HIDDEN IN PLAIN SIGHT:
Elevated Shoe Heels Have Deformed The Entire Modern Human Body

This is a short, nine-page summary of an investigation into the unanticipated effects of a heretofore unexplained anomaly in human anatomy. At the time of its 1939 disclosure in the ***Lancet***, the anomaly was apparently considered so trivial that it was largely forgotten soon after and has remained so.

The unexplained anomaly is this: footprints are the same between individuals from different human races who have never worn shoes (**FIGURE 1A**); in contrast, a modern human foot that is subjected to the everyday use of modern shoes is rolled to the outside into a **supination** position (**FIGURE 1B**).

This overlooked anomaly strongly suggests that some attribute of modern shoes alone causes an actual physical deviation in the modern foot. My detailed analysis of published data from a 2015 **ISB** prize-winning biomechanical study by **Steffen Willwacher et al.** in ***Footwear Science*** has produced new and accurate experimental confirmation of that deviation: an average of about **6° of artificial, shoe sole-induced supination** occurs during midstance in running for 222 male and female subjects in modern running shoes.

Furthermore, the **decoupling** of calcaneal/tibial motion observed during running is shown to be directly caused by this artificially-induced supination. It partially counteracts the normal coupling that would otherwise occur naturally. The **6°** supination also interrupts the natural equilibrium between joint forces and creates an abnormal instability that must be compensated for within each runner's body. It forcibly creates idiosyncratic preferred paths of joint motion with unnaturally large ranges of variation.

My result of about **6° of shoe sole-induced supination** during midstance while running is in basic agreement with the landing position of the foot while running, which is about **6° of calcaneal inversion** by **Joe Hamill** et al. and about **8° supination** by **Peter Cavanagh,** who with **Ned Frederick** and **Chris Edington** compiled an average **7.2° rearfoot touchdown angle** from thirteen running studies by well-known researchers (compared to an average angle of **1.5°** for modern barefoot runners in three studies).

Moreover, the result is firmly supported by unpublished data from **Dr. Willwacher** that his test subjects had **4° of ankle inversion for males** and **5° of inversion for females** while standing in their own running shoes, which also seems very close to the amount of standing supination shown in the **FIGURE 1B** footprint.

Willwacher's **4° of standing ankle inversion for males** is essentially the same as the **4°** of varus used to put the foot into a neutral position, developed by the noted podiatrist **Steven Subotnick**, who pioneered the treatment of running injuries, at that time mostly of males. In 1976 Dr. 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 shown on the left in **FIGURE 1C**, 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 1C**, 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.

Unfortunately, the varus wedge maintains the heel, ankle, and lower leg in an abnormal varus position, instead of in a naturally stable vertical position. As we will soon see, this causes major structural abnormalities in the human body.

It does indicate clearly, however, that the problem of the anomalous supination position of the modern foot shown on right of **FIGURE 1C** has been well recognized as a fact for many decades. The varus wedge was even recommended for basketball shoes in a classic book, ***Functional Disorders of the Foot***, by Frank Dickson and Rex Diveley, both MD's, in 1939 (ironically, the same year as the unexplained footprints of **FIGURES 1A&B**).

Instead of wedging against varus effects, at least one company, **OESHshoes**, introduced a compliant sole technology developed by Dr. **Casey Kerrigan**, MD, with a valgus tilt to counteract the varus of elevated heels so that the leg itself becomes more vertical. Her design is particularly for women to avoid the high knee joint torques from elevated shoe heels that cause osteoarthritis – research she pioneered at Harvard Medical School. That technology has apparently been superseded with a 3D-printed flat sole.

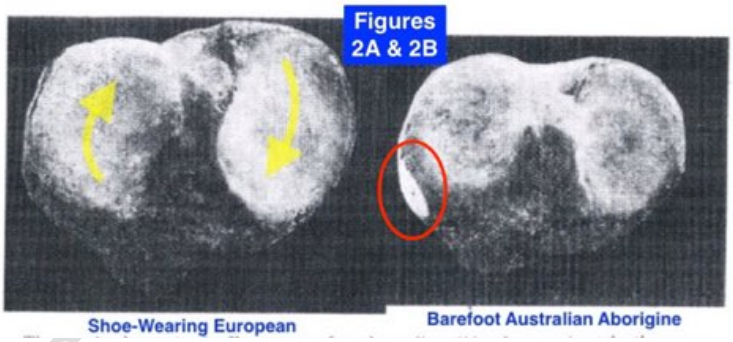
In addition to all of this compelling evidence, there is a definitive new study of such extraordinarily greater accuracy that it obsoletes previous studies. The 2017 running study by **Fischer** et al. in ***Footwear Science*** that uses intracortical pins fixed into the bones of the foot, ankle, and lower leg. My analysis of Fischer's uniquely accurate data indicates that the **subtalar joints of all three male test subjects were supinated throughout the entire stance phase of running, even at peak load, even while barefoot,** just as seen above in **FIGURE 1B**. The previous studies noted above indicate with high probability that the same methodology applied to runners in conventional running shoes will result in substantially higher degrees of supination of their subtalar joints.

It cannot be over-emphasized that this is the opposite of the existing consensus of expert opinion. **Astonishingly, Fischer's data indicates that the subtalar joints of all three modern runners are still supinated at peak loadbearing, even though they were running barefoot!** This provides remarkably strong evidence of the persistent effect of a lifetime's use of elevated shoe heels, even when barefoot as shown by **FIGURE 1B**.

Given the preponderance of all this strong evidence firmly based on peer-reviewed studies and careful clinical evaluation from outstanding researchers, it is difficult to doubt the reality of shoe sole-induced foot supination. What, then, might be its anatomic effects?

Since their motion is coupled, the 6° of shoe heel-induced supination of the modern foot automatically twists the lower leg unnaturally to the outside about 10° during running. That result is similar to Dr. Willwacher's unpublished data that just standing in running shoes creates an average of **5° (male) to 6° (female) of external rotation of the tibia**, which corresponds to about the 4° to 5° of standing foot supination.

The shoe heel-induced **10°** outward twisting of the **modern knee joint** creates an unnatural rotary torsion that is directly built into the abnormal bone structure of the modern tibia (**FIGURE 2A**), enlarging and weakening either or both knees, promoting arthritis and otherwise avoidable patellar, ACL and meniscus injuries.



In contrast, the rarely injured **natural barefoot knee** (**FIGURE 2B**) of non-shoe wearers of all races has a smaller, simpler structure, with no abnormal rotary motion built into it and with much stronger ligament attachments (iliotibial tract, circled in **red**).

Similar tibia samples from **barefoot Caucasian populations in India** (**FIGURE 2C**), show the same simple, non-rotary articular surface structure as the barefoot Australian Aborigine of (**FIGURE 2B**).

In addition, an **ancient Roman** tibia (**FIGURE 2D**) shows the same 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 2E**), unlike those of a barefoot knee.

Figure 2E
Modern Knee Joint

The outward tilted tibia causes the knee ligaments to loosen on one side of the joint, allowing motion, and tighten on the other side, creating a relatively fixed center of rotation.

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 small **6°** supination deviation cascades throughout the entire modern human body, slowly deforming and destabilizing every part of it.

That is because the **6°** deviation occurs during running, when the highest repetitive forces in the human body are experienced. That pounding, highly repetitive load of 2-3 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 3A**) 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 no supination or pronation. Evidence indicates that **Asians** and **Caucasians** who have not worn conventional modern shoes**,** such as Kim Phuc as a child and Zola Budd as a young adult, have the same typical natural body structure.

In contrast, the typical modern body of a **shod Finnish marathoner** (**FIGURE 3B**), who doubtless grew up wearing modern shoes, is **unnaturally deformed: his legs and torso are both tilted and twisted away from a vertical centerline**.

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 promoting heart disease.

The neck and head of the **Finn** are tilted-**in** to counterbalance his tilted-**out** spine, so it is even possible to speculate that, just like the modern knee, the twisted modern human brain itself is an artificial structural reaction to unnatural rotary torsion caused by shoe heels.

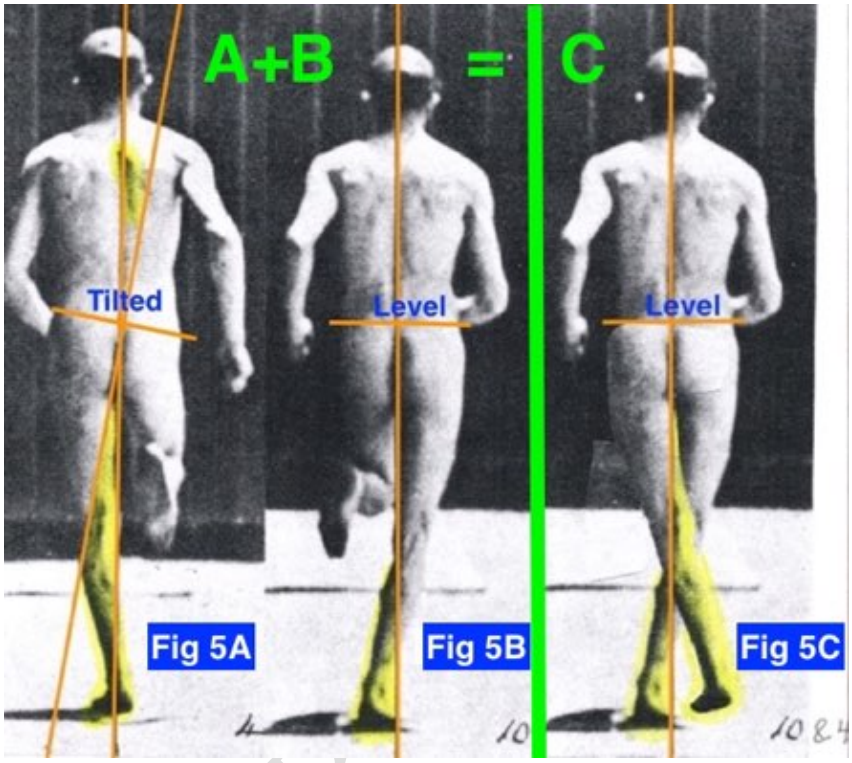
Even the most elite modern athletes, like **Roger Bannister** breaking the 4-minute mile barrier (**FIGURE 4**), demonstrate the same misaligned and deformed body structure under the duress of maximum effort, in contrast to upright and aligned structure of the barefoot **Bushman** of **FIGURE 3A**.

During running, at the point of maximum load of two-to-three 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 5 A+B**)

Consequently, **a modern runner's pelvis is forced to tilt down abnormally** (**FIGURE 5A**) 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 artificially kept leveled** (**FIGURE 5C**)**, instead of tilted**, his maximally flexed and loaded legs become so criss-crossed that running would be impossible.

That theoretical level pelvis position (**FIGURE 5C**) 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 it into an abnormally adducted position, which weakens the hip and restricts its natural range of motion, promoting fractures. The neck of the femur is also unnaturally deformed and weakened, bending 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, making the pelvis wider and flatter, thereby reducing the birth canal width.

Again, supporting evidence comes from published and unpublished data from Dr. Willwacher's earlier cited study. The standing hip angle for 222 test male and **female** test subjects is **2°** to 3° of abduction or tilting-out of the leg, not adduction (tilting-in).

However, at the very beginning of the stance phase of running, the initial hip angle immediately becomes 8° to **10°** of adduction (tilting-in), not abduction. This is an **amazing** change, the total the hip angle increasing by a full 11° to **12°** of **in**ward 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 adduction angle for females climbs to **17°** and to **14°** for males. The total hip angle adduction or tilting-in change from standing to peak load running is **19°** for females and **17°** for males. For the typical barefoot runner shown in **FIGURE 3A,** the support leg is almost vertical!

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.

The observed bent-**in** position of both legs is because both legs are anchored to the body at the hip joint, but obviously not anchored at the ground, so the counterintuitive

answer is: the legs – that are abnormally bent-**out** by the moveable ankles – are <u>in direct reaction</u> forcibly bent-**in** by the relatively unmovable hip joints (fixed by torso inertia).

That answer, of course, only leads to another obvious question, which is the most fundamental of all. What causes both ankle joints to unnaturally bend-out each leg?

The more helpful answer is a scientific discovery that explains all the previous anomalies of the modern human body: the modern foot is forced into an abnormally supinated position by a hidden effect of the relatively modern **elevated shoe heel**.

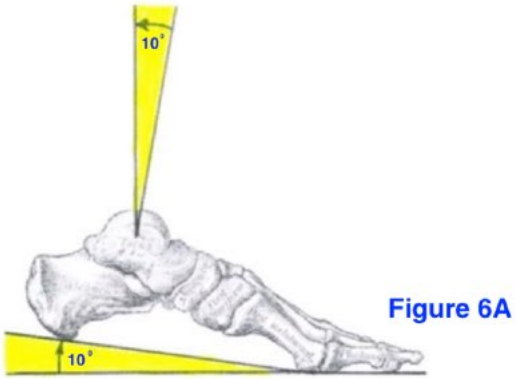
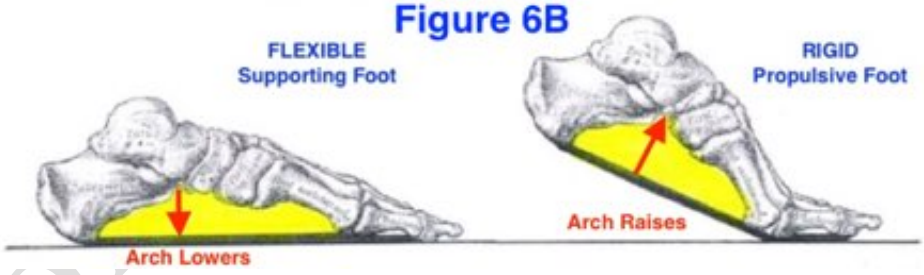


Figure 6A

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 by 10° into what is called a plantarflexed position (**FIGURE 6A**).

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 6B**). <u>The windlass mechanism automatically externally rotates the position of the ankle bone (talus) on top of the calcaneus (heel), so that the subtalar joint points to the outside.</u>

Figure 6B



The elevated shoe heel artificially forces the foot into the unnatural **supinated position** (**FIGURE 6C**) 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.

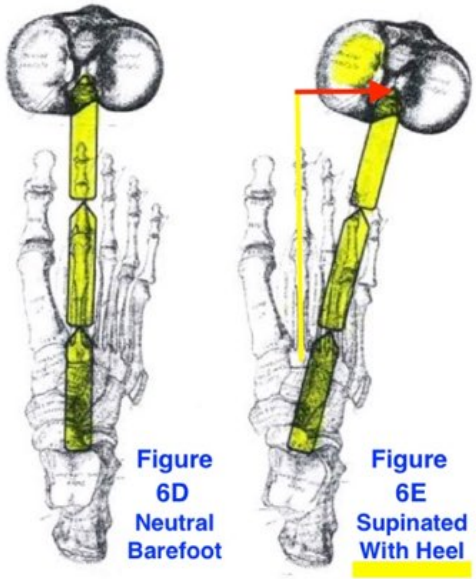


Figure 6D Neutral Barefoot

Figure 6E Supinated With Heel

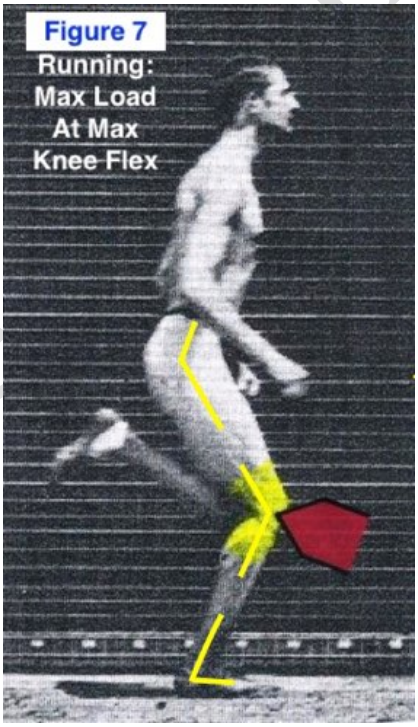
FIGURE 6D shows a natural, unshod right foot and the natural, un-twisted right knee position pointed straight ahead in the flexed-knee midstance running position. The ankle joint is pointed straight

ahead and the knee joint is flexed to absorb the full force of body weight, especially when running at the maximally loaded midstance position of **FIGURE 7**.

FIGURE 6E, in contrast, shows the unnatural, maximally loaded, tilted out right knee position caused by an elevated shoe heel when walking and especially running, at the maximally loaded midstance position of **FIGURE 7**.

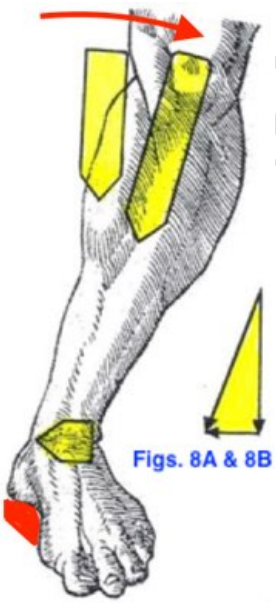
The outwardly rotated ankle joint forces the knee to twist to the outside. **FIGURE 6E** also shows that the inside (medial) half of the knee joint abnormally carries most of that maximal load, an amount as great as 80-90% for some individuals, due to the tilting-out of the knee to the side.

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 two-to-three times body weight occurs at exactly the worst possible time: when knee, hip, and ankle joints are maximally flexed. (**FIGURE 7**)



Runners' Legs Are Forced into an Inherently Unstable, Twisted & Tilted-Out Position by Elevated Shoe Heels

FIGURE 8A below shows a front prospective view of the tilted-out runner's leg shown previously in **FIGURE 6B**. 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**.


Figs. 8A & 8B

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 8B**. 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 no horizontal component vector.

Remarkably, evidence indicates that **never-shod barefoot runners do not pronate** with each running stride because they have untilted, vertical legs, like the Bushman in **FIGURE 3A**, as well as the Bantus of South Africa. 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 8A&B**.

THE UNNATURAL CAUSE: SUPINATION In summary, as shown in **FIGURES 6B & 8A**, the elevated shoe heel unnaturally forces the knee to tilt outward 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 action.

THE UNNATURAL EFFECT: PRONATION Simultaneously, in compensation to the abnormal bow-legged position, the ankle is unnaturally forced inward by an unstable horizontal force vector resulting from the tilted lower leg, resulting in unnatural pronation, as shown in **FIGURES 8A&B**. This is the reaction.

Simply put, the unnaturally supinated foot directly forces the foot to pronate unnaturally in reaction.

Where the action and reaction forces balance in equilibrium for each leg of any given individual is dependent on that individual's personal body structure and chance in the form of personal injury.

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.

Therefore, the repetitive peak joint loading occurs just when the maximal abnormal knee, hip and ankle joint bending occurs – while 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.

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 by **Davis's Law**.

FIGURE 9 provides an overview of the structure of the **unnaturally deformed modern human body**, as specifically degraded by running with elevated shoe heels.

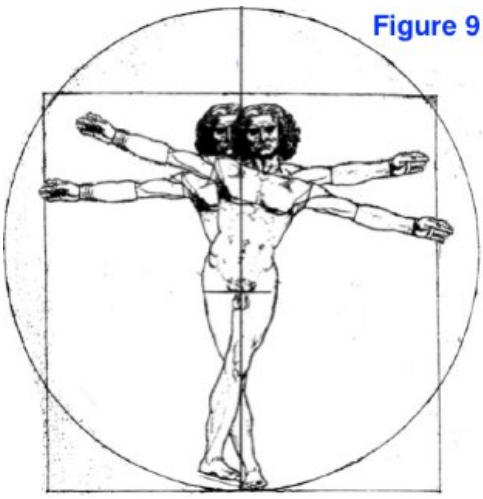


Figure 9

Its primary deformities, like those of the Finnish runner, consist of abnormally bent-in legs forcibly tilting and twisting the pelvis, resulting in an unnaturally bent-out lumbar and thoracic spine, as well as tilted-in cervical spine and head. As a result, 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 knee example (**FIGURE 2A**). 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.

Given the link between shoe heels and the anatomical damage they inflict biomechanically on virtually every part of the modern human body, the associated medical costs for shoe heels in the United States alone could well be as high as $1.5 trillion each year. Although these financial costs are shocking, the effect of elevated shoe heels on our general well-being is even more costly. In the course of our lifetime – but especially as we age – shoe heels drastically degrade our overall health and quality of life.

There really is no way to describe the untenable situation that we, as modern shoe-wearers, are all trapped in now, except to say that all of us have been little more than **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 reverse-evolution that first began for each of us as a fetus in our mother's modern womb (unnaturally formed and functioning), then continued when we took our first infant steps in baby shoes, and continues uninterrupted today.

Each day our bodies become more deformed and farther away from their true natural state. For now, we know little about how to stop or even slow that inexorable progression.

Simply going barefoot is not the answer. For those with significant physical deformity who are most in need, the artificial shoe heels have become an essential structural prop for them, and removing it leads to a further physical collapse in bilateral symmetry. There are no known simple, general answers now.

It is therefore urgent that we, for the first time, focus on the true cause – elevated shoe heels – of this global mass epidemic of modern human deformity, with its untold level of cost and misery, and on finding effective treatment for the direct effects of that cause, rather than blindly continuing the mere treatment of its multitude of seemingly unrelated symptoms.

In summary, the modern human body has been deformed – artificially by footwear, rather than preordained by genetics – resulting in unnaturally exaggerated differences between human races and between genders. And strictly by happenstance through the routine work of cobblers and their modern equivalent, all still entirely ignorant of the enormous negative impact of elevated shoe heels.

The evidence 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.

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 is already known, and the research effort urgently needed now, are outlined there. A first draft of the both abridged book and the complete book are available at my website, **www.AnatomicResearch.org**.

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Research Note:

I should also include here a note about the extent of my research effort. I have conducted over a period of many years a comprehensive analysis of all peer-reviewed research I could find in many different disciplines like biomechanics, anatomy, orthopedics, podiatry, physical anthropology, archeology, and many others that were related to shoe heel-induced supination, including many 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 73 pages, mostly listing the many peer-reviewed articles I reviewed and concluded were relevant, 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.

LIST OF FIGURES

plateaus (lower surface of the knee joint) from W. Quarry **Wood** (1920). The Tibia of the Australian Aborigine. In the ***Journal of Anatomy*** Vol. LIV: Parts II & III (January and April): 232-257, Figure 1 on page 235.

Figure 2C 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.

Figure 2D View of ancient Roman tibial plateau from *Roman Catacomb Mystery*, **NOVA PBS** (air date 2/5/14).

Figure 2E A typical modern tibial plateau of right knee showing asymmetrical and malformed meniscus cartilage on the left, forward of the knee, based on Figure 349 of *the 1918 Edition of Gray's Anatomy.*

Figures 3 A&B A rear view still photo frame of a Bushman (A) and Shod Finn (B) from a **YouTube** video clip of ***Barefoot running Bushman versus me (shod Finn)*** https://www.youtube.com/watch?v=H1Ej2Qxv0W8. Published on May 26, 2013.

Figure 4 Roger Bannister crossing the finish line as he broke the 4-minute mile barrier on May 6, 1954, by Associated Press.

Figures 5A-B Plate 23 Man Running, Frame 4 & 10, rear view at midstance, from Muybridge, Eadweard (1887). **The Human Figure in Motion**. New York: Dover Publications, Inc. (1955).

Figure 5C Composite of previous Frames 4 and 10 above with pelvis leveled in order to show the true relative e position of the flexed legs at the maximum weight-bearing load in the midstance position.

Figure 6A Figure 6A is Elevated shoe heel elevating the wearer's foot heel and thereby plantarflexing the ankle joint, based on Figure 290 *of* the classic 1918 Edition of Henry ***Gray's Anatomy of the Human Body***, available online at www.Bartleby.com/107/. Fig. 2B is from unknown web source.

Figure 6B Based on Figure 290 of the ***1918 Edition of Gray's Anatomy*** *and a*dapted from Hicks, J.H. (1961) The three weight-bearing mechanisms of the foot. In: Evans, F.G., ed. ***Biomechanical Studies of the Musculo-Skeletal System***. Springfield, IL: Charles C. Thomas. From Kelikian, Armen (2011). ***Sarafian's Anatomy of the Foot and Ankle***, page 620. Philadelphia: Wolters Kluwer.

Figure 6C Based on Figures 16 and 20, pages 61 and 67, from Sgarlatto, T. E. (Ed.) (1971). ***A Compendium of Podiatric Biomechanics***. San Francisco: California College of Podiatric Medicine.

Figure 6D&E Comparison between barefoot and heeled shoe of the path of the ankle joint (talar trochlear) when rotated externally to the outside by shoe heel-induced supination of the subtalar joint, based on Figures 244 and 258 of the ***1918 Edition of Gray's Anatomy***.

Figure 7 Figure 3.2 based on Plate 18 Man Running, Frame 10 side view, from Muybridge, Eadweard (1887). ***The Human Figure in Motion.*** New York: Dover Publications, Inc. (1955).

Figures 8A&B Perspective view of body weight forces during running on the lower leg tilted to the outside, based on a part of a figure from *De dissectione partium corporis humani libri tres* by Charles Estienne. Paris, 1545. Simple graph of the force vectors of Fig. 8A.

Figure 9 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.

October 28, 2018