary to examine the individual trees in detail, I think I could see the forest clearly enough.

"Form Follows Function" is Largely Ignored in Running Biomechanics Research

More to the point, unanswered is the question of why it is not important to at least measure shoe soles stationary in the frontal or coronal plane prior to studying pronation and supination during running. Footwear sole structures vary widely in thickness, material density, width, and shape in the frontal plane, and they typically vary from one frontal plane section to another, and do so many times throughout the length of the sole. Yet these variations are almost never accounted for, even partially, in peer reviewed published studies, and never in rigorous detail.

The structure of footwear soles is a critical but unknown variable in running biomechanics research, even in its most easily measured form: that is, its pre-test stationary condition. That omission means that all existing running biomechanics studies are insufficiently complete and therefore cannot produce reliable conclusions.

"Form follows function" is a truism in functional design, but the actual form of a shoe sole – that is, its structure – is almost always ignored in running biomechanics studies. The majority of such studies do not even mention the specific shoe model or models used in the study. None specify the parameters of the structure of the shoe soles in detail, which is the actual physical structure directly supporting the running foot being studied.

Nor, for that matter, is the actual structure of the wearer's foot or shape of the wearer's foot sole ever measured in any way in these running studies, even for basic size, much less for the foot sole's overall shape or its bone and joint structure compared specifically to the supporting structures of the shoe sole in a stationary condition.

Nor is the wearer's foot structure ever correlated in any way with corresponding shoe sole structure, even for basic fit, but much less for the dynamic interaction between the two during running. If any shoe companies do research on any of these issues, their results are not public, but probably are not done, since they are not replicated in the few studies published by these companies.

Conclusion

Although the science of biomechanics generally uses all the latest technological tools provided by modern technology, its peer-reviewed studies on running and footwear cannot be accepted as scientifically valid. Rather, they are all incorrect, incomplete, and misleading for a substantial number of methodological reasons, but two of the most fundamental stand out as most damning.

All of these studies are based, with incredibly perverse irony, on using test subjects selected from the very tiny elite fraction of the modern human population who are seldom or never injured and therefore the least adversely affected by the flawed basic design structure of modern footwear soles. Consequently, these existing running studies ignore the vast majority of all other footwear users, particularly the one third of the population who are the most severely damaged by conventional modern footwear, and ignore the actual injury mechanisms.

Just as important, none of these running studies include a valid control group, which must include barefoot test subjects who have never worn shoes, so that any long term effects of modern shoe soles can be excluded from the study. Many other critical methodological problems also exist. However, correcting these basic problems cannot be undertaken comprehensively without fundamental financial restructuring because the science of biomechanics is currently far too underfunded to do so. In large part, that is because the major footwear companies neither conduct nor fund basic biomechanical research on shoe sole structure and function.

Despite a formal peer-review process, the critically important biomechanical study of running does not meet the most basic standards of valid scientific research. Consequently, modern footwear is structurally defective, causing major adverse effects to human health with substantial financial costs and reduced quality of life that are easily avoidable.

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