HALLUX LIMITUS AND NON-SPECIFIC GAIT RELATED BODILY TRAUMA

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ABSTRACT

Many musculoskeletal complaints have been linked to excessive pronation of the foot. This paper describes a specific biomechanical failure that can be shown to cause excessive pronation. Functional hallux limitus, or the inability of the great toe joint to dorsiflex adequately during the heel lift phase of gait, can inhibit normal foot mechanics so severely that excessive pronation motion results. This restriction of great toe motion directly blocks efficient heel lift. Compensation occurs by lowering of the arch and ankle dorsiflexion, thereby hiding the original etiologic factor of hallux limitus. During this compensatory phase, a series of simultaneous and directly opposite rotations of any of the weight bearing joints proximal to the toe joint can occur. When repeated millions of times a year, these aberrations in gait can create significant bodily trauma. Objective examination of these motions can be made utilizing currently available computerized gait analysis systems. Based upon objective data, modifications can then be made of the typical ankle/foot and standard foot orthotics for improved clinical results, as well as a device that can fit into many more contemporary shoes.

INTRODUCTION

Patients with chronic musculoskeletal pain often present with a complex clinical picture and a difficult problem to manage. A seldom-thought-of etiology that has recently come to light involves the biomechanical function of the human foot and its relationship to the remainder of the body. Minor, subtle and easily overlooked functional abnormalities when repeated thousands of times a day in the course of normal ambulation need to be considered in order to effect successful management. The difficulty in clinical management has been to quantitatively evaluate these abnormalities in order to rule out apparent from true malfunctions. A new computer system designed for gait evaluation will be discussed. This device can create an objective assessment of pedal function. New concepts concerning the effect of lower extremity malfunction on the remainder of the body and a new, strictly functional, pathologic condition will be described. Randomized, retrospective study results will also be presented to indicate the improved results attainable with the new information presented in this paper.

PEDAL PERSPECTIVE

Throughout medical history, the foot has been viewed as being lowly placed at the end of the body with little effect on the whole. Few have pursued the biomechanical relationship of the malfunctioning foot as an etiologic factor of musculoskeletal symptomatology in the remainder of the body. In order to explain the biomechanical importance of the foot, it is imperative to examine it in the correct perspective.

To best understand the foot-upper body relationship, imagine what would be seen when walking on a mirror. At heel strike, a body image, exactly equal, would be visible from below, in the mirror, striking in the same point. As the body passed over the foot, the mirror image would pass below. Finally, just prior to toe off, both the body and its image would have moved to their maximum point beyond the planted foot. This picture represents Newton's Third Law of Motion: for every action, there is an equal and opposite reaction. As the body reacts with the ground, an equal yet opposite force develops. The center point of these forces is the foot. The foot to floor interface, therefore, is the pivotal point around which all motion occurs. Keeping these points in mind, the foot should be visualized as the center of motion during the single support phase of a step.

SOURCE OF POWER IN GAIT

In this section, a new hypothesis for understanding the source of power in gait is presented. Previously, muscle activity of the weight bearing limb has been viewed as the primary power source, creating maximum force moments about various joints during a particular step.[1] In published studies, however, peak power output has been shown to actually precede the power requirements and this is recognized as a major discrepancy. The weight bearing muscles have also been noted not to significantly shorten in length during their active phase. In fact, numerous EMG studies indicate that these lower extremity muscles in general, fire to resist a particular motion, rather than create one. This permits the muscles to act in the eccentric mode, a far more efficient method of operation. For example, although an ankle joint plantarflexor, the gastrocnemius muscle is active while the ankle joint dorsiflexes, and ceases activity just after the earliest phase of plantarflexion begins. Keeping this in mind, an alternative view is presented describing the power source in gait.

The body has been shown to power itself by the motion of the swing limb.[2,3] It therefore creates the kinetic energy necessary for forward motion in the side with the least impedance. Swing limb function can be described as follows: imagine a rock tied to a short string. The rock is tossed forward, with the loose end of the string held in the opposite hand. When the string becomes taut, the rock will move back towards the hand, and the hand will move towards the rock. In the lower extremity, the foot and leg of the swing limb serve as the rock. The hamstring muscle functions as the string and actual body mass becomes the hand holding the string. As the leg is "tossed out", the hamstrings fire, resulting in the center of mass being pulled toward the foot, and therefore in the forward direction. Gravity perpetuates this motion by pulling the center of mass towards the ground as it passes over the lower extremity. Intrinsic muscular activity of the weight bearing limb creates the necessary joint steadiness and stability under load.[4] These two concepts, when coupled with conservation of momentum, effectively move the body over the standing limb. As this occurs, the weight bearing limb serves as a simple lever against the ground. Under the pull force described, this lever can drive the ground backwards. Since the ground does not move, the body is pushed forward by this action.

The physics involved in the action of the swinging limb encourages efficient function. Acting as a pendulum in a coupled system, each limb is capable of providing significant energy to assist in the subsequent movement of the opposite side. Efficiency is maximized in this manner.

Herman, et.al., have found that swing phase activity appears to be instinctive in humans and that it is governed by neural control mechanics. He has shown statically that there is insignificant temporal variation in the swing phase action between neurologically normal subjects regardless of age, sex or general body morphology.[5] Swing function is the piece of the ambulation puzzle humans are born with, stance activity is the learned component.

The general viewpoint of this section is that a synchronous, mechanically efficient system for ambulation exists utilizing the two limbs. Understanding that the power portion is developed extrinsic to the weight bearing side, and that swing activity is so standard so as to occur in a prescribed time period, then malfunction of the stance side for even brief moments can alter the synchronous function between the two. The kinetic energy developed for movement on the swing side in the presence of malfunction of the stance side must therefore be stored and/or dissipated in some manner. This point forms the basis for understanding non-specific trauma to the body.

PEDAL BIOMECHANICS

So far throughout this paper, the placement of the foot in the center of the physics of movement, as well as the power for ambulation have been described. The general biomechanical properties the foot possesses permit it to be ideally suited for its multi-tasked purpose and will be described. The total realm of pedal biomechanics, however is far beyond the scope of this paper, and only a overview is provided.

Pedal function has been divided into three to five phases all corresponding to different weight bearing segments. In a simpler way, this paper will describe these actions into two distinct functional episodes, the adaption phase, and the lift phase.

During heel contact and through foot flat, the foot is functioning in its adaption phase. At this time, it must accommodate both the reactive force of the ground at impact as well as the internal rotations of the leg and thigh. The subtalar joint, through it's ability to pronate, permits the necessary shock absorption and accommodation for inward limb rotation at this time. This period of contact pronation has been viewed as the time when excessive pronation occurs and, in a treatment sense, the time it must be limited through orthotic control or arch support. Published evidence, indicates that this motion is relatively unalterable. Clements and Taunton,[6] Smith,[7] and others, have shown that for each individual, custom orthotic inserts have little effect on the total amount of pronation which occurs during this phase. Since this motion appears to be significant to normal function, and not affected by standard support mechanisms, it will be considered that full range contact pronation is a passive event. It will be referred to as Primary, Passive, Contact Pronation.

The lift phase is the second episode present in pedal mechanics. The power created during the lift phase is described in the previous section. As the upper body advances, it uses the weight bearing limb's efficient eccentric muscle contraction mode to connect the various segments much like a series of cables. As the upper body advances, the adductor magnus and gastro-soleus action tie the pelvis to the posterior calcaneus. The heel is then pulled from the ground, pivoting about the metatarsophalangeal joint. Since the weight bearing limb is maintaining all of the body weight at this time, (due to the opposite limb's, off-weight bearing, swing phase motion) the act of heel lift requires the ability to raise body weight, and therefore becomes the active portion of the step.

In order to permit the above motion, the foot is designed with a hingeable, flex area at the metatarsophalangeal (MTP) joint articulation. It permits the skin of the ball of the foot as well as the toes to maintain ground contact, while the remainder of the foot passes directly over the fixed digital anchor. The complex mechanical make-up of the first metatarsophalangeal joint should be noted. The first metatarsophalangeal joint is a ginglymoarthrodial-type joint. It possesses the ability to both hinge and glide to permit an adequate range of motion. The primary motion, the hinge, is approximately 15-20 degrees of the total motion. The secondary motion, glide, makes up approximately 50 degrees, the remaining total. The 1st metatarsal head articulates with the plantar sesamoid apparatus, and when acted upon by lift mechanics, permits the plantar-posterior motion of the 1st metatarsal over the sesamoids. This plantar-posterior motion creates room for dorsiflexion of the metatarsophalangeal joint. The combined effect is a total of 65-70 degrees range of motion in dorsiflexion. This permits the necessary range to effectively raise the heel and advance the leg while maintaining digital ground contact.[8]

While heel lift and 1st metatarsophalangeal joint dorsiflexion occur, a previously described form of natural arch support is created. This is known as the windlass effect as described by J.H. Hicks in the Journal of Anatomy (GB) in 1954.[9] Hicks states that extending the great toe over the first metatarsal head causes the plantar aponeurosis to shorten, and thus raises the arch automatically. He describes this maneuver as "irresistible".[10] In addition to raising or resupinating the arch, the windlass effect additionally externally rotates the lower leg. This permits lower leg synchrony with external thigh and pelvic rotation brought about by swing limb function.

The now resupinating foot can also develop the metatarsophalangeal joint into the fulcrum point for the weight bearing limb's lever effect against the ground. As the body passes above, the ball of the foot serves as the contact point with the ground, permitting normal function in its pivotal capacity.

All the above described events occur in response to "automated" swing limb activity and are dependent on carefully timed, synchronous function.

FUNCTIONAL HALLUX LIMITUS

It has been stated that metatarsophalangeal joint break is an obvious occurrence as noted by the crease in the upper of a well-worn leather shoe. This statement is actually conjecture based on an assumption of what was believed to have occurred.

The shoe crease only indicates that some amount of motion has occurred, but does not indicate when that same motion occurs or what amount occurs during the gait cycle. In the previous section, metatarsophalangeal dorsiflexion is described as one of the most basic motions present in the human foot. Its occurrence at the proper time is essential for normal function. All prior theories regarding pedal operation take for granted that this motion simply occurs.

Functional hallux limitus can be defined as the inability of the proximal phalanx of the hallux to dorsiflex on the first metatarsal head only during the stance phase of gait. Functional locking may vary in length and be less than 100 milliseconds in duration. It is extremely important to note that full range of motion may be present in the first metatarsophalangeal joint during non-weight bearing exam. Symptoms of pain may not be present in the joint and the patient's chief complaint may not appear to be associated with the first metatarsophalangeal joint.

Once the great toe reaches the ground, it no longer moves, and motion at the metatarsophalangeal joint is created by the foot flexing over it. During visual examination of gait, any 1st metatarsophalangeal joint dorsiflexion, therefore, can only be visualized as related to heel lift. As described in the previous section, heel lift is accomplished via 1st metatarsophalangeal joint dorsiflexion, and therefore, if functional hallux limitus is present, heel lift can be delayed or totally restricted. The net effect of this delayed lift would be to hide the etiologic functional hallux limitus and explain why this simple entity has gone virtually undetected by visual examination of gait.

After forefoot contact in the stance phase of the gait cycle, functional hallux limitus can occur at almost any point. If the power segment of the swing phase coincides with this blockade of motion, then the kinetic energy developed must be stored as potential energy until such time as release of it is possible. The following description will help illustrate the effect of functional hallux limitus on the foot as well as the body.

The act of heel lift, occurring as a result of the pull of the upper body, is a motion which takes place through the sagittal plane. (The sagittal plane is one of the three cardinal planes and divides the body into left and right sides. It is also the plane through which the body advances in the forward direction.) The failure of the metatarsophalangeal joint to permit dorsiflexion, and therefore, sagittal plane motion while the heel is attempting to be pulled forward necessitates a compensatory action that must occur elsewhere.

A brief examination of the body will indicate the other joints where forward, sagittal plane motion can occur. In the foot, the midtarsal joint (talo-navicular, calcaneo-cuboid) and ankle joints are capable of allowing this motion. Continuing proximally, the knee, will not allow for forward motion once extended. The hip and low back can permit this motion by bending forward at the waist.

When compensation for functional hallux limitus occurs in the foot, function of the ankle and midtarsal joints are affected. During gait, the ankle joint dorsiflexes through approximately 50% of the stance cycle to a point of approximately 10 degrees dorsiflexed. It then must initiate plantarflexion, with neutral reached by approximately 65% of the stance cycle. In the midtarsal joint, sagittal plane motion occurs at it's oblique axis, with neutral position achieved at approximately 50% of stance. When these joints are forced to undergo compensation for failed sagittal plane motion at the metatarsophalangeal joint, their normal directions of motion are altered 180 degrees. Since the ankle joint permits forward sagittal plane motion through dorsiflexion, then normal ankle joint plantarflexion must be substituted with an opposing action. The same is true for the midtarsal joint. Normal oblique axis motion results in a raising medial longitudinal arch. Compensatory motion results in a lowered medial longitudinal arch.

Dynamically, these combined actions result in a forced arch lowered position during the heel lift phase. With this arch lowered posture, a retrograde subtalar joint pronation occurs as an accommodation. The talus is forced to slide in a medial, inferior direction (internal rotation), off the dorsal surface of its calcaneal articulation, actually dropping through the transverse or ground parallel plane. Since the talus acts as the support for the tibia, then the tibia must drop as well. This falling occurs while the advancing body is attempting to raise these same structures.

At the hip joint, extension is taking place at this time. Sagittal plane accommodation, however, creates the need for hip flexion in its place. Since this is the period of time that the weight bearing limb is in single support, then direct flexion of the hip through femoral motion cannot occur. The upper torso, can however, bend at the waist, accomplishing the same end result of hip flexion.

The net effect of the above described compensatory actions are a series of opposing, counter-rotatory motions occurring across the various weight bearing joints. The body is attempting to create lift while externally rotating the limb. The compensation results in a falling, internally-directed motion in its place. Keeping in mind that the driving force behind this system is repetitious, extrinsic to the weight bearing limb, and of significant magnitude to move the entire body. Each step taken in the above described manner actually forces the affected joints and capsular structures to be considerably stressed. This can create a mechanically advantaged non-specific traumatic event to the weight bearing components of the body. When these motions are performed over a lifetime, then the accumulated number of steps can total well into the hundreds of millions.

CLINICAL EXAMINATION FOR FUNCTIONAL HALLUX LIMITUS

During a routine evaluation of joint range of motion, the patient is examined in a non-weight bearing attitude. Since functional hallux limitus is an entity that is only present during gait, a non-weight bearing examination will not identify this pathologic disorder.

In order to initially assess the first metatarsophalangeal joint range of motion, a non-weight bearing examination is necessary. With the foot held in the neutral position, the hallux should be able to be dorsiflexed on the 1st metatarsal head 65-70 degrees. Motion should be without crepitus or pain. It should also be possible to dorsiflex the digit straight back, without any varus or valgus rotation. Any amount of motion less than 65 degrees can indicate the presence of hallux limitus or hallux rigidus, the sequel to the functional variety.

It is then important to load the 1st metatarsal by palpating the plantar surface of the head, and forcing it in a dorsal direction until no further range is available. Next, using the other hand, attempt to dorsiflex the great toe. If the first 15-20 degrees of motion is difficult to achieve, or no range of motion is available, then the presence of functional hallux limitus can be anticipated.

An alternative form of examination can be performed by having the patient stand with all the body weight on one foot. Attempt to dorsiflex the great toe. If marked restriction of motion is noted, or if no motion is available, then the presence of functional hallux limitus may be suspected as well. However, both of these examination techniques are subjective and certainly unreliable for true identification of a functional hallux limitus condition.

The actual analysis of the effect of functional hallux limitus on pedal mechanics and subsequently, on the entire body can only be done through computerized techniques in gait analysis. Additionally, the immediate effect of treatment on this condition as well as an objective fabrication of foot orthotics can be preformed. It is beyond the scope of this paper to discuss computerized gait analysis, but results of treatment based on the concepts gleaned from this approach will be presented. This is not to say that treatment is impossible without a computer system, however, the objectivity of therapy is not assured.

METHODS AND MATERIALS

A randomized retrospective selection of 18 patients was performed. Their presenting complaints ranged from chronic cephalalgia and temporomandibular joint dysfunction, to chronic knee and leg pain. The primary complaints are represented in table 1. These patient were chosen from a larger group of patients whose postural symptoms had originally not been thought to be related to foot malfunction. Additionally, all of the patients included in this study were demonstrated to have functional hallux limitus.

TABLE ONE

Primary Complaint	Percentage of Patients
Cephalalgia/TMJ/Neck pain	22%
Lower back pain	22%
Hip pain	22%
Knee/Leg pain	34%

Each patient underwent a comprehensive lower extremity examination consisting of: inspection for gross orthopedic deformities; range of motion of hips, knees, ankles, subtalar, midtarsal, loaded and unloaded first metatarsophalangeal joints; limb length; and arch classification in both weight bearing and non-weight bearing attitudes. Gait examination is beyond the scope of this paper and will not be discussed.

Of the initial 18 randomly selected patients, 14 were available for personal interviews. The patients answered five basic questions:

1. What were their presenting symptoms?
2. Did their condition result in a loss of time from work and or a change in recreational activities?
3. Did the patient receive previous treatment for this condition?
4. At the present time were they still using their orthotic devices?
5. What was their perceived percentage of relief of their symptoms?

RESULTS

The initial presenting complaints can be found in Table 1. Fifty percent (7/14) responding stated that they had either a loss of work time or at least a significant change in recreational activities. Regarding previous treatment, thirty-five percent (5/14) had received some form of previous treatment but all remained symptomatic. At the present time, all responding patients were using their orthotic devices. Each patient was also able to return to all previous activities. All patients noted improvement in their symptoms, no patient was worse since beginning treatment. The breakdown of improvement is as follows:

42% or 6/14 were seventy-five to one-hundred percent better
35% or 5/14 were fifty to seventy-four percent better
23% or 3/14 were less than twenty-five percent better.

It is again important to note that all these patients demonstrated the presence of functional Hallux Limitus. None, however, presented with a chief complaint involving the feet. As stated above, 77% of the patients reported to be at least 50% improved with foot orthotics prescribed as the only method of treatment. What follows is a discussion of the treatment methods and protocol. In the subsequent section is a rationale for the success of this form of therapy on conditions previously believed to be unrelated complaints.

TREATMENT, METHODS AND PROTOCOL

The treatment upon initial consultation consisted of a low-dye, flexible adhesive taping with the incorporation of a 1/8" felt pad cut into a triangular configuration.

The felt pad was placed on the plantar surface of the foot just proximal to the level of the metatarsal heads. The pad should be positioned under metatarsal heads 2,3,4,5 leaving the first metatarsal head uncovered. This initial treatment is a valuable prognostic indicator of orthotic therapy.

The patients were then scheduled for a computerized gait analysis session. The system employed is known as the Electrodynogram or EDG. The EDG system has been previously described.[11] Essentially it is a segmental, sensitive vertical load analysis system. It consists of a desk-top computer console, printer and custom components capable of sensing, collecting and storing force data from the plantar surface of the foot and then transferring that information for further analysis. There are seven separate sensors or foot switches per foot and their locations are as follows: medial heel, lateral heel, 1st, 2nd, and 5th metatarsal heads, and the plantar surface of the interphalangeal joint of the hallux. A variable or "X" sensor is the seventh and can be placed on any site. The data collected is then displayed as a series of force/time wave forms on a graph. Additional information relating to the averaging of force data are correlated and compared to normal values.

Utilizing the Electrodynogram as part of the patient's gait analysis, a temporary orthotic can be fabricated in a short period of time and its effectiveness evaluated. The temporary orthotic will closely resemble the prescription orthotic in design and function.

The standard arch support/orthotic has been the mainstay of foot treatment. By design, it functions by giving external support to the medial longitudinal arch and restricts motion of the subtalar joint when a substantial heel seat is present. The UCBL type appliance is a classic example. Other types of modifications known as posts have been added to both the rear and fore part of the orthotics. These have been used to accommodate both varus and valgus relationships of the foot to the floor.

Recognizing the effect of functional hallux limitus on the height of the arch, the orthotic is modified to prevent first metatarsophalangeal joint lockup and encourage more normal biomechanical function.

Understanding that the metatarsals, particularly the 1st, must be able to plantarflex to permit normal toe dorsiflexion, it is imperative that the most distal aspect of the orthotic end proximal to the metatarsal heads. If the orthotic were to extend beyond the metatarsal heads, normal motion would be impeded. Utilizing this type of device permits the advanced design to function in the appropriate fashion. The modification involves the removal of the distal, medial portion of the orthotic and allows for a plantarflexion, eversion motion of the 1st metatarsal. This can be accomplished in one of three ways:

Standard First Ray Cutout—This involves removing a small portion of the orthotic at the distal, medial section. This type of modification is effective in a foot type with average range of motion present in the foot joints, and moderate off-weight bearing arch. Moderate weight bearing midstance pronation should be present during gait.

Bi-Directional First Ray Cutout—This method is desirable when significant range of motion is available in the foot but a moderate off-weight bearing arch is present. Substantial midstance pronation is evident during gait.

First Metatarsal-Cuneiform Cutout—This modification is effective in flexible, pes planus type feet. The lower the arch is off weight bearing, the more applicable this design becomes.

The computerized results are examined and correlated with the static joint range of motion findings. The appropriate orthotic is then fabricated. The patient is then tested again and results analyzed. Corrections are made at this time. The computerized tests are reviewed again, and when satisfactory, the testing is concluded. A prescription is then written for a precise orthotic device based on the effectiveness of the test orthotic. Made on a neutral plaster of paris impression in a custom orthotic lab, the devices are dispensed when ready. During the time delay between casting and dispensing, the test orthotic will serve as a temporary orthotic.

DISCUSSION
UPPER BODY MUSCULOSKELETAL SYMPTOMS AS RELATED TO PATHOLOGIC FOOT BIOMECHANICS

Mechanical stresses caused by structural inadequacies are well recognized in the field of rehabilitation. Rush and Steiner indicate that in 1,000 cases of lumbosacral pain, 77% have measurable leg length inequality.[12] Sicuranza, B.J., et.al., have found that a short leg syndrome was noted in pain in the back and lower extremity pain.[13] He reported excellent results once discrepancy was treated. Joint degeneration is similarly noted when stress is cyclically applied. Joint malalignment is cited for imposing unequally distributed loads resulting in cartilage breakdown.[14] Abnormal physical forces have also been indicated as an etiology for joint destruction. Excessive compression of opposing joint surfaces results in the interference of cartilage nutrition. Necrosis of chondrocytes results with eventual decrease in the ability to withstand further force and degeneration results. The assumption has been made that impact force has been the major contributing factor to the above-described malfunctions. Leg length discrepancy causing unequal weight bearing was blamed as well as apparent joint malalignment. It appears, however, that the mechanism of stressful force to the joint is not directly related to weight. Voloshin and Wosk have reported that "no correlation was found between attenuational capacity (shock absorption) and the weight of the subject. They conclude that "reducing a subject's weight will not necessarily improve the condition of the damaged joints."[15] It is the contention of this paper that the sole examination of impact force is insufficient to explain the stresses on the joints.

The interaction of the foot to the remainder of the body can create a form of mechanical stress as previously described. Merely absorbing impact shock at heel strike without regard to the mechanism required to raise the heel at the time of lift limits the effectiveness of treatment. It is important to remember that these mechanical, stressful events are repeated thousands of times per day. Simons and Travell indicate the importance of "Perpetuating Factors" as a source of mechanical stress to the body. Short leg syndrome as well as a Morton's type foot are described as prime causes of mechanical stress factors.[16] If pronounced pathologic movement occurs in the foot, it is certainly significant enough to create symptoms. The problems, however, may be quite subtle, and not directly cause difficulty. Once a particular site is injured or stressed sufficiently to create local symptoms, then the irritation created by pedal malfunction can result in perpetuating the acute inflammatory condition into a chronic one.

As indicated above, leg length discrepancy can create upper body symptoms through a variety of mechanical interactions. In review of pedal malfunction, the inability of the foot to elevate the tibia in the presence of functional hallux limitus was described. This is noted as lowering of the medial longitudinal arch and is commonly referred to as excessive pronation. In examination of the standing patient, an increase in pronation can often be seen in left-right comparison. During gait, one side may excessively pronate, and a unilateral tibial lowering may occur. This, in effect, is creating a functional leg length discrepancy that will not respond to the conventional wisdom of a unilateral heel elevation. Patients suffering from chronic lower back pain, for instance, who have not responded to standard treatment, might well have a functional, rather than an anatomical, leg length discrepancy which has gone unrecognized. Coupling this with the opposing vertical and counter-rotary movements described earlier, the mechanism of action creating chronic trauma is clarified.

SUMMARY

The authors have indicated a form of non-specific gait-related trauma to the body. By rethinking the conventional concepts associated with general ambulation, the power generated to create movement can instead be shown to be dissipated in a pathologic manner in the symptomatic patient. When sufficient damage has occurred over time, the body must respond by attempting to repair the affected site. Since the primary healing response to injury is inflammatory, swelling and stiffness must result. Keeping in mind that this is a step-by-step process occurring on a daily basis, repair must be initiated each day. Chronic inflammation leads to chronic swelling and stiffness, the hallmarks of "arthritis and rheumatism" of old age. The greater the age, the greater the chance for pathologic gait to be an etiologic agent by virtue of the total of accumulated steps. The inflammation is difficult to treat simply because it is a normal response secondary to trauma. Successfully identifying and treating functional hallux limitus results in a marked reduction of symptoms and return to normal function. The results of the study presented clearly indicated that all the patients treated with the principles described showed significant improvement. Although this is not a panacea for treatment, it represents one tool in the armamentarium of the practitioner treating debilitating musculoskeletal pathology.

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