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Reducing Lower Extremity Injuries in Female Athletes by Identifying and Correcting Biomechanical Faults

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Abstract

In the Sports Medicine universe, there is currently no proactive or preventive mechanism. All research and every dollar spent, as well as the care given by healthcare professionals globally within all sports, is strictly reactive. Once a player is injured, then he/she begins the reactive sports medicine journey. An independent third-party observer would certainly expect that advanced technology and cutting-edge techniques would increase the expectation of lower injury rates. However, this is not the case. Athletes are injured without knowing the true cause of these injuries. A major underlying reason for musculoskeletal injuries is the biomechanical faults that all athletes, and all humans, are born with that exacerbate throughout one's lifetime. The first step in reducing injuries would be to a) examine for biomechanical faults prior to injury and b) use the advanced technology that is available today to correct or improve these faults. When looking at lower extremity injuries in the female athlete, injury rates are more than men's. This study will highlight the primary cause of lower extremity injuries in women while also discussing the contributing factors that increase women's vulnerability.

Keywords: Athletes; Biomechanical Faults; Cutting-edge techniques; Biomechanical x-rays; Musculoskeletal systems

Abbreviations: BMI: Body Mass Index; SEBT: Star Excursion balance Test; LEI: Lower Extremity Injuries; ACL: Anterior Cruciate Ligament

Introduction

It is quite easy for any researcher to find numerous articles and scientific manuscripts about return to play protocols. The goal with all injured athletes is to achieve an accelerated recovery through varied treatments and rehabilitative exercises that gets a player back as quickly and safely as possible. When it comes to professional and college athletes' rehabilitation protocols, battalions of trainers, orthopedists, chiropractors, physical therapists, sports psychologists, massage therapists, nutritionists and other professionals collectively offer their services to achieve a speedier return to play. While all this attention appears to make the athlete look totally cared for, the fact remains that all the above takes place only after a player gets injured.

On the contrary, there is very limited, if any, research being done today which looks at preventive and proactive measures that will help athletes before injury. All prevention largely occurs in the strength department and efforts to reduce injuries are usually only seen in taping and bracing of vulnerable areas of an athlete. While strength training is perceived to only provide benefits for an athlete, the biomechanical faults that lead to injuries are also subject to excessive overloading in the weight room even prior to the athlete participating in a practice or competition. In the absence of examining for biomechanical faults, "load management" is the industry's solution to reducing injuries, while in truth, this is more of a confession that they don't actually know what else to do.

As discussed in a prior research study [1], all sports teams invest very little in their injury prevention departments, however, that's where the results are seen. The injury treatment department registers enormous costs including physical therapy and chiropractic treatments, pharmaceuticals, surgeries, as well as many other ancillary costs. The NFL, NBA and MLB spent more than $1B in 2022 on injuries. This cost doesn't even consider the emotional toll to the athlete, team and community when an athlete is injured, nor the economic cost to a community, city or state. Injury prevention departments will be the future, and the costs will be controlled and dramatically reduced compared to current costs. A biomechanical exam consisting of standing structural x-rays, possible MRI's of discs, meniscus status and possible bone marrow edema sights, feet evaluations, range of motion evaluations, leg length tests and structural centers of gravity measurements will be performed on each athlete prior to the season starting. Preventive corrections and treatments will reduce the incidence of injuries, and treatments will consist of chiropractic adjustments, physical therapy, cold laser therapy, nutrition, spinal decompression, myofascial release, and orthotics with lifts, if necessary. Athletes will visit the injury prevention department on a frequent and scheduled basis, dramatically reducing the stressful and costly needs of the injury department. Costs in the injury department will be dramatically reduced.

Background

A meta-analysis in 2021 composed of sixty-nine studies which captured 2,902 lower limb injuries in 14,492 female athletes analyzed 80 distinct factors [2]. Risk factors for any lower limb injury, including ACL and ankle injuries, included greater body mass index (BMI), older age, greater star excursion balance test (SEBT) anterior reach distance and smaller single leg hop distance. Additional risk factors included prior knee injuries and the onset of osteoarthritis. What stands out is a) the significant prevalence of musculoskeletal injuries in female athletes and b) the studies can only define "risk factors" while unable to clearly understand the true underlying "causes" of these injuries.

Another more recent and reliable systematic review and meta-analysis tried to predict factors related to lower extremity injuries (LEI) in elite women football players. The risk factors were consistent with those of the prior meta-analysis; however, the conclusion was the excessive valgus found in women was the primary predisposition to lower extremity injuries [3]. Statistics clearly show that women athletes suffer more lower extremity injuries than their male counterparts due to anatomical "faults" which cannot be corrected. At this point, the only solid recommendations to date are core stability exercises and more research.

Materials and Methods

In 2020 we published a series of studies addressing the relationship of the biomechanics of the feet and the architectural effect the feet have on the rest of the human structure. The studies broached the impact these studies could have on healthcare industry policy makers [4]. Our goal was to highlight the effect of proactive efforts compared to the stress and costs of reactive care. In our first study, we identified five Crooked Structures, each having specific and unique biomechanical faults (Figure 1).

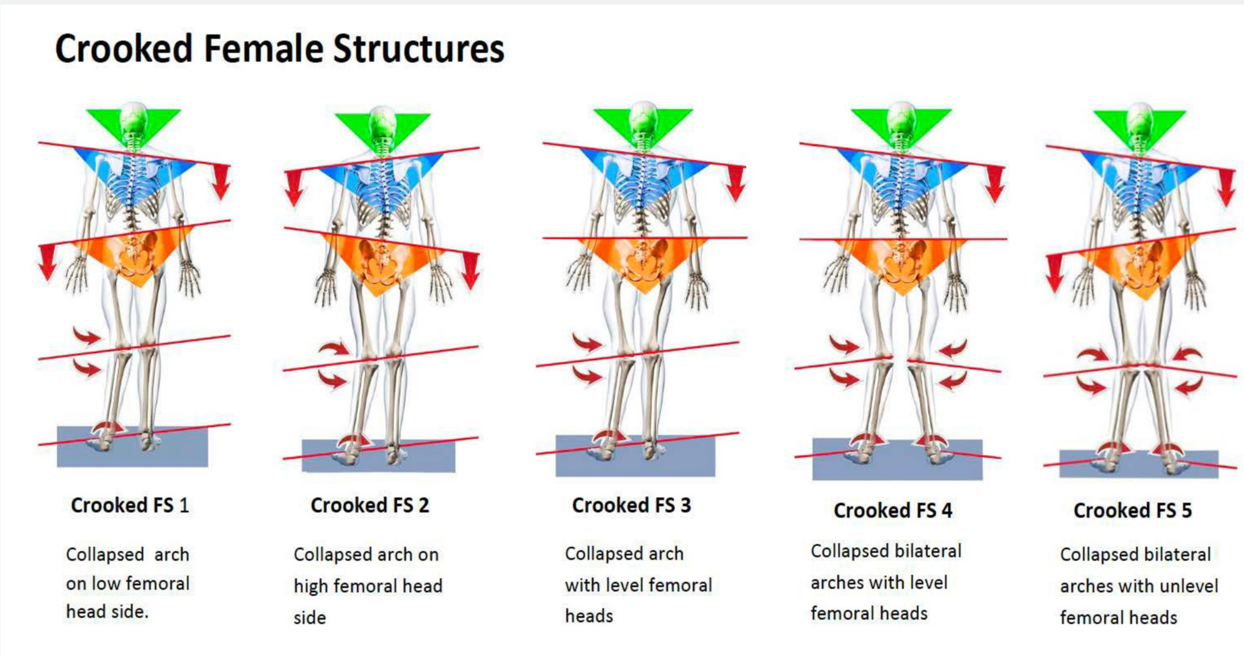

Figure 1: Five Crooked FS, each having specific and unique biomechanical faults..

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In our second study, we proved there was a significant likelihood there is a meaningful difference in hip heights, even with orthotics, necessitating a heel lift [5]. The assumption that orthotics will automatically level hip heights couldn't be more wrong. An A-P L-S x-ray must be taken once orthotics are put into shoes, regardless of whether the hips are level upon that same x-ray while barefoot (Figure 2). Hip heights need to be re-measured. 3mm and less is normal. Above 3mm is abnormal and creates a domino-like compensatory effect up the entire structure.

Figure 2: An A-P L-S x-ray.

In our fifth study, we performed a digital laser foot scan (Figure 3) on 1,001 patients to detect any collapse of the three arches of the feet. Each scan would produce a number known as the Collapse Index Number. This made all findings objective. The number ranged from 0 (optimal arches) to 200 (total collapse of all arches). Our results showed there was a degree of collapse in every patient ranging between moderate collapse to total collapse. Not one patient had optimal feet or mild collapse [6].

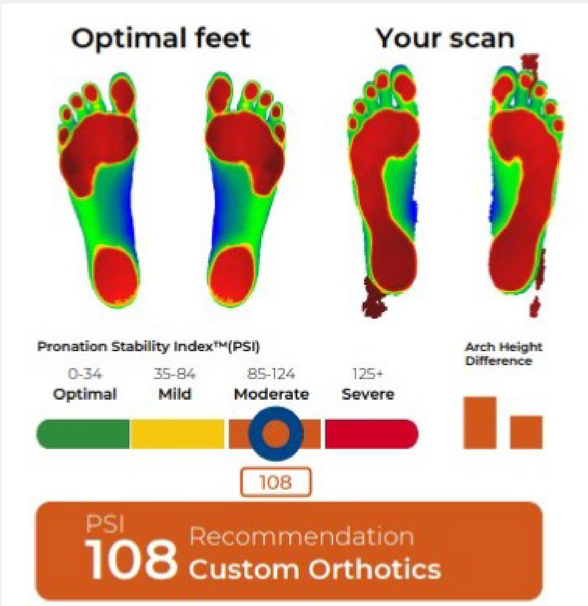

Figure 3: Digital laser foot scan.

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Present Study

In this study of 186 women ranging in age from 11 to 83, our goal is to identify abnormal biomechanical findings that can be detected prior to injuries allowing corrective proactive measures to be taken to reduce the risk of injury.

On each patient, there was a 3-step process. We started with a digital laser foot scan to identify the collapse index number. We then took an A-P Lumbo-sacral digital x-ray to measure the femoral head height (hip height) difference (fhhd) while the patient was barefoot (Figure 4). We then ordered the orthotics which took exactly one week to arrive. Once we had them, we inserted them into each patient's shoes and immediately re-took the same A-P Lumbo-sacral x-ray (Figure 5). We again measured the hip height difference. The mm difference while barefoot was documented as was the new mm difference with orthotics in the shoes. These 2 numbers would then classify which Crooked Female Structure (FS) category each patient fell into and if the difference was >3 mm with orthotics on, an appropriate lift would be placed under the orthotic on the low hip side.

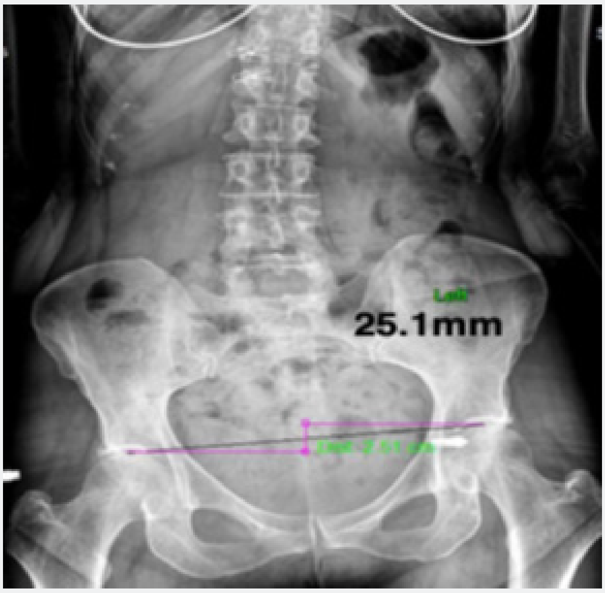

Figure 4: Barefoot.

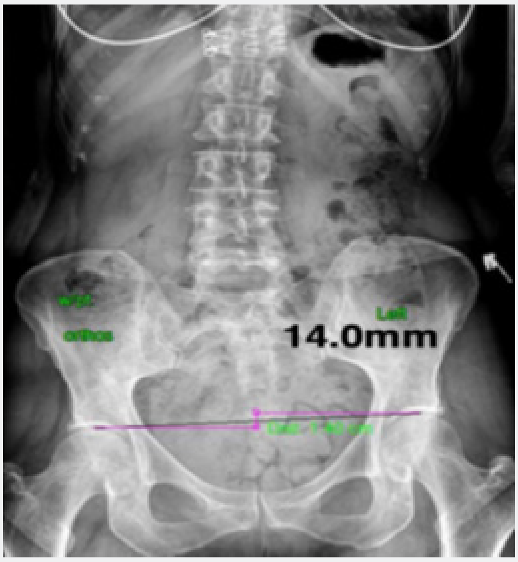

Figure 5: With Orthotics.

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Collapse Index - this number represents the number of pixels that appear as red and represents the foot making direct contact with the digital scanner (collapse). As is seen in the results of scanning 186 women, none of them had optimal feet, 3 of them had mild collapse, 60 of them had moderate collapse, 90 of them had severe collapse, and 33 of them had total collapse (Figure 6).

X-Ray Findings - by taking an A-P lumbosacral x-ray with orthotics on, we're able to remove the influence of the unique collapse of the feet (by providing support and creating symmetry with orthotics) and isolating just the leg length difference. This is done by measuring the new hip height difference. These 2 x-rays will now allow us to classify which Crooked FS category each individual falls into (Figure 7).

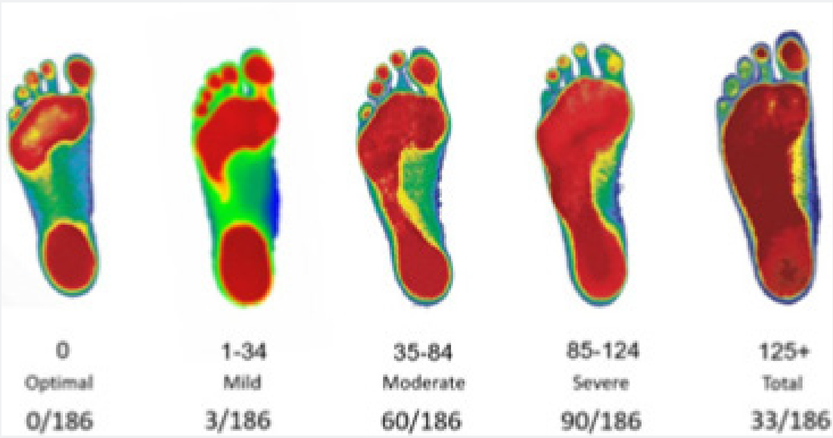

Figure 6: Results of scanning.

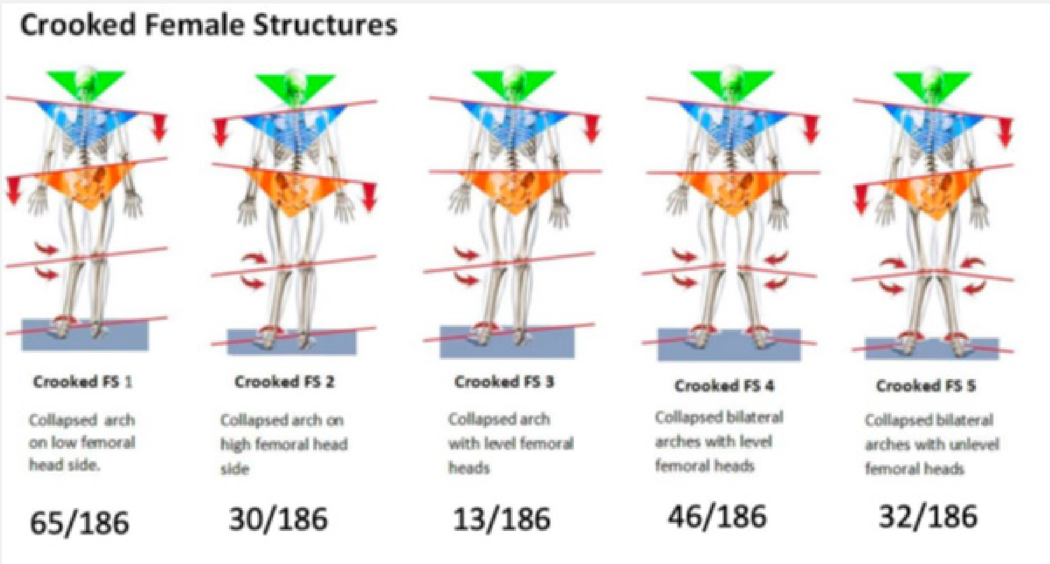

Figure 7

Crooked Man Categories

Crooked FS Categories Crooked FS 1 - increased collapsed arch on low femoral head side with >3mm fhhd when barefoot. With orthotics, fhhd decreases by at least 1mm (Figure 8). ** 65/186.

Crooked FS 2 - increased collapsed arch on high femoral head side with >3mm fhhd when barefoot. With orthotics, fhhd increases by at least 1mm (Figure 9). ** 30/186.

Crooked FS 3 - unilateral increased collapsed arch with <3mm difference when barefoot. With orthotics on, fhhd is >3mm difference (Figure 10). ** 13/186.

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Crooked FS 4 - bilateral collapse of the feet with <3mm difference barefoot. With orthotics on, fhhd remains <3mm difference (Figure 11).** 46/186.

Crooked FS 5 - bilateral increased collapsed arches with >3mm difference while barefoot. With orthotics on, fhhd remains <1mm difference (same) (Figure 12). ** 32/186.

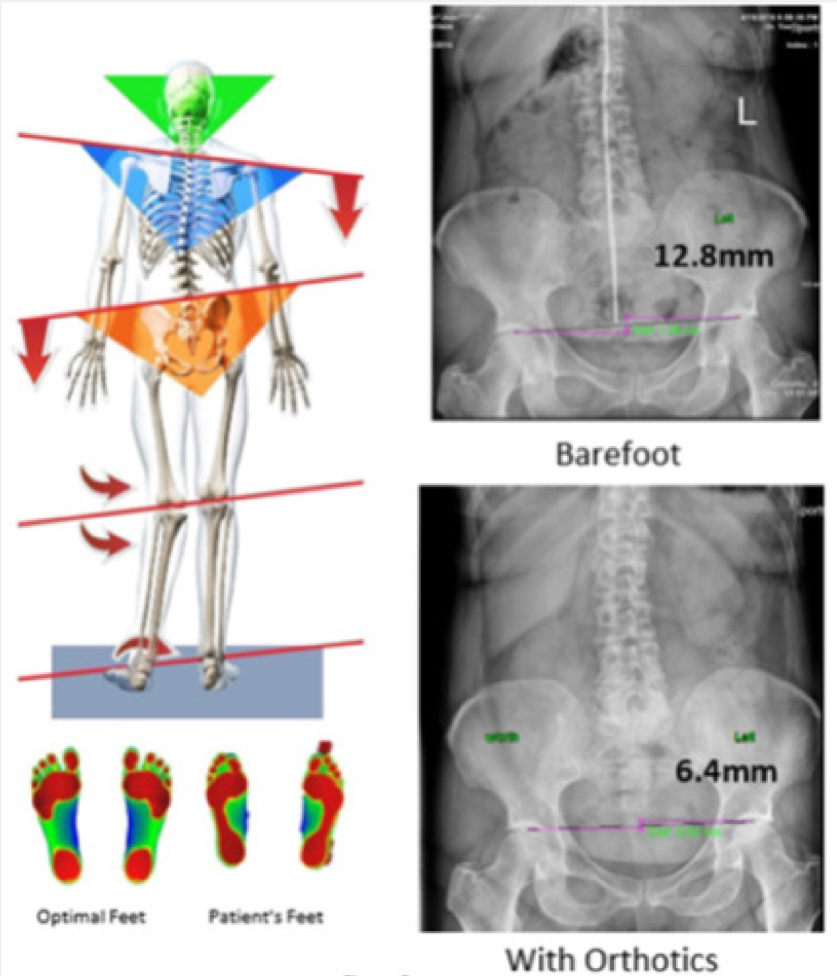

Figure 8

Discussion

Statistics prove that female athletes suffer more lower extremity injuries than male athletes. Consider the anterior cruciate ligament (ACL), which is a vital structure in the knee that provides stability under stress. Injuries of this ligament are up to 6 times more common among women than men. The primary cause of ACL injuries in women is biomechanics and the structural imbalances described in this paper. The industry attributes secondary contributors as the primary causes while ignoring the more important biomechanical faults. While the following secondary contributors are unique to women and play a role in many injuries, the incidence of biomechanical faults that lead to these injuries occur equally in men and women. The unique secondary contributors of lower extremity injuries in women are:

i. Higher estrogen levels, along with less muscle mass and more body fat.

ii. Greater flexibility (due to looser ligaments) with less powerful muscles.

iii. A wider pelvis, which alters the alignment of the knee and ankle.

iv. A narrower space within the knee for the ACL to travel through.

v. A greater likelihood of inadequate calcium and Vitamin D intake.

Modern day sports medicine realizes there is little that can be done with the above contributing factors, so the reactive approach is the result. This paper outlines that the primary cause of these lower extremity injuries is due to biomechanical faults, and, unfortunately, very few are trained in this field. With

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the current reactive approach, there is never a correction of underlying biomechanical faults, so the likelihood of re-injury always remains high. Regarding a wider pelvis contributing to misalignment of the knees, this factor is mitigated greatly with the inclusion of orthotics and leveling of the hips. When the collapse of the feet is addressed with orthotics, the alignment of the knees is automatically improved.

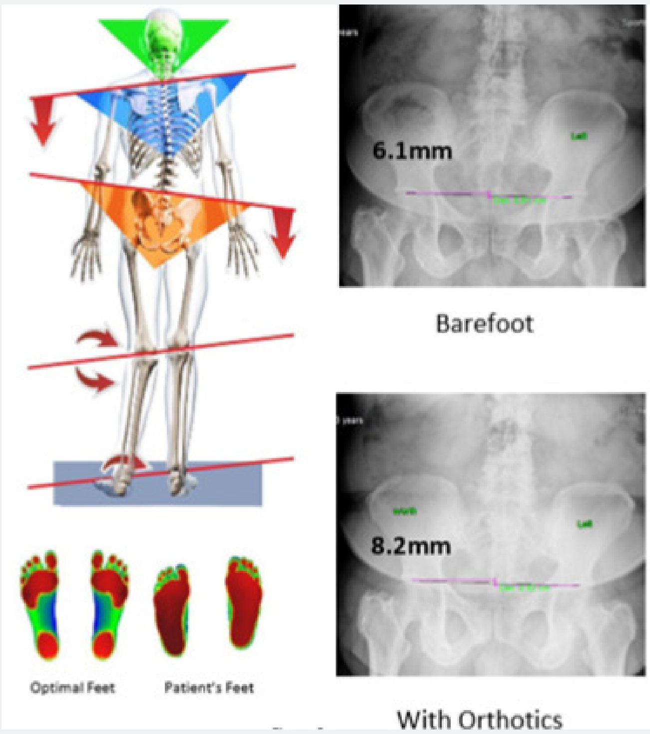

Figure 9

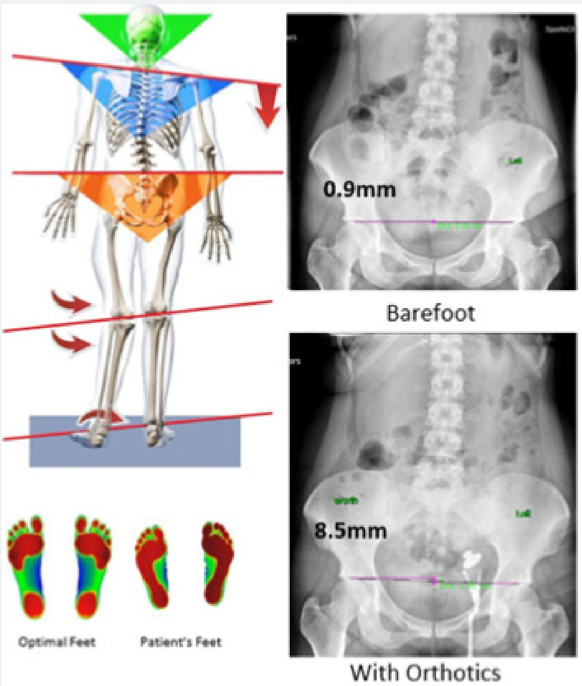

Figure 10

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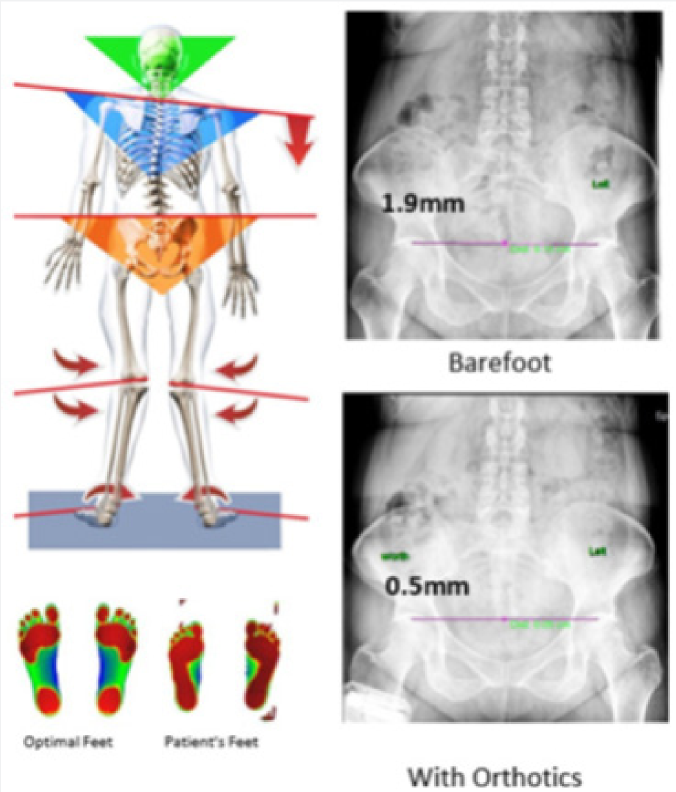

Figure 11

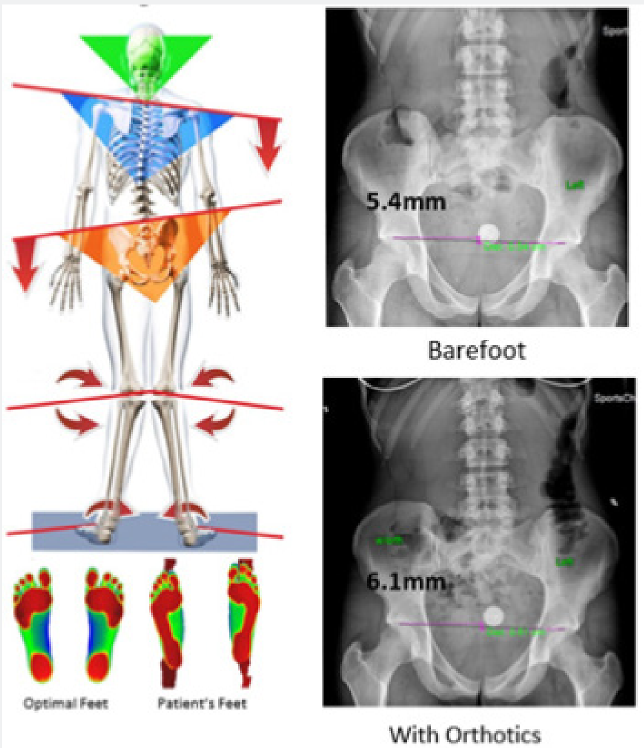

Figure 12

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The balancing of body weight takes on a more serious understanding when applying Wolff's Law. Julius Wolff (1836-1902), a German anatomist and surgeon, theorized that bone will adapt to the repeated loads under which it is placed. He proposed that, if load to a bone decreases, homeostatic mechanisms will shift toward a catabolic state, and bone will be equipped to withstand only the loads to which it is subjected. It is now recognized that remodeling of bone in response to a load occurs via sophisticated mechano transduction mechanisms. These are processes whereby mechanical signals are converted via cellular signalling to biomechanical responses [7]. The key steps involved in these processes include mechanocoupling, biochemical coupling, signal transmission, and cell response [8].

The exact equivalent regarding soft tissue healing and adaptation is what is known as Davis' law. This law states that soft tissue will also model across the lines of stress. However, neither bone nor ligaments and muscles have the infinite ability to adapt and to heal and this is reflected in Dr. Maggs℠ Law of Tissue Tolerance. This law states that when the loading of a tissue exceeds the capacity of that tissue, compensatory physiological changes occur [1]. Ultimately, tissue that is victim to overload due to biomechanical faults will ultimately go through physiological change increasing that tissue's vulnerability to injury.

This approach recognizes through extensive research that all humans have varying degrees of unique collapse of the arches of their feet. The feet act as the foundation that governs normal and abnormal loading for the rest of the body. We know, through research, the importance of providing support and creating symmetry of the feet in the effort to reduce the incidence of injuries in the lower extremities. A quality orthotic is the first step in this process. The more important test, once the orthotics are in the shoes, is the A-P Lumbo- sacral x-ray. A measurement of the femoral head height is then done and if the difference is greater than 3mm, an appropriately sized heel lift is inserted under the heel of the orthotic on the low femoral head side. 7-9 mm is the maximum recommended lift to be put in a shoe.

Conclusion

The human structure must be looked at as an architectural structure. It is a victim of gravity, aging and stress accumulation. Current evaluations of all athletes today ignore this architectural consideration. Adding complexity to this fact, each human being has a 100% unique architectural structure, starting with genetics. There are no two musculoskeletal systems that are identical. There are no two nervous systems that react to a disturbing factor identically. Adding even more complexity, the human architectural structure moves. Repeatedly. The Structural Fingerprint® Exam remains the only full structural biomechanical exam performed today. For all athletes, this is the optimal exam, and should be performed pre-season. The exam begins with the evaluation of the feet and includes 4 standing biomechanical x-rays. This exam can begin at the age of 12. While optimal for all athletes, this exam is not accessible for the masses.

Ultimately, it's not necessary to know which Crooked FS category an individual falls into. What is necessary is to know the femoral head height difference once the orthotics are put into the shoes, meaning, only one standing x-ray is needed. This is known as the Dr. Maggs℠ Leg Length Test. If the fhhd is >3 mm, an appropriate lift should be placed under the othotic on the low hip side.

As this study and all prior studies prove the importance of orthotics as the first step in injury prevention and reduction, guidance is needed to recommend appropriate orthotics. Ideally, quality orthotics can be purchased online, shipped directly to an athlete's residence with directions on how to get the exact x-ray from someone in each athlete's respective community. This would allow everyone to immediately take advantage of the many years of study used to write this paper. The sole purpose of orhotics is to provide proper support and symmetry of the feet and to place the feet in the optimal biomechanical position. All orthotics create symmetry while there are many variables when it comes to optimal support.

Women may have an added contributing factor leading to more injuries of the lower extremities today, however, with a concerted effort on all our parts, biomechanical corrections will dramatically reduce these injuries tomorrow.

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