The Critical Foot-Brain Connection

A Guide to Natural Gait Mechanics and Therapeutic Foot Care

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SECTION 1

The Science

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SECTION 1
The Science

Neuromuscular Lower Limb Mechanics and Foot-Related Problems: The New Paradigm

(For more detailed coverage of this topic, refer to The Future of Foot Care monograph, pages 3-4.)

According to the American College of Foot and Ankle Surgeons, more than 66% of the North American population currently experiences some type of foot-related discomfort. And, according to the American Orthopedic Foot and Ankle Society, 85% of the population will consult a medical professional for one or more foot-related problems over their lifetimes.

Contrast that with habitually barefoot populations, less than 3% of which exhibit foot-related problems and almost none of these are debilitating.

> *"Conventional footwear is designed around 'normal' foot function ideologies that are based on the accumulated observations of shoe-wearing populations — 'normal' being an accepted standard, means, or average."*
>
> – William A. Rossi, Podiatrist

At Biopods, we view the realm of foot-related pathologies from a completely different perspective than the current, commonly held views.

Commonly held view	Biopods perspective
The feet need to be artificially supported to correct lower limb musculoskeletal misalignment.	• During optimal neuromuscular function, optimal musculoskeletal alignment is observed. • In most instances, lower limb musculoskeletal misalignment is the result of maladaptive neuromuscular function. • Maladaptive neuromuscular function can be effectively rehabilitated.
The feet need to be artificially cushioned to mitigate gait-related shock forces	• During optimal neuromuscular function the body can safely and efficiently manage virtually all gait-related forces. • Gait-related forces only manifest in damaging stresses as a result of maladaptive lower limb neuromuscular function and the related musculoskeletal misalignment. These damaging stresses manifest at the weakest link(s) in the kinetic chain. • Cushioning insoles and footwear actually cause lower limb maladaptive neuromuscular mechanics.
Tight supportive footwear is preferred to protect, support, and stabilize the feet.	• Tight supportive footwear is a leading cause of lower limb maladaptive neuromuscular mechanics.

Table 1.1. How the Biopods perspective differs from commonly held views about foot-related pathologies.

Our intention is to create a new status quo for viewing lower limb neuromuscular mechanics, the related causes of maladaptation, and the resultant injuries, as well as to develop effective therapeutic treatment methodologies that employ disruptive technologies.

From a neuromusculoskeletal physiological perspective, the feet are no different from any other part of the body's neuromusculoskeletal system. The feet should be treated with the same physiological principles with respect to optimal function, pathologies, rehabilitation, and performance enhancement.

The body's innate intelligence will, at all times, attempt to maintain optimal neuromusculoskeletal function, create better health, and heal ailing/injured body parts. The feet alone are not isolated from this functional process; however, this optimal function can only be maintained in the right environment, one that facilitates optimal neuromusculoskeletal dynamics.

This raises a very controversial question: Why do we attempt to stabilize or protect feet with tight shoes, orthotics, and cushioning when we do not do this with any other area of the body unless there is an unstable fracture, unstable dislocation, or Grade 3 ligament tear? Even in those cases, splinting, casting, or bracing is employed for the shortest period possible.

Feet are not inherently unstable. They require neither some form of artificial support, to correct alignment and stabilize the lower extremities, nor cushioning to mitigate shock-related forces.

Regardless of an individual's genetic predisposition, foot-related neuromuscular dysfunction and related structural misalignment are a conditioned response resulting from an individual's habitual use of conventional footwear. In essence, from a sports training perspective, conventional footwear creates a "Poor Technique" environment that trains the neuromusculoskeletal maladaptations, which are the root cause of nontraumatic, foot-related pathologies. For example, we do not view over-pronation as the cause of specific foot-related pathologies; rather, we view over-pronation as a symptom of maladaptive neuromusculoskeletal mechanics.

At Biopods, rather than focus on the intricacies of the vast array of symptoms, we focus on providing therapeutic "Proper Technique" solutions that rehabilitate and optimize the lower limbs, hips, and lower back neuromuscular performance. Biopods solutions are based widely on accepted neuromusculoskeletal physiology and on the same state-of-the-art conditioning principles employed by elite athletes and sports medical professionals in rehabilitation, performance enhancement, and injury prevention training programs.

> *"Natural gait is biomechanically impossible for any shoe-wearing person. 'Natural gait' means the pristine, ideal state, the ideal form and function stemming from nature itself."*
>
> – William A. Rossi, Podiatrist

The Science: Optimal Neuromuscular Mechanics

FACT: Healthy neuromusculoskeletal function = optimal performance (strength, flexibility, endurance, coordination, balance, agility, robustness, quickness, speed, and biomechanical alignment) with minimal propensity to injury.

FACT: Optimal healthy neuromusculoskeletal function ("Proper Technique") requires:

- Appropriate and variable stimulus (since the brain tunes out constant and/or repetitive stimuli and stops responding to it), herein referred to as "Right Stimulus."
- Unrestricted and optimally aligned joint and soft tissue movement and mobility, herein referred to as "Right Movement."

Subsumed within the body's innate intelligence are protective reflex mechanisms, which always attempt to facilitate optimal healthy neuromusculoskeletal function. However, this ability is compromised by environments that dampen "Right Stimulus" or restrict "Right Movement."

Where are we now?
Because the vast majority of footwear attenuates "Right Stimulus" and restricts "Right Movement," it will condition the maladaptive function that is the underlying cause of the vast majority of foot-related problems that can manifest symptoms throughout the feet, knees, legs, hips, and lower back.

Using cushioning and supportive products, such as insoles and orthotics, in an attempt to treat foot-related symptoms, can have many negative consequences that include:

- They further dampen "Right Stimulus."
- Prolonged use results in functional atrophy and an increasing dependence upon the artificial support/cushioning.
- They can cause poor neuromusculoskeletal function.

- They can facilitate “Poor Technique” neuromusculoskeletal mechanics throughout the feet, knees, legs, hips, and lower back, leading to poor functional performance, pain, and disability.

Where do we want to be?
We must address the cause of maladapted foot-related lower limb neuromusculoskeletal physiological function with rehabilitation using “Proper Technique.” This can lead to optimal neuromusculoskeletal physiology, enhanced functional performance, and optimized quality of life.

How do we get there?
We can achieve optimal neuromusculoskeletal physiology, enhanced functional performance, and optimized quality of life by:

- introducing the “Right (varied) Stimulus” into footwear
- using footwear that facilitates “Right (musculoskeletal) Movement”
- addressing abnormal joint mechanics and any preexisting fibrotic/scar tissue caused by the maladapted mechanics that can inhibit functional performance of the feet, knees, hips, and lower back.

Biopods products provide the “Right Stimulus,” but Biopods Insoles’ optimal effectiveness may be inhibited relative to the degree that the footwear in which they are used restricts “Right Movement.” (Even in restrictive footwear, Biopods Insoles have been shown to be more effective than custom orthotics at addressing foot-related problems.)

Biopods footwear provides the “Right Stimulus” and facilitates “Right Movement.”

Significance and benefits for healthcare professionals.

The underlying science of Biopods disruptive technologies offers a new paradigm for assessing and treating the vast majority of foot-related pathologies. While Biopods create an environment within footwear that stimulates and enhances optimal neuromusculoskeletal function, they do not address abnormal joint mechanics, preexisting fibrotic/scar tissue or inelasticity that inhibits the return of a full range of functional mobility. To achieve optimal benefits, joint and soft tissue manipulation therapies should be employed to break down the fibrotic tissue and return optimal elasticity and joint mobility. In some instances, mobilization or manipulation therapies need to be employed prior to the use of Biopods technologies.

Biopods Stimsoles can also be used as a diagnostic tool for identifying nonsymptomatic fibrotic tissue. As neuromusculoskeletal function improves with use of Bioods, these nonsymptomatic fibrotic areas may become symptomatic. Once identified, they are easily addressed, as noted above.

The Biopods therapeutic rehabilitative approach to treating feet and foot-related pathologies is ideally suited to the chiropractic profession, offering a unique opportunity to establish participating chiropractors as leaders in rehabilitative and therapeutic foot care. This scientifically based, yet innovative, approach very strongly differentiates itself from the current medical/orthotic treatment strategies.

The Underlying Science: Back to the Basics

“Simply put, function is the outcome of any activity.”
– Robert S. Gotlin, Director of Orthopaedic and Sports Rehabilitation, Department of Orthopaedic Surgery, Beth Israel Medical Center and Professor of Physical Medicine and Rehabilitation, Albert Einstein College of Medicine of Yeshiva University.

The following is an excerpt from Gotlin's Sports Injuries Guidebook: Understanding Functional Conditioning:

"Everyday functional movements include running, biking, throwing, walking, carrying a child, tying shoelaces, getting out of bed, and even switching from sitting to a standing position. Thus the benefits of functional conditioning are not limited to athletics. Its movements occur in some form in work, home, and sport environments. To perform these tasks, a chain reaction involving muscles, nerves, and joints occurs. If this chain is interrupted because of inadequate flexibility or lack of strength in part of the chain, a breakdown results, leading to a decrease in performance and to possible injury.

Exercises to help condition the body for functional improvements must meet all four of these criteria:

1. They must include movements in all three planes (sagittal, frontal, and transverse).
2. They must properly condition the body's nerves and muscles to develop memory and help make movements "automatic."
3. They must condition a response to external forces and allow the body to make best use of outside influences such as gravity, ground reaction forces, and momentum.
4. They must condition biomotor abilities (flexibility, strength, power, endurance, agility or coordination).

A quick look at these four criteria confirms that functional conditioning works beyond the realm of physical fitness and benefits the body during the activities that most people, athletes and non-athletes alike, do every day.

1
KEY TAKEAWAY

The mechanisms of functional improvement for the weight bearing neuromusculoskeletal system for optimal function and symptomatic relief must:

- Enact movement in all three planes
- Properly condition "automatic" movement memory
- Condition responses to external forces encountered in real life
- Condition for flexibility, strength, power, endurance, agility, and coordination
- Condition neurology via restoration of nonpathologic physiology

Neuroplasticity: Conditioning the Neuromuscular System

Functional conditioning requires training of the nervous system. For example, when bending down to pick up an object off the ground, you are unaware of the intricate coordination it takes for your body to execute this movement. The actions involved in the flexion and rotation of your spine, hips, knees, and ankles are not premeditated. The nervous system plays an integral role in this process. The body's nerves send messages to the muscles, which direct the timing, means, and speed of movement. To clarify how this occurs, let's take a closer look at the neurological mechanisms of the nervous system that are used during movement and their relation to functional conditioning and injury prevention.

The brain learns movement by developing motor programs. According to Physical Therapist, Gray Cook, motor programs are ways that the brain stores information about movement. Every time someone learns how to shoot a basketball or ride a bike, the brain creates a motor program that allows the athlete to repeat this activity without relearning the mechanics each time (Cook 2003). This is the nervous system's method for running efficiently. Conditioning the neural network through repeated functional movements improves the way the body develops motor programs and helps the neuromuscular system operate to its highest potential.

Conditioning the nervous system through repetitive functional movements improves the proprioceptive feedback to the muscles in the body. Proprioceptors are sensory receptors located within the joints, muscles, and tendons. They receive input about the physical state of the body, constantly informing the central nervous system about muscle tone and the coordination of certain movements. Likewise, the way the body senses both touch and movement is referred to as proprioception, which means 'sense of self.'

It is through proprioception that the body communicates with itself at a subconscious level. For example, you do not have to think about maintaining a particular posture or how to position your various body parts during a familiar movement. Your proprioceptors govern the spatial and temporal relations of your body and limbs in space, freeing your conscious mind to focus on other matters.

With conditioned proprioceptors, an athlete is in a better position to react, as joints and muscles respond automatically to protect the body from injury and other physical problems. For example, someone with a highly conditioned proprioception can slip on ice and land on the ground without turning an ankle. Essentially, to improve the nervous system's response to movement, it is necessary to implement a conditioning program (Cook 2003)."

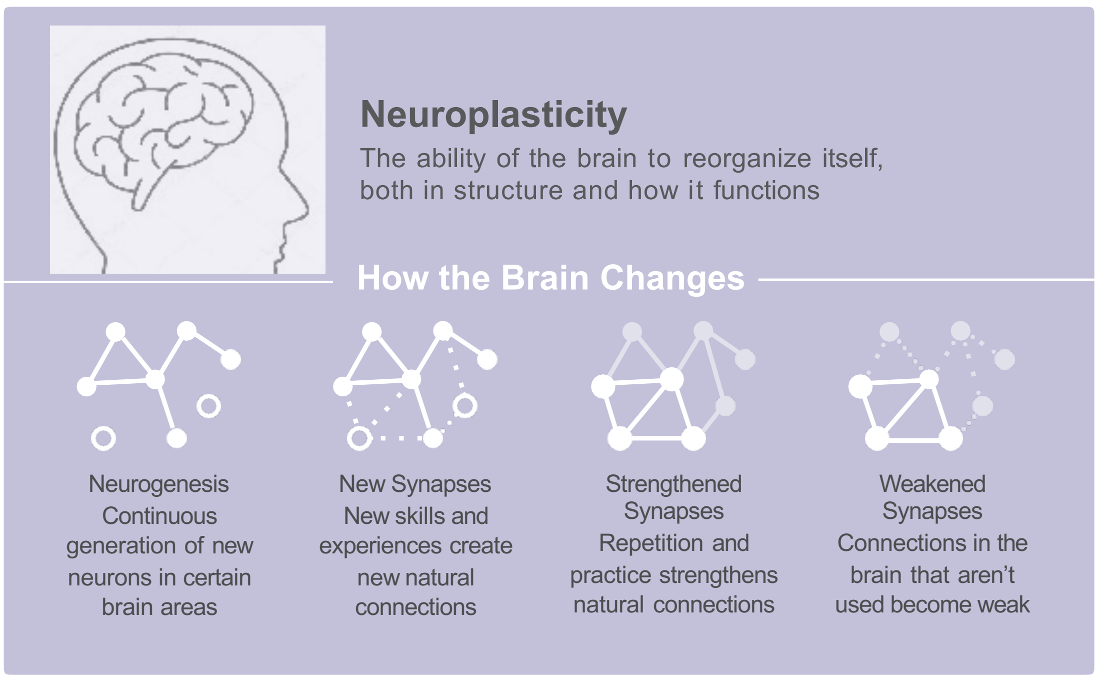

Figure 1.1. Neuroplasticity and the brain.

The following is an excerpt from: K. Pearson, J. Gordon, Introduction to Sensory Motor Systems, University of Texas: Reflexes

"During normal movements, the central nervous system uses information from a vast array of sensory receptors to ensure the generation of correct pattern of muscle activity. Sensory information from muscles, joints, and skin, for example, is essential for regulating movement. Without this somatosensory input, gross movements tend to be imprecise, while tasks requiring fine coordination are impossible.

Reflexes have been viewed as stereotyped movements in response to the stimulation of peripheral receptors. This view arose primarily from early studies on reduced animal preparations in which reflexes were examined under a set of standard conditions. However, as investigators extended their studies to measure reflexes during normal behavior, our concept of reflexes changed substantially. We now know that under normal circumstances reflexes can be modified to adapt to a task.

Three important principles are involved in the adaptation process. First, transmission in reflex pathways is set according to motor task. The state of the reflex pathways for any task is referred to as functional set.

Second, sensory input from a localized source generally produces reflex responses in many muscles, some of which may be distant from the stimulus. These multiple responses are coordinated to achieve an intended goal. Third, supraspinal centers play an important role in modulating and adapting spinal reflexes, even to the extent of reversing movements when appropriate.

Proprioceptive Reflexes Play an Important Role in Regulation of Both Voluntary and Automatic Movements

All movements activate receptors in the muscles, joints, and skin. These sensory signals generated by the body's own movements were referred to as proprioceptive by Sherrington, who proposed that they control important aspects of normal movements. A good example is the Hering-Breuer reflex, which regulated the amplitude of inspiration. Stretch receptors in the lungs are activated during inspiration, and the Hering-Breuer reflex eventually triggers the transition from inspiration to expiration when the lungs are expanded. A similar situation exists in the walking systems of many animals; sensory signals generated near the end of the stance phase initiate the onset of the swing phase.

The primary function of proprioceptive reflexes in regulating voluntary movement is to adjust motor output according to the biomechanical state of the body and limbs. This ensures a coordinated pattern of motor activity during an evolving movement, and it provides a mechanism for compensating for the intrinsic variability of motor output.

An Overall View

Reflexes are coordinated involuntary motor responses initiated by a stimulus applied to peripheral receptors. Some reflexes initiate movements to avoid potentially hazardous situations, whereas others automatically adapt motor patterns to maintain, or achieve, a behavioral goal. The purposeful responses evoked by reflexes depend on mechanisms that set the strength and pattern of responses according to the task and behavioral state (known as functional set).

Many groups of interneurons in the reflex pathways of the spinal cord are also involved in producing complex movements such as walking and transmitting voluntary commands from the brain. In addition, some components of the reflex responses, particularly components of reflexes involving the limbs, are mediated via supraspinal (brain stem nuclei, cerebellum, and motor cortex). The convergence of afferent signals onto spinal supraspinal interneuronal systems involved in initiating movements provides the basis for the smooth integration of reflexes into centrally generated motor commands."

The following is an excerpt from: D. Berger, K.Kain
Orienting and Defensive Responses: A Motor Development Perspective:

"Motor reflexes, which provide for optimal self-protective responses, may be disrupted as a result of trauma, but may also be disturbed in the course of otherwise normal motor development. These developmental disturbances may then be intertwined with disruptions caused by traumatic incidents. Proper functioning of the sensory systems is another critical element in the overall mechanism of self protection. As with motor reflexes, sensory systems may be disrupted due to trauma, or via disturbances in the original development process for these systems.

Orienting and defensive responses cannot be completely separated (e.g., orienting is a primary part of our capacity to defend). Likewise, the sensory and motor functions which are critical for self-protection often serve to support both orienting and defense.

In order for the threat response cycle to function properly, the sensory systems and motor functions that contribute to the ability to orient and defend must be integrated, functional, and available. Interruption of the normal development of the sensory systems or early protective reflexes may leave the person with an impaired capacity for defensive movements that predates the current traumatic event. Fortunately, the techniques for restoration of developmental reflexes parallel those for restoration of orienting and defensive responses. The essential repair process for each is similar: gently increase the demand for the missing reflexes until the body brings the appropriate movements into play.

The body systems related to orienting and defense must have the appropriate level of function available in order to meet the challenges to those systems. If there has been serious physical damage to any of the systems or orienting and defense, there may be a limit to how fully the orienting and defensive responses can return to full function.

Finally, the person must have an appropriate level of self-regulation in the autonomic nervous system ("ANS") to accomplish the work of orienting and efensive response repair. It is the nature of orienting and defending that the triggering of these body responses happens when there is an experience of threat, or potential threat. By extension, these will be more activation of the sympathetic system when the perceived need for orienting and defense arises. If the person has limited self-regulatory capacity in ANS function, the increased activation associated with perceived threat will sometimes overwhelm rather than encourage orienting and defense responses. Ironically, when orienting and defense are perceived as being successful, it invariably leads to a calming of the sympathetic activation.

Proprioceptive System

Proprioceptors are nerve endings that give information about where different parts of the body are in relation to each other and how fast they are moving. The proprioceptive system supports three main functions: muscle tone, body image, and control of effort. These functions provide the foundation for learning motor patterns which become the skilled movements we call coordination.

Physical repair of orienting systems is a common focus in body therapy modalities. It is standard practice, for example, to do proprioceptive repair and re-training in a classical physical therapy treatment, using hands-on techniques, balance boards, and movement exercise.

Impairment of Orienting and Defensive Responses

Our capacity to gather information about our surroundings, to correctly process that information, and to respond appropriately depends upon proper functioning of all of the orienting systems. If one of our "paying attention" systems is deficient, we will likely be predisposed to poor assessment and response to potential threat. In addition, lack of healthy ANS self-regulation and poor protective reflex development often means that our ability to choose appropriate defensive strategies is impaired. This combination of insufficient orienting and poor defensive response almost guarantees greater likelihood of injury. The irony is that traumatic injury often further impairs the orienting and defensive systems. It is common in both Failure of Physical Defense and Physical Injury categories to trauma to see this cycle of disruption of orienting and defensive responses, followed by further injury, repeated again and again. After each cycle, the capacity to orient and defend is more limited. When proper orienting and defensive responses are restored, this cycle is interrupted and the person is able to meet future physical challenges appropriately and successfully.

Assessment, Restoration and Repair

Assessing the possible impairment of orienting and defensive responses is, in effect, the assessment of the different "paying attention" systems, in combination with the protective reflexes and responses. The restoration and repair process for these functions seems almost impossibly simple: demand that they function to do their job. Finding ways to demand the orienting responses, motor reflexes and responses to function is sometimes time-consuming and requires creativity in order to be specific enough about which reflex and which response is damaged – and which we are asking to function."

2
KEY TAKEAWAY

Neuromuscular patterns are capable of considerable remodeling relative to the stimuli received and the fitness of the involved structures.

This is called **Neuroplasticity**.

Wolff's Law of Bone Transformation

Wolff's Law, originally formulated mathematically, but now considered to be a more general concept, is a statement pertaining to the functional adaptation of bone to mechanical loading. Named after its developer, German anatomist and surgeon Julius Wolff in the 19th century, the law essentially states that bones of healthy humans, when subjected to a change in mechanical stress over time, will gradually remodel to become stronger and denser to resist the higher loading, or, in response to lower loading, will become weaker and less dense.

The internal architecture of the trabeculae undergoes adaptive changes, followed by secondary changes to the external cortical portion of the bone, perhaps becoming thicker as a result. The inverse is also true: if the loading of the bone decreases, the bone will become weaker due to diminished cellular activity, at that site. It is also less metabolically costly to maintain and there is no stimulus for the continued remodeling that is required to maintain bone mass. The bottom line is that bone shape, structure, and density alter over time as a direct indication of the forces applied habitually to them.

Figure 1.2. Spinal osteophytes

Figure 1.3. Calcaneal heel spur

Figure 1.4. Bunion

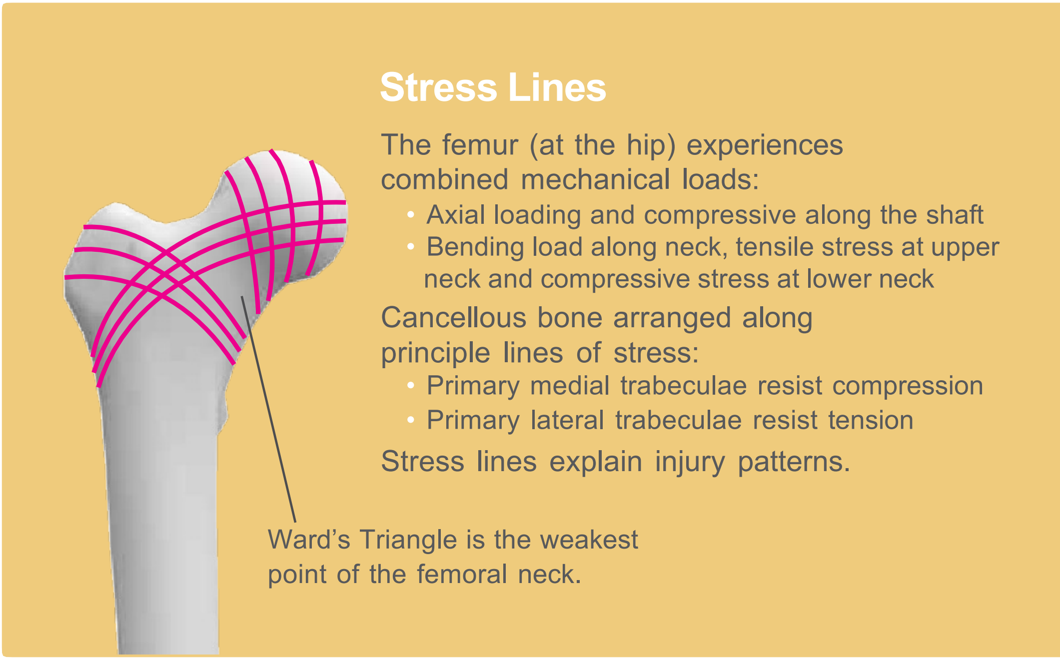

Figure 1.5. Anatomy: Stress lines

3 KEY TAKEAWAY

The shape, density, and strength of a given bone will vary according to the forces applied to that bone.

The Mechanostat Model

The Mechanostat Theorem, developed by American orthopedist and surgeon Harold Frost, is essentially an enhancement of Wolff's Law. It describes how bone adapts to mechanical stress, and thus also the relationship between muscle and bone.

According to the Mechanostat model, bone growth and bone loss are stimulated by the local mechanical elastic deformation of bone. The peak forces of muscles exerted onto bones, which are measurable by mechanography, cause their elastic deformation. The adaptation of bone, a type of feedback control loop, is considered a lifelong, dynamic process. Bone adapts its mechanical properties according to the required mechanical function – bone mass, bone geometry, and strength, the latter of which may be quantified by Stress-Strain Index (SSI) – and adapts according to everyday usage and demands.

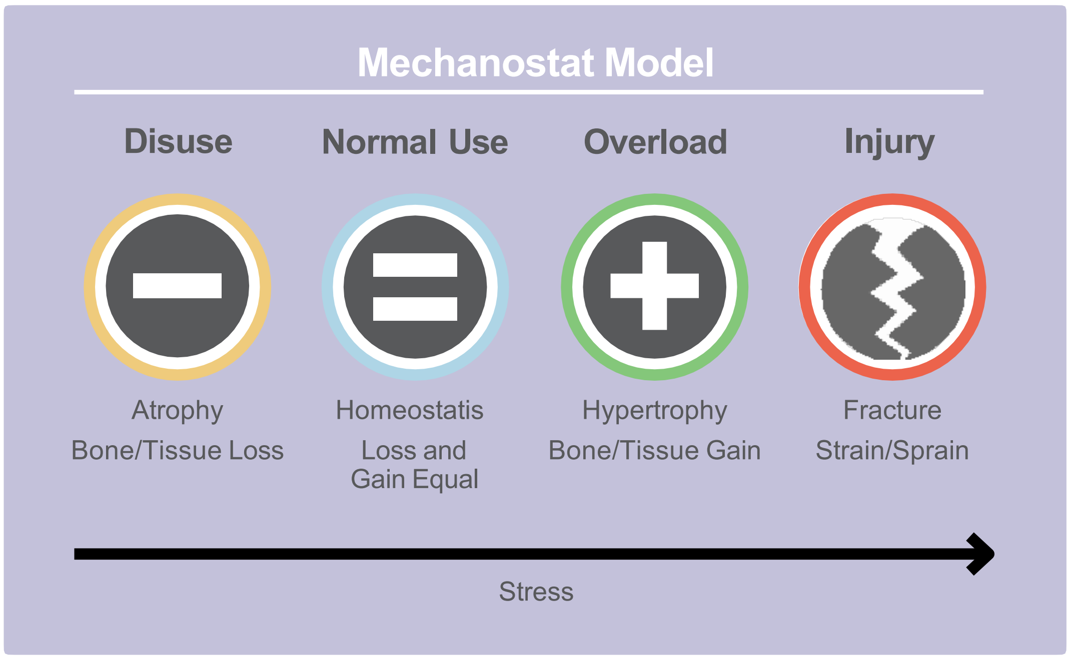

Figure 1.6. The Mechanostat model.

Thanks to this control loop, in a healthy body, there is a direct relationship between muscle cross-sectional area (as an approximation of the typical maximum force the muscle is able to produce under physiological conditions) and the cross-sectional area of the bone (as an approximation of bone strength) associated with that muscle. This relationship is of great importance, especially with regard to the loss of bone seen in conditions such as osteoporosis.

Through appropriate adaptive training, using the required threshold forces applied to the affected bones, new bone growth may be stimulated and bone loss may be minimized or prevented. Examples of this training are trampolining and rebounding, which are so effective at stimulating bone growth, strength, and density that the National Aeronautics and Space Administration (NASA) has used bands and band harnesses with astronauts in orbit to simulate trampolining, thus opposing bone loss while in a gravity-free environment.

Davis's Law

Davis's Law is a corollary of Wolff's Law that pertains to soft tissue and is commonly cited in the fields of anatomy and physiology. It is named after the American orthopedic surgeon Henry Gassett Davis (1807-1896), who also researched traction methods. It describes how soft tissue and, principally, tissue containing collagen fibers (e.g., ligaments, tendons, and fascia) will model via imposed demands similar to the way in which Wolff's Law describes the same phenomenon for bone. It is used, in part, to describe muscle-length relationships and helps to predict the effects of rehabilitation and postural distortion treatments in which muscle length is of concern.

Davis's Law also applies to muscle tissue and explains how a muscle will lengthen or shorten in response to stretch or load, respectively. Since most major muscles oppose the function of another major muscle (within an agonist – antagonist pairing) they, along with their synergistic and associated muscle groups, tend to reciprocate each other's length. For example, a strong yet inflexible Gastroc-soleus (calf) complex will often result in a weak and highly flexible tibialis anterior (shin) muscle, and, possibly, vice versa as well.

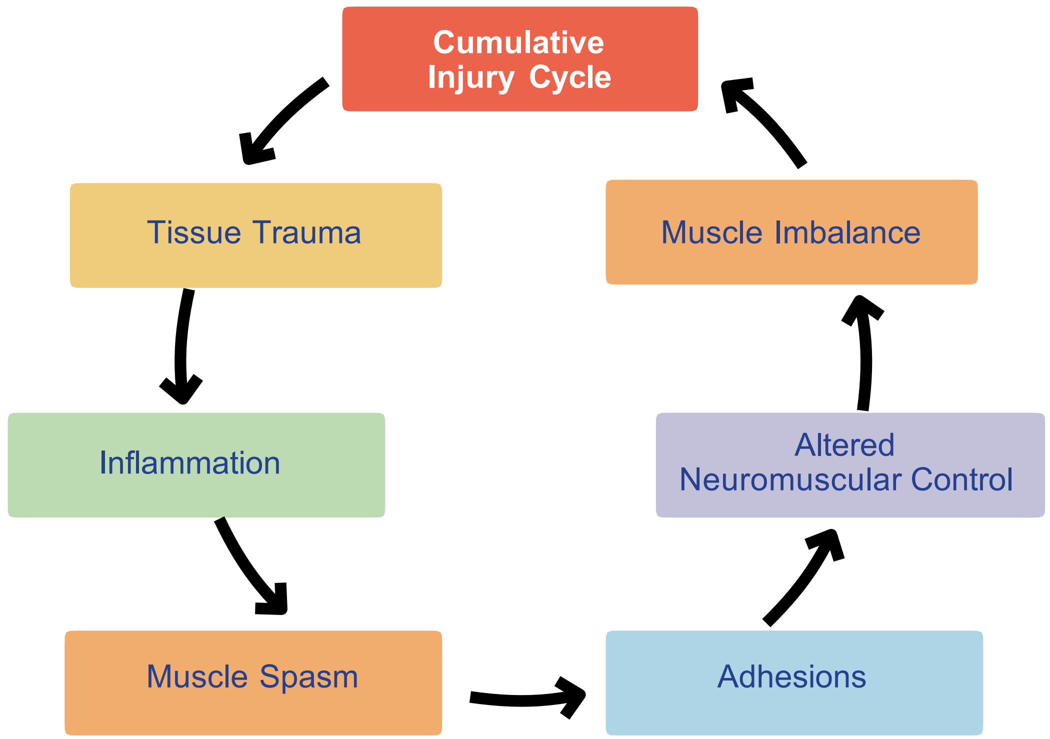

Figure 1.7. Cumulative injury cycle. The cycle follows a path of inflammation, muscle spasm, and the development of soft tissue adhesions that can lead to altered neuromuscular control and muscle imbalance.

Tendons are soft tissue structures that respond to changes in mechanical loading. Bulk mechanical properties such as modulus, failure strain, and ultimate tensile strength, decrease over long periods of disuse as a result of micro-structural changes on the collagen fiber level. In micro-gravity simulations, human test subjects can experience gastrocnemius tendon strength loss of up to 58% over a 90-day period. Test subjects who were allowed to engage in resistance training displayed a smaller magnitude of tendon strength loss in the same micro-gravity environment but modulus strength decrease was still significant. (Reeves; J Applied Physiol; Jun 2005; 2278) “Influence of 90 day simulated micro gravity on human tendon mechanical properties and the effect of resistance countermeasures.”

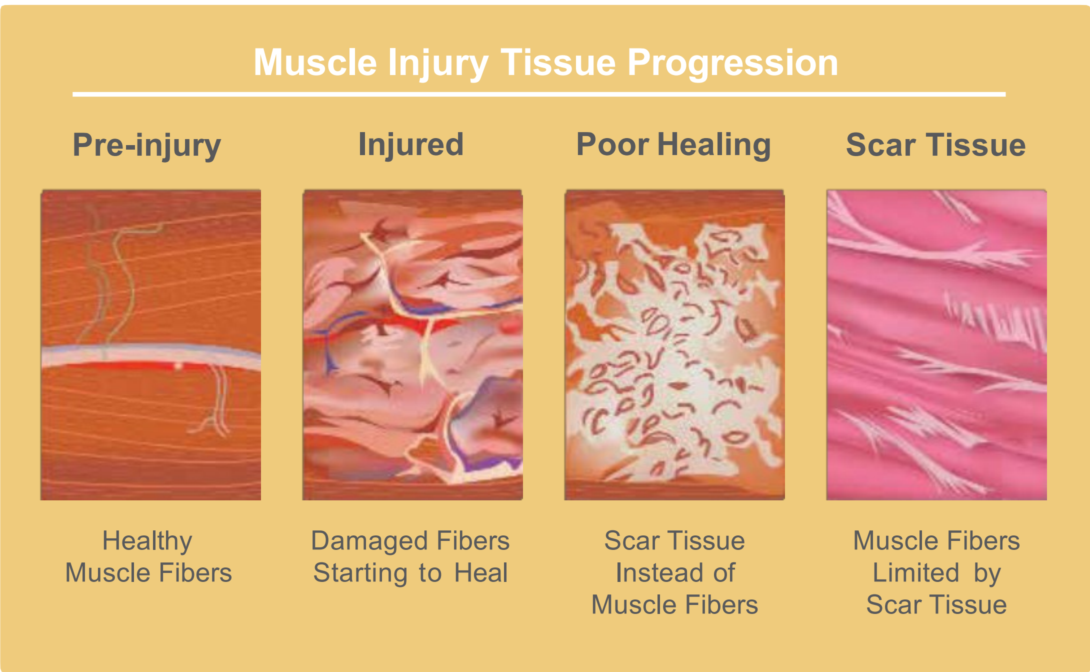

Figure 1.8. Muscle injury tissue progression.

Conversely, tendons that have lost their original strength due to extended periods of inactivity can regain most of their mechanical properties through gradual reloading of the tendon, due to the tendon's response to mechanical loading. Biological signaling events initiate re-growth at the site, while mechanical stimuli further promote rebuilding. This 6-8 week process results in an increase of the tendon's mechanical properties until it recovers its original strength. However, excessive loading during the recovery process may lead to material failure, i.e. partial tears or complete rupture. Additionally, studies show that tendons have a maximum modulus of approximately 800 Mpa; thus, any additional loading will not result in a significant increase in modulus strength. (Wren; Clinical Biomechanics; 2001; 16(3); 245) "Mechanical Properties of the Human Achilles Tendon."

These results may change current physical therapy practices, since aggressive training of the tendon does not strengthen the structure beyond its baseline mechanical properties; therefore, patients will still be susceptible to tendon overuse and injuries.

4
KEY TAKEAWAY

Soft tissue (muscle, tendon, fascia, and ligament) density, strength, propensity to injury and, in fact, the amount of fibrotic damage accrued, will vary according to the forces applied to that region.

Physiology

(For more detailed coverage of this topic, refer to The Future of Foot Care monograph, pages 18-20.)

In essence, human gait is simply another physiological system that must have three essential components: input, central processing, and output. Figure 1.9 illustrates these components as a feedback control loop.

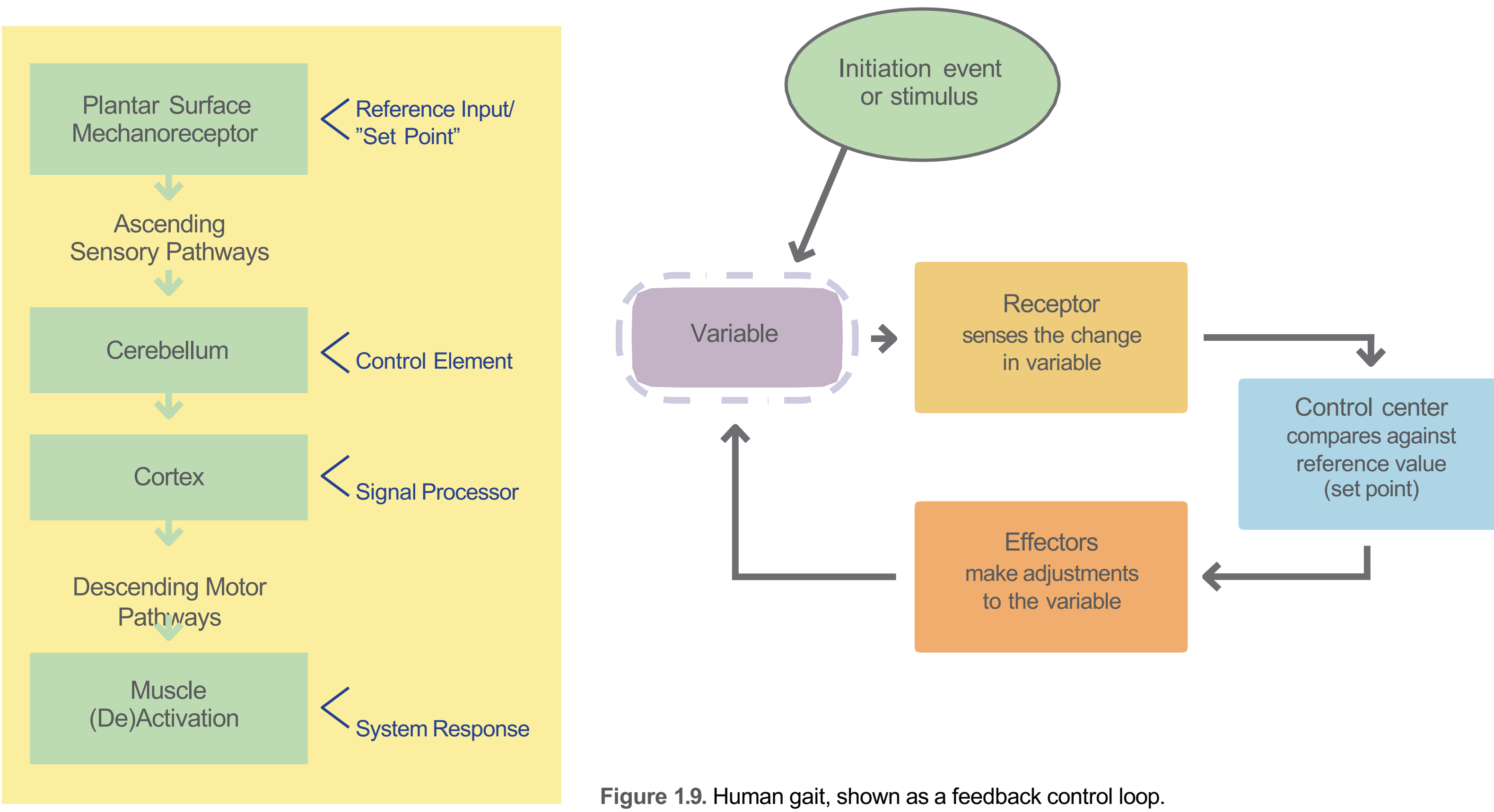

Figure 1.9. Human gait, shown as a feedback control loop.

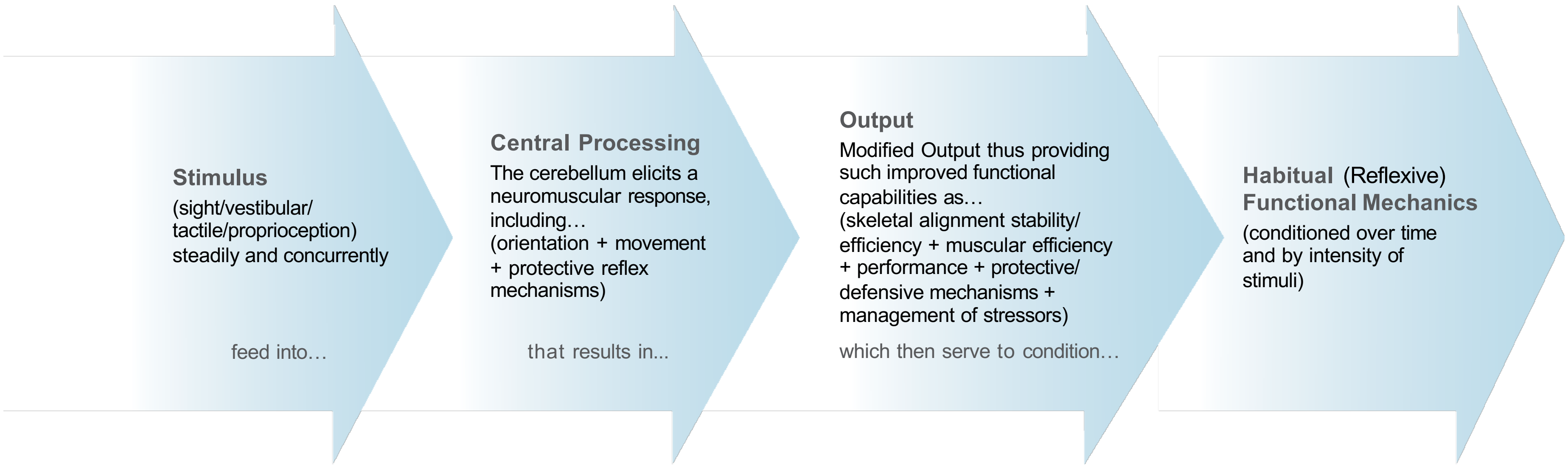

Figure 1.10. The sensory motor components of human gait.

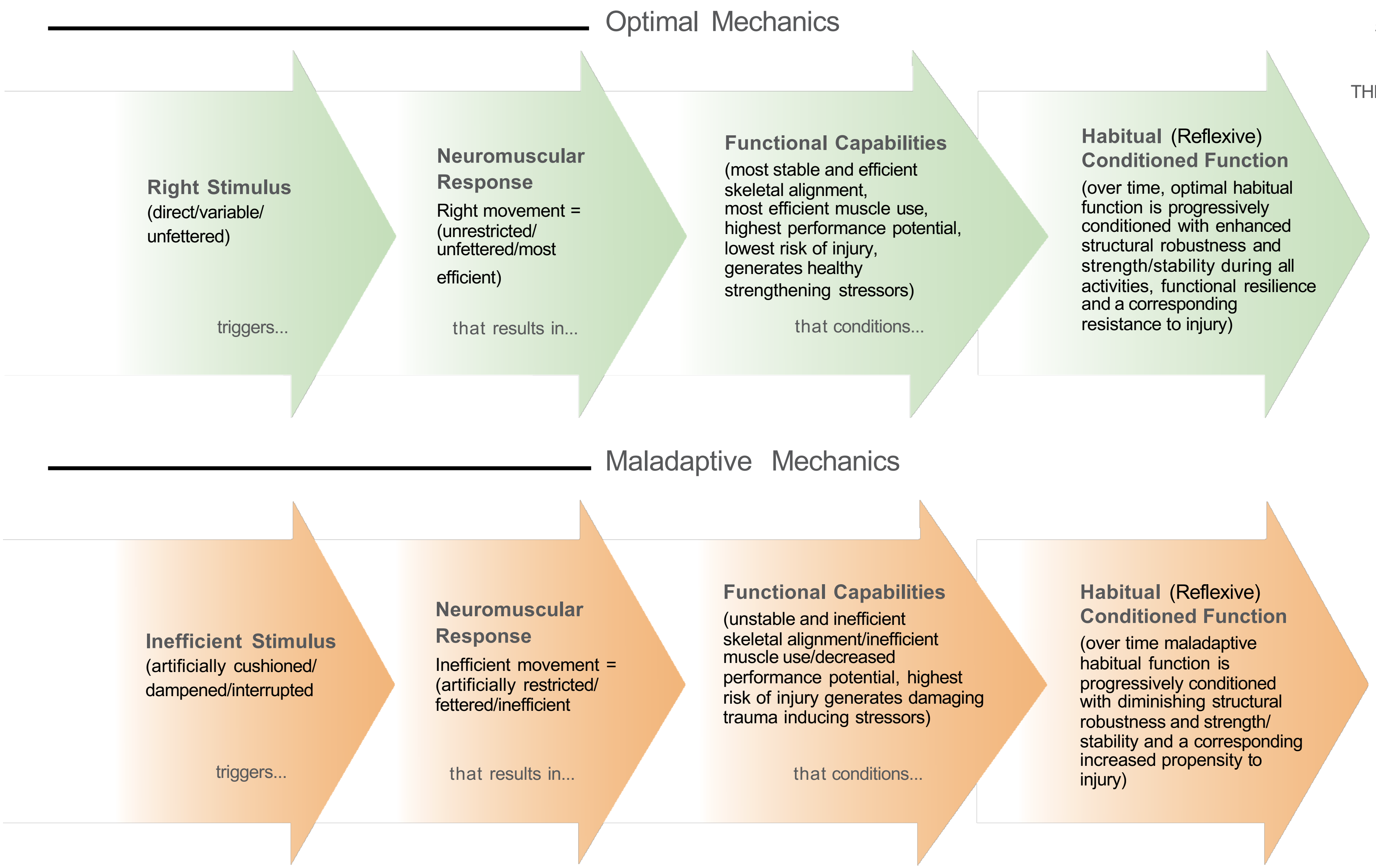

Figure 1.11. Factors that affect optimal mechanics and maladaptive mechanics.

5 KEY TAKEAWAY

Neuroplasticity: all sensory-related and associated motor functions adapt according to use.

These include sight, hearing, taste, smell, touch, pain, balance, acceleration, temperature sense, and proprioception.

Achieving optimal mechanics and the means for achieving optimal mechanics and optimal restorative and repair processes for maladaptive mechanics seem almost impossibly simple – simply demand that the neuromuscular and skeletal systems do their jobs. As the age old adages say, “Use it, or lose it!” and “Garbage in, garbage out.”

Neuromusculoskeletal Adaptation

The neuromuscular and skeletal systems of the human body continually adapt in response to the way we use our bodies. The ways in which we regularly employ our bodies and the environments that we use them in, determines our overall functional capability.

For example, challenging the body with regular exercise causes it to adapt by strengthening and becoming more capable. Conversely, the body also adapts to a lack of exercise by weakening and becoming less capable.

Integral to our body’s functional capabilities are the neural networks that first collect sensory information through touch, pressure, pain, and spatial positioning before sending signals to trigger muscle activations. These neural networks also adapt to challenges imposed by, or the relative lack of sensory information from, usage and environmental influences.

6 KEY TAKEAWAY

Human gait, as in all physiological systems, employs sensory input, central processing, and modified output in an ongoing functional feedback loop. Optimal gait requires Right Stimulus input, while a maladaptive gait results from inefficient stimulus input.

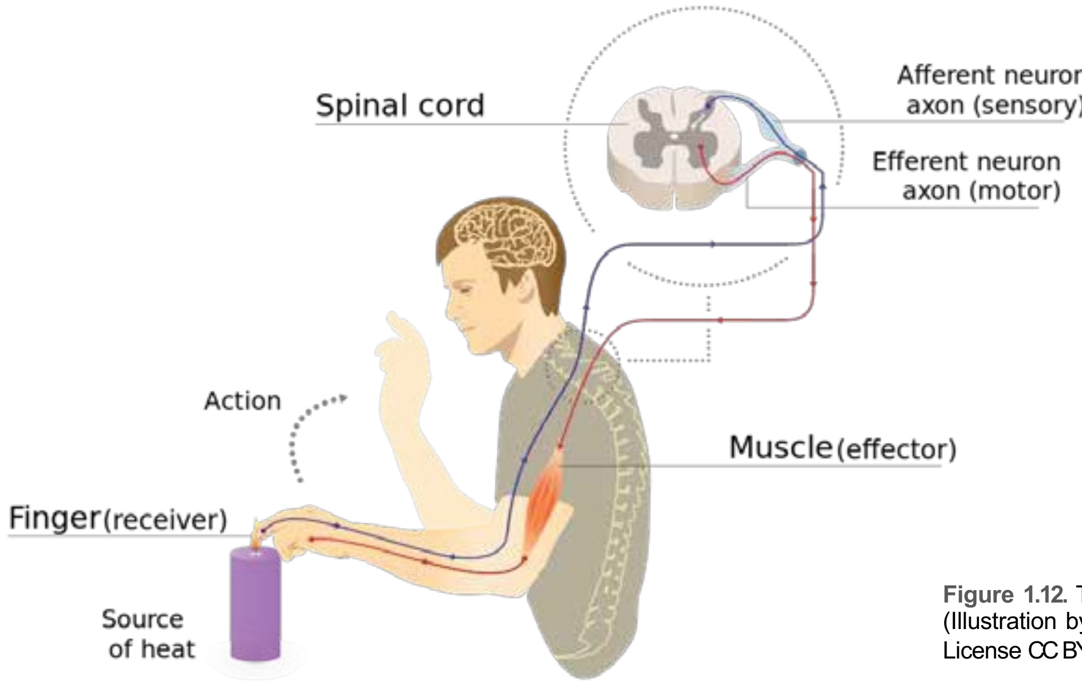

Figure 1.12. The reflex arc demonstrated. (Illustration by Marta Aguayo, used under License CC BY-SA 3.0)

Proprioception and Reflexes

The coordination of our limbs, and all body movements is determined by proprioceptive sense ("proprioception"). Every movement the body makes requires the intimate, full engagement of the neuromuscular and skeletal systems in an integrated and harmonized fashion.

Neuromuscular function

The neuromuscular system is responsible for muscle activations that control the movement of the body. The body's muscular reflex actions, such as its innate protective reflexes and conditioned reflexes, involve proprioception, which is the body's ability to sense the relative speed and position of its neighboring parts. Proprioceptive movements can either be conscious or unconscious (reflexive).

With sufficient regular repetition or training, conscious proprioceptive movements gradually become unconscious. In this regard, the phrase "use it or lose it" is often applied to the maintenance of optimal neuromuscular functional capabilities.

7
KEY TAKEAWAY

The ability to walk or run safely and efficiently is determined by synergistic proprioceptive and reflex nerve 'loops' that are detected via the feet, legs, hips, and back and processed in the cerebellum, ultimately to fine-tune motor output to the feet, legs, hips, and back.

Conditioned responses

Proprioceptive abilities are adaptive; regular use and environment hone their functional capabilities. Examples of this are learning to write, walk, swing a club, catch a ball, or drive a car. Initial conscious focus on the activity gives way to unconscious and reflexive movement through repetition.

Similarly, the body's protective reflex responses are conditioned through use. Protective reflexes can be triggered by a variety of sensory stimuli, such as touch, vision, and fearful anticipation (psychological). Brush your hand too close to a flame and it will reflexively pull away. Trip and fall and, before you can think, your hands will reflexively reach out to protect you from impact.

However, when an experienced driver in the passenger seat of a car reacts to perceived danger by reflexively pressing a nonexistent brake pedal, that is consciously trained protective reflex in action. By repeatedly practicing a new response with sufficient intensity and duration, you can modify a reflexive proprioceptive movement or reaction to an alternative adaptation.

Environmental influences

Environmental influences significantly affect proprioceptive and protective reflex functional capabilities. For example, if an avid writer's hand and wrist are put in a cast, the functional capability of that area will quickly adapt to the restriction and lack of stimulation by losing much of its "coordination" and strength capability. This lost function, or maladaptation, can be regained by consciously retraining the proprioceptive movements through repetition so the affected area adapts in such a way that the function becomes reflexive again.

Habituation

The definitions of habituation are:

- the gradual adaptation to a stimulus or to the environment
- the extinction of a conditioned reflex by repetition of the conditioned stimulus

(Dorland's Medical Dictionary). We can infer that this indicates that the nervous system has a built-in means of adapting to, and ultimately ignoring unimportant and/or unchanging sensory input.

When considering human gait, optimal neuromuscular function and skeletal alignment are reliant upon a continuous source of disparate information; otherwise the central processor will habituate and ignore a flow of unchanging sensory input. This habituation thus diminishes, or even eliminates, the appropriate motor output necessary for optimal neuromuscular gait mechanics. This is critical to appreciating the variable stimulus capacity of Biopods Technology and the inadequacy of current custom, contoured, and cushioned insoles.

"Sweet spot" function and healthy adaptation

Everyone has a "sweet spot" for optimal musculoskeletal function – the point at which stressors actually enhance the capabilities of the body. This is known as healthy stress. Each individual's "sweet spot function" is encouraged and enhanced by activities that promote a balance of strength and flexibility in opposing muscle groups at the joints.

Daily activities or movements that encourage sweet spot function lead to optimal proprioceptive conditioning by safely increasing the functional robustness of the musculoskeletal structure, and reducing the risk of injury and degenerative stress. In the world of athletics, this is also known as training with Proper Technique.
Even those with severe genetic deformities or those who have suffered irreversible debilitating trauma, joint fusion, or similar ailments, will have an optimal functional sweet spot, though these capabilities may be limited.

Even those with severe genetic deformities or those who have suffered irreversible debilitating trauma, joint fusion, or similar ailments, will have an optimal functional sweet spot, though these capabilities may be limited.

Maladaptation and Degenerative Stresses
The body will maladapt when it is unable to safely manage stressors that exceed its conditioned functional capabilities. Maladaptation, in the form of atrophy and/or weakening, can develop in response to a lack of stressors.

Most individuals, regardless of genetic predisposition, exhibit maladapted proprioceptive and reflex functions in proportion to their daily activities and environment.

In a sports training context, Poor Technique conditions a less than optimal version of musculoskeletal function, promotes maladaptation, encourages degenerative stress, increases injury risk, and hampers performance capabilities. In this situation, stressors created during functional use exceed the sweet spot by pushing structural function beyond safe or healthy tolerances. The resultant degenerative stresses can cause, exacerbate, or otherwise contribute to systematic breakdowns and disease.




Engaging in daily Poor Technique activities causes maladaptive changes as the body attempts to compensate for the degenerative stressors as well as proprioceptive and mechanical inefficiencies. In addition to possible joint and muscle stiffness and pain, this leads to more pronounced and local/global imbalances in:

- strength
- flexibility
- mobility
- endurance
- coordination
- balance
- kinesthetic

Often, maladaptive proprioceptive and mechanical functions remain reflexive long after the actual stressors have ceased or been retrained away.

Some soft tissue and bone tissue damage will present obvious symptoms, while some fibrosis and scar tissue may be symptom-free. The inelastic nature of fibrotic or scar tissue further contributes to maladaptive function.

Aside from severe genetic deformities and acute trauma, the majority of foot, leg, hip, and back problems and pain are caused by functional maladaptations that have become reflexive. These conditioned reflexive inefficiencies impair the body's ability to safely manage increased activity.

Therapeutic programs that incorporate Proper Technique are the most effective means to safely retrain the reflexive maladapted function in the feet, legs, hips, and back. By employing repetitive Proper Technique activities, the body's proprioceptive and reflex systems readapt so that healthier optimal function becomes reflexive.

9 KEY TAKEAWAY

The alleviation of maladaptive and degenerative stresses is the secondary goal of Biopods technologies.

Kinetic Chain and Biomechanics

A kinetic chain (sometimes referred to as a kinematic chain) can be defined as a "combination of several successively arranged joints constituting a complex motor unit" (Steindler). This functional concept is useful in the study of human movement, because it directly implies that movement (or alignment) at one joint produces, or affects, movement (or alignment) at another joint within that kinetic chain (Reuleux). In particular, the posterior fascial line, which extends from the bottom of each foot to the top of the head (Wolf), is a series of contiguous myofascial slings, nicknamed the powerhouse of movement, and directly implies that a disturbance of movement (or alignment) at the feet results in a disturbance of movement (or alignment) throughout the rest of the line. Of particular interest, within this line, is the stirrup-like effect created by the contiguous insertion points of the tibialis anterior and the peroneus longus (a.k.a. fibularis longus) muscles, on the 1st metatarsal. (See Figures 1.13 and 1.14.)

Their functional balance largely determines the alignment and stability of the foot in both a biomechanical sense and within the kinetic chain concept.

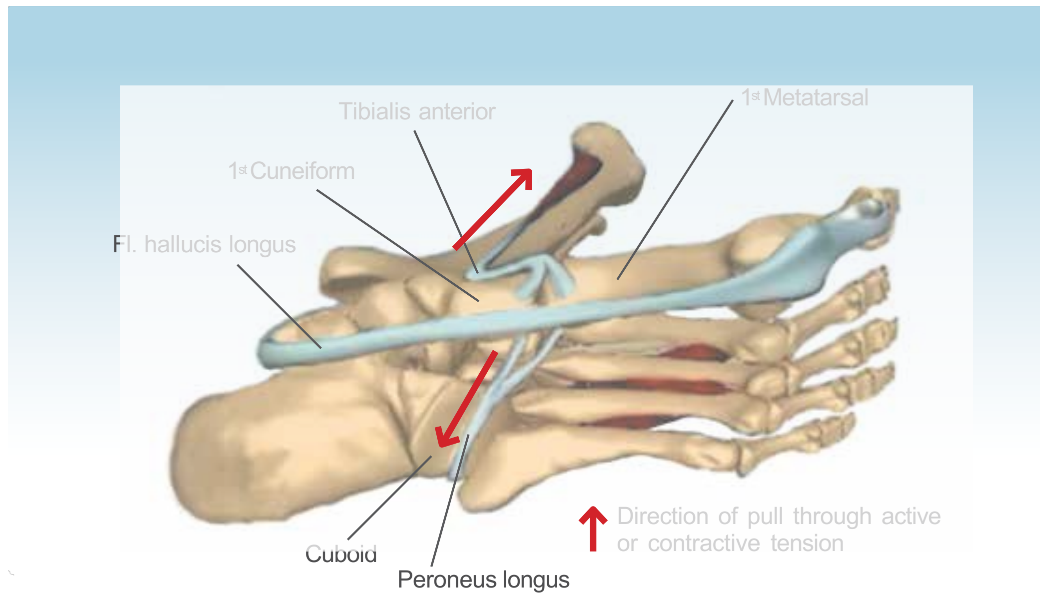

Figure 1.13. Left foot/plantar surface. Active or contractive tension on peroneus longus creates a pulley effect around the cuboid, cinching the first cuneiform and first metatarsal together.

Further, there are basic classifications of kinetic chain:

- Closed kinetic chain – functional movement performed during which the foot (regarding leg motion) is fixed in space and cannot move; thus the extremity remains in constant contact with the immobile surface
- Open kinetic chain – functional movement performed during which the foot (regarding leg motion) is free to move.

Based upon these definitions, the lower limb, during human gait, continuously cycles through episodes of closed kinetic chain (i.e., stance phase) and of open kinetic chain (i.e., swing phase) activity. The body's challenge is to attain a close-packed condition (i.e., skeletal alignment in which articular surfaces are in maximum congruency state for those joints, resulting in the optimal mechanical stability, which by necessity implies that all the ligaments and capsules involved are optimally taut) for the foot and entire lower limb, as it transitions from swing phase to stance phase. This is where "the rubber meets the road" and is the focal point of our discussion.

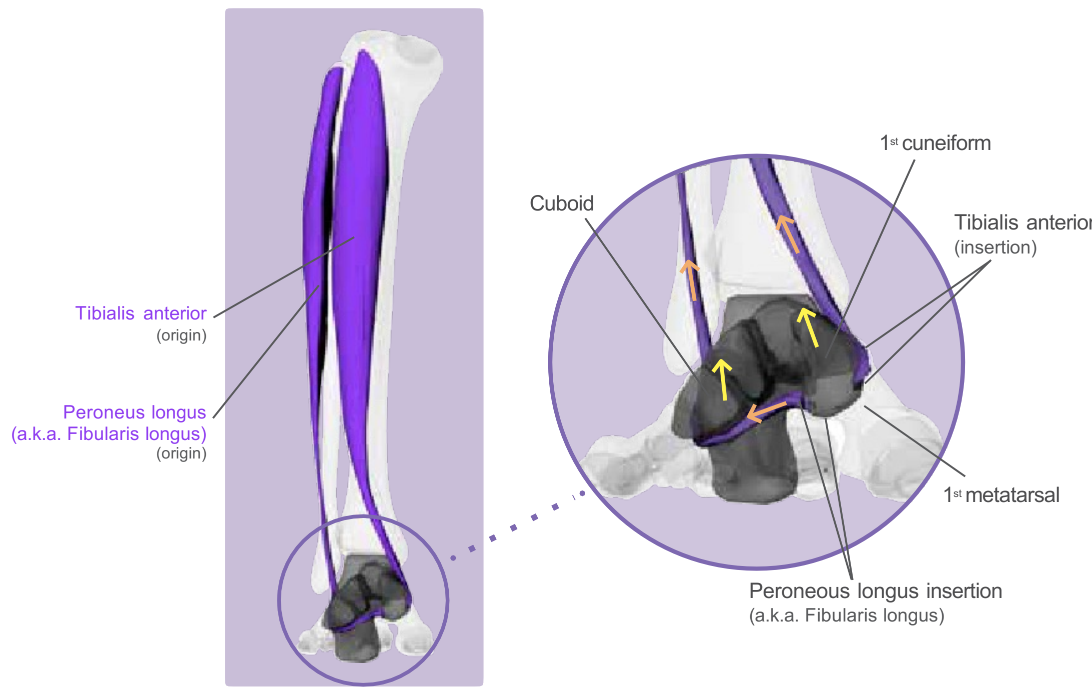

Figure 1.14.

10
KEY TAKEAWAY

Both the kinetic chain model and the biomechanics model of optimal foot alignment are reliant upon the tibialis anterior and peroneus longus (a.k.a. fibularis longus) muscles acting in an ideal state of balance via a stirrup/"transverse tie beam" effect.

SECTION 2

Optimal "Natural" Foot and Lower Limb Function

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SECTION 2

Optimal "Natural" Foot and Lower Limb Function

(For more detailed coverage of this topic, refer to The Future of Foot Care monograph, pages 5-26.)

The Gait Cycle

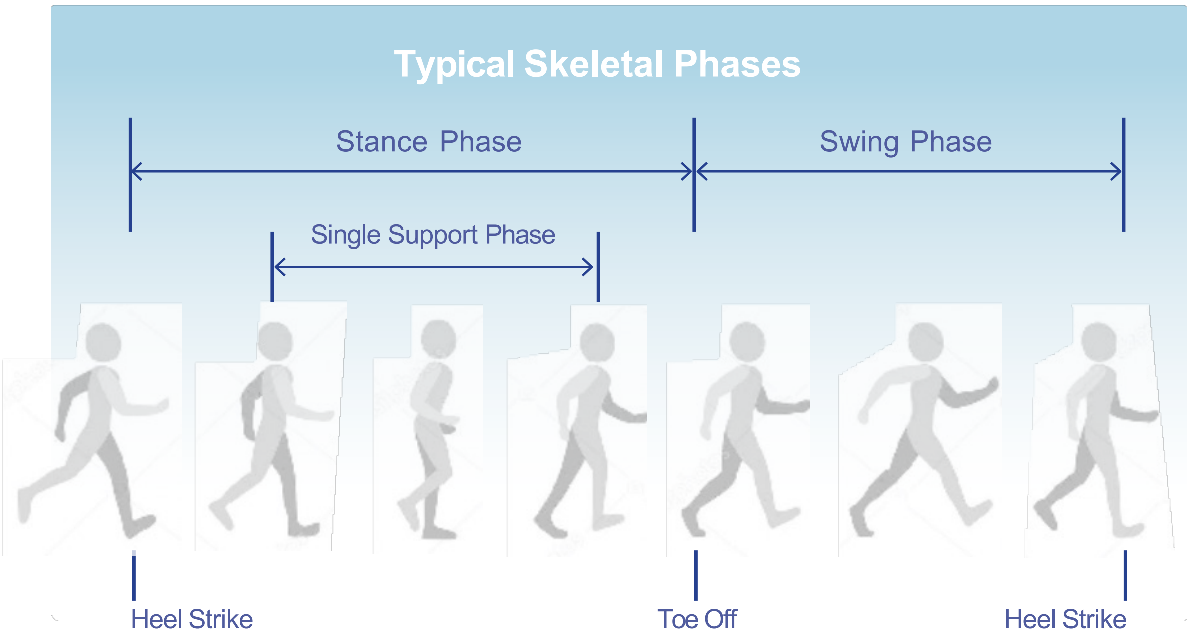

Figure 2.1. Typical skeletal phases.

Optimal Neuromusculoskeletal Mechanics During Gait

Optimal neuromusculoskeletal mechanics are typically and exclusively observed within individuals who are in a habitual barefoot environment. When barefoot, the sole of the foot picks up the subtle variations in terrain (texture and orientation) and this tactile stimulus from the ground is not dampened. The brain uses these tactile stimuli, in concert with the proprioceptive stimuli received from the feet, ankles, legs, hips, and back to initiate protective muscle activations throughout the lower limbs such that they are capable of safely managing the dynamic forces generated by the demands of three-dimensional activities. When barefoot, the foot is unfettered and thus there is no restriction to the dynamic musculoskeletal movement. When barefoot, the foot receives Right Stimulus and, as a result, Right Movement is uninhibited.

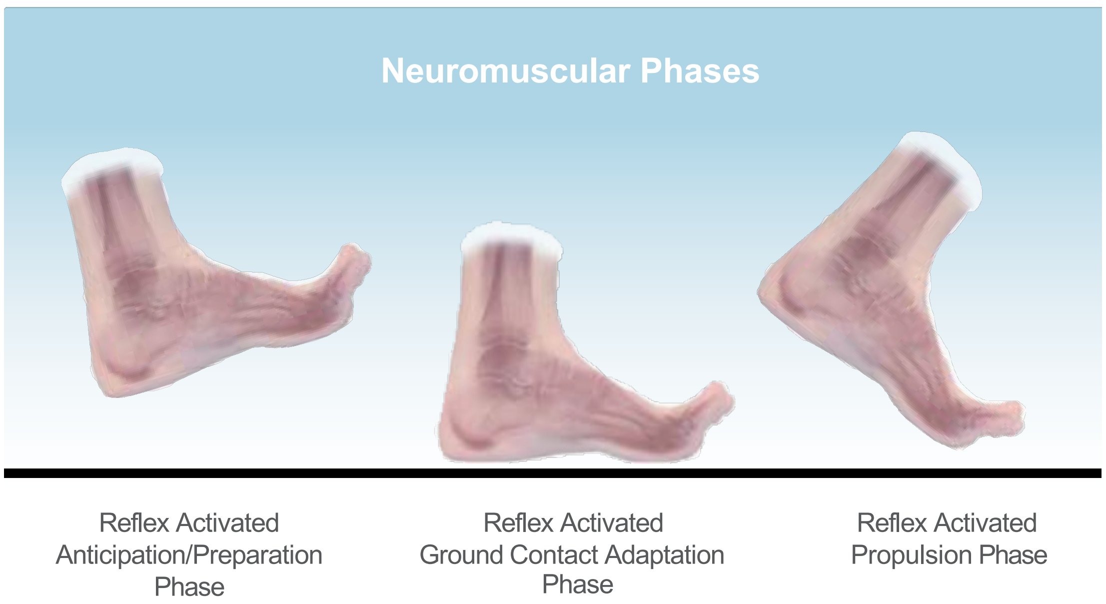

Figure 2.2. Neuromuscular phases.

11 KEY TAKEAWAY

Only 3% of unshod populations present foot-related problems (and most problems are not debilitating). More than 66% of shod populations are currently experiencing some form of foot-related problem or pain.

Neuromuscular Reflex-Activated Anticipation/Preparation Phase

Movement-generated proprioceptive sensory input and tactile stimulus (from the foot's ground contact) initiates a protective reflex response during the skeletal swing phase (while the foot is off the ground) in anticipation of the imminent next step's ground contact.

Neuromuscular Reflex-Activated Ground Contact and Propulsion Phases

The protective reflex response activates muscle contractions to optimally align and stabilize the bones of the foot, ankle, leg, and hip in order to safely manage the forces anticipated during the next step's ground contact (skeletal heel stance phase). The resultant optimal alignment and stability not only protects the structure, but also ensures optimal muscular efficiencies and performance capabilities. Activity-related stresses are safely managed and, therefore, contribute to the neuromusculoskeletal structure becoming more robust (i.e., stronger and more flexible), thus significantly reducing the risk of injury.

Ideal Gait Mechanics of the Foot and the "Optimal Arch Apex"

During natural healthy foot function (as observed in the habitually unshod community), optimal neuromuscular function and related musculoskeletal mechanics/alignment are ideally a dynamic response to activity levels and terrain. In other words, the muscles of the foot should act to optimally align the bones to most effectively manage the forces generated during varying activities and terrain. Thus, the dynamic stable arch system would provide a capable foundation for the kinetic chain of the lower limbs and body while promoting optimal neuromusculoskeletal alignment/function/performance so that little or no degenerative stress is generated throughout the kinetic chain.

From a strictly mechanical perspective, the lower limb structure can be considered to comprise a ball and socket joint at the hip, a simple hinge joint at the knee, with the foot and ankle functioning similar to that of one-half of a universal joint, in order to provide an effective interface with the ground. However, closer examination of the skeletal structure of the foot and ankle suggests that, with appropriate muscle contractions, the bones of the foot are capable of aligning into a dome-like configuration, which can thus behave much like a socket moving around an imaginary ball. (Figure 2.3).

To date, it has been widely accepted that the shape of the interlocking bones and ligament strength combine to maintain the transverse, medial longitudinal, and lateral longitudinal arches of the foot. This established viewpoint, while technically correct, overstates the role that bone shape and ligament strength play in maintaining optimal structural integrity of the foot. For example, if we isolate the bones of the foot from the muscle, tendons, ligaments, etc., and view the structure from a physics perspective, it becomes clear that the relative alignment and positioning of the bones are the primary determining factors in the foot's structural capabilities.

Within the medical community, the foot is commonly described as consisting of the medial longitudinal, lateral longitudinal, and transverse arches. This view, from a physics perspective, is inordinately simplified and ignores the complexity of the structure as a whole. The structural physics of the foot more accurately demonstrates a series of intersecting arches that run medially to laterally and posteriorly to anteriorly from the calcaneus to the metatarsal heads. To better understand both the simplicity and complexity of this arch system, it is important to identify the dynamics of a single arch and its intrinsic relationship within a system of arches.

Figure 2.3.

In the foot, the structural mechanics of a single arch (Figure 2.4) are determined by its components:

- the material composition of the arch: interlocking bone structure and ligaments – their relative strengths (e.g., tensile, compressive.) and elasticity
- a tie beam: soft tissue, i.e., tendons, muscles, fascia, etc., and their relative strengths (tensile and elastic).

Within the material composition of any given arch structure, there exists a central "keystone" about which opposing forces must equalize as a means of maintaining the arch integrity. When force is applied to an arch structure, the stronger and more stable the material composition, the lower the degree of tensile (or pulling) force produced on the tie beam.

When combined in a multi-arch system such as the foot, these singular arch dynamics work synergistically to maximize relative strength and stability while greatly minimizing stress, and are more effective collectively than individually.

Therefore, from a physics perspective, the most inherently sound structural mechanics would be achieved if the bones of the foot could interlock and maintain the multi-arch functional dynamics of a dome shape. Such a dynamic could manage greater loads with minimal contribution from, or stress on, the ligaments and extrinsic/ intrinsic musculature. The dome shape of the interlocking bones would function much like a socket, capable of rotating around an imaginary ball (Figures 2.3 and 2.5). The level of functional stability of the dome would be determined by the "ideal" or "optimal arch apex" height necessary to most effectively maintain structural integrity in the interlocking bones as they manage the forces generated throughout three-dimensional activity.

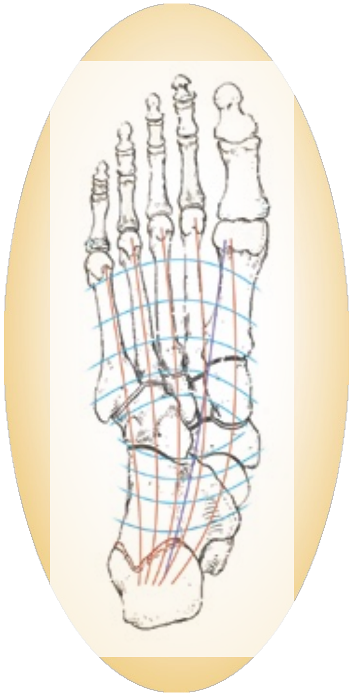

Figure 2.4. The structural mechanics of a single arch.

Further, the location of the "optimal arch apex" would ideally correlate to the location of the "conceptual" arch keystone for optimal force management.

Figure 2.5. The dome shape of the interlocking bones.

The relative positioning of the mid-foot joints (i.e., the optimal arch apex) is significant to the degree and pattern of forefoot segment motion, which in turn, is indicative of the foot's stability.

Biomechanically, and within the kinetic chain model, the integrity of the foot's structural alignment plays a significant role in managing the forces and stresses generated during gait. It is clear that an ideal dome-like structural alignment in the foot is possible, and that there is an inverse relationship between the structural integrity of the foot and the muscular effort required to facilitate and manage its relative alignment. The more structurally sound the arch, the less muscular effort is required to manage the alignment.

12 KEY TAKEAWAY

The multidimensional arch system is created via the Windlass and Cuboid Pulley Effects, which cinch the bones of the foot into a dynamic dome-like structure that is both a mobile adaptor and rigid lever at various times throughout the ground contact and propulsion phases of gait.

As indicated earlier, during ideal natural healthy foot function, the optimal neuromuscular function and related skeletal alignment is a dynamic (protective) reflex response to the activity levels and terrain currently being experienced. That is, the muscles of the foot act to optimally align the bones to most effectively manage the forces generated during varying activities and terrain prior to each step's ground contact. For example, while running, tactile, nociceptive, mechanoreceptive and proprioceptive stimuli trigger reflex muscle activations to proactively create a higher (mechanically stronger) and more stable arch system than when walking. Thus, the protective-reflex based and activated, dynamic, stable arch system provides a capable foundation for the lower limbs and body (kinetic chain) while promoting optimal neuromusculoskeletal alignment/function and minimal degenerative stress throughout.

An excellent example of neuromusculoskeletal conditioning potential can be found in individuals who have lost their arms, yet developed the dexterity of their feet to the extent that they function as "hands" – still capable of performing many complex tasks, all with a considerable degree of finesse and precision. Extrapolating from this model, there is no reason that the neuromusculoskeletal function of the feet cannot be conditioned to achieve ideal, dynamically domed, structural alignment, as described in the previous Lesson.

It would be virtually impossible to quantify the role of specific muscles throughout such a multiplicity of activities. We can, however, examine the relative roles (primary and supporting) that muscles are ideally capable of performing throughout the gait cycle, from a mechanical perspective.

The extrinsic muscles of the foot comprise the extensors (originating in the lateral aspect of the shin), the flexors (originating in the posterior side of the lower leg) – both groups are connected to the foot via long tendons – and the ankle flexors (i.e., the calf muscles). The intrinsic muscles of the foot (located primarily in the plantar region of the foot) comprise flexors, adductors, and abductors.

13
KEY TAKEAWAY

The optimal dome-like arch system's apex is created, muscularly, during swing phase, via the stimulus received from the stance phase of gait of the contralateral foot. The optimal dome-like arch system apex can only be achieved with "Right Stimulus."

From an ideal mechanical perspective, the following muscles are grouped according to their gait-related roles (see Figures 2.6 and 2.7):

Prior to weight bearing:

- Alignment of the foot and ankle structure: via active extrinsics — extensor hallucis longus and digitorum longus, tibialis anterior, and peroneus longus (aka fibularis longus) (Group A),
- Stabilization of the foot and ankle structure: via active Group A (re: foot), active peroneus brevis (aka fibularis brevis) and tibialis posterior (Group B) (re: ankle), in concert with passive extrinsics – flexors hall. long. and brev. and digitorum longus (Group C), and passive intrinsics – quadratus plantae and flexors dig. brev. & min., and lumbricals (Group D)

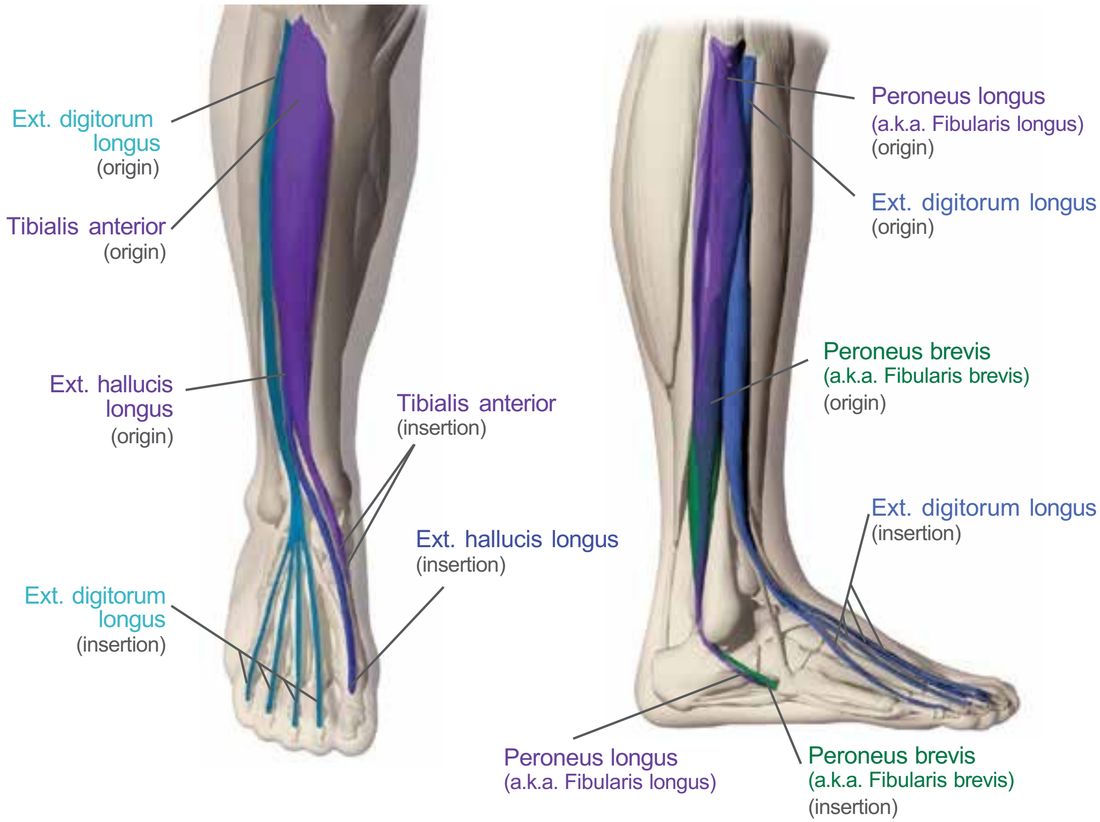

Figure 2.6.

During weight bearing:

- Stabilization of the foot and ankle structure: via active Group A and peroneus brevis (aka fibularis brevis) with passive to active Group B, Group C, and abductors hallucis and digitorum minimi, adductor hallucis and the interossei (Group E), in addition to the plantar fascia (Group F)

Propulsion:

- Stabilization of the foot structure: via active Groups B, C, D, and E and active to passive Group A and peroneus brevis (aka fibularis brevis)
- Propulsion: via active Group B and active extrinsics – gastrocnemius and soleus.

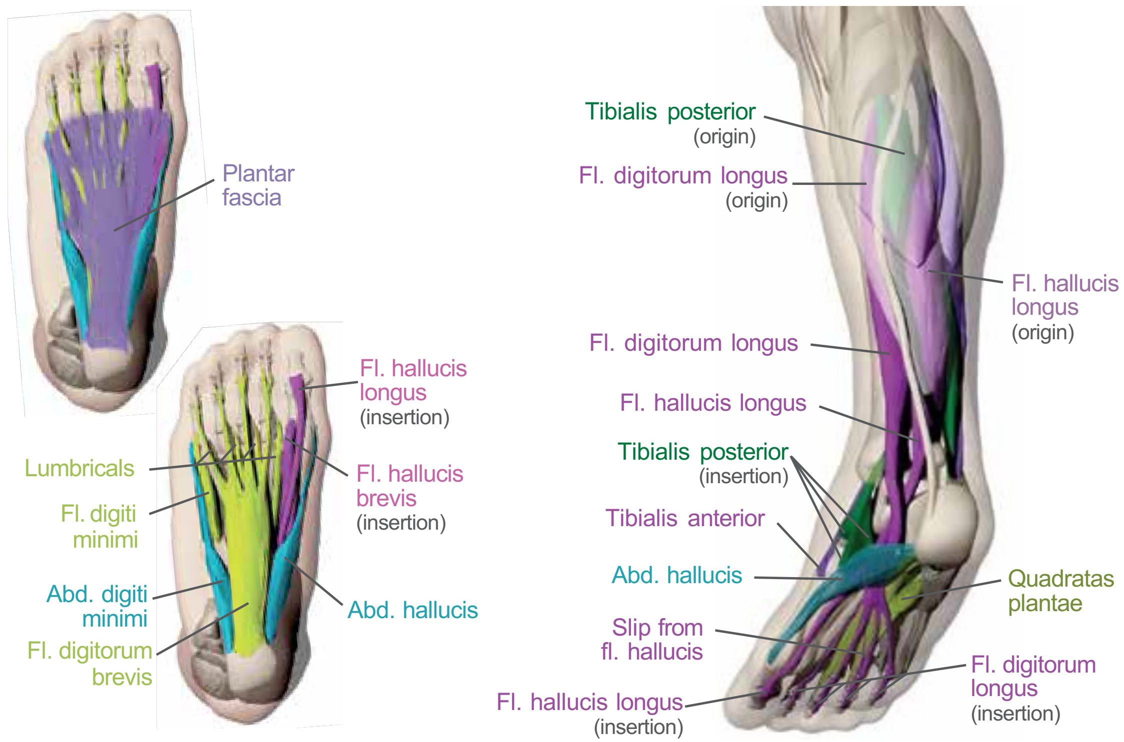

Figure 2.7.

14 KEY TAKEAWAY

The optimal dome-like arch system must be created via a pre-ground contact protective reflex muscle activation, in anticipation of the unknown next ground contact.

Ideal Neuromuscular Gait Mechanics— The Windlass and Cuboid Pulley Effects

If the supporting musculature of the foot aligned and stabilized its interlocking bones into a functionally dynamic dome shape prior to weight bearing, the structure would be inherently strong and resilient. This would provide the most stable and stress-free foundation for the rest of the body, requiring the lowest degree of muscular effort during the weight bearing and propulsion phases of gait. This alignment and stabilization process is, indeed, exhibited in barefoot gait, and is easily achieved during the swing phase as the foot moves from the muscle-firing sequences of propulsion to the extensor muscle-firing sequences of dorsiflexion (Figures 2.8 and 2.9).

When examining the muscle-firing sequences of the lower leg extensors during the gait cycle, EMG analysis shows a co-contraction of the peroneus longus (a.k.a. fibularis longus) and tibialis anterior, prior to heel strike, reinforcing their implied significance in the alignment and stabilization process of the foot and ankle, as discussed in the above section on the kinetic chain.

Figure 2.8.

Figure 2.9.

Coupling this information with their respective origins and insertions, these opposing contractions cause a transverse pulling or cinching action that essentially aligns the bones of the foot's midtarsal region into a dome-like position with an ideal (maximum) transverse arch apex height (Figure 2.10)

This is further supported by the fact that the main actions of the tibialis anterior are dorsiflexion and inversion, while the main actions of the peroneus longus (aka fibularis longus) are dorsiflexion and eversion. When these two muscles act in functional balance, they have a "stirrup-like" effect as the ground contact base of the posterior fascial line.

The cinching action of the peroneus longus (a.k.a. fibularis longus) tendon around the cuboid is essential to the control of the transverse arch's feature of stability with adaptability. This process, often called the "Cuboid Pulley Effect," with the antagonistic activity of

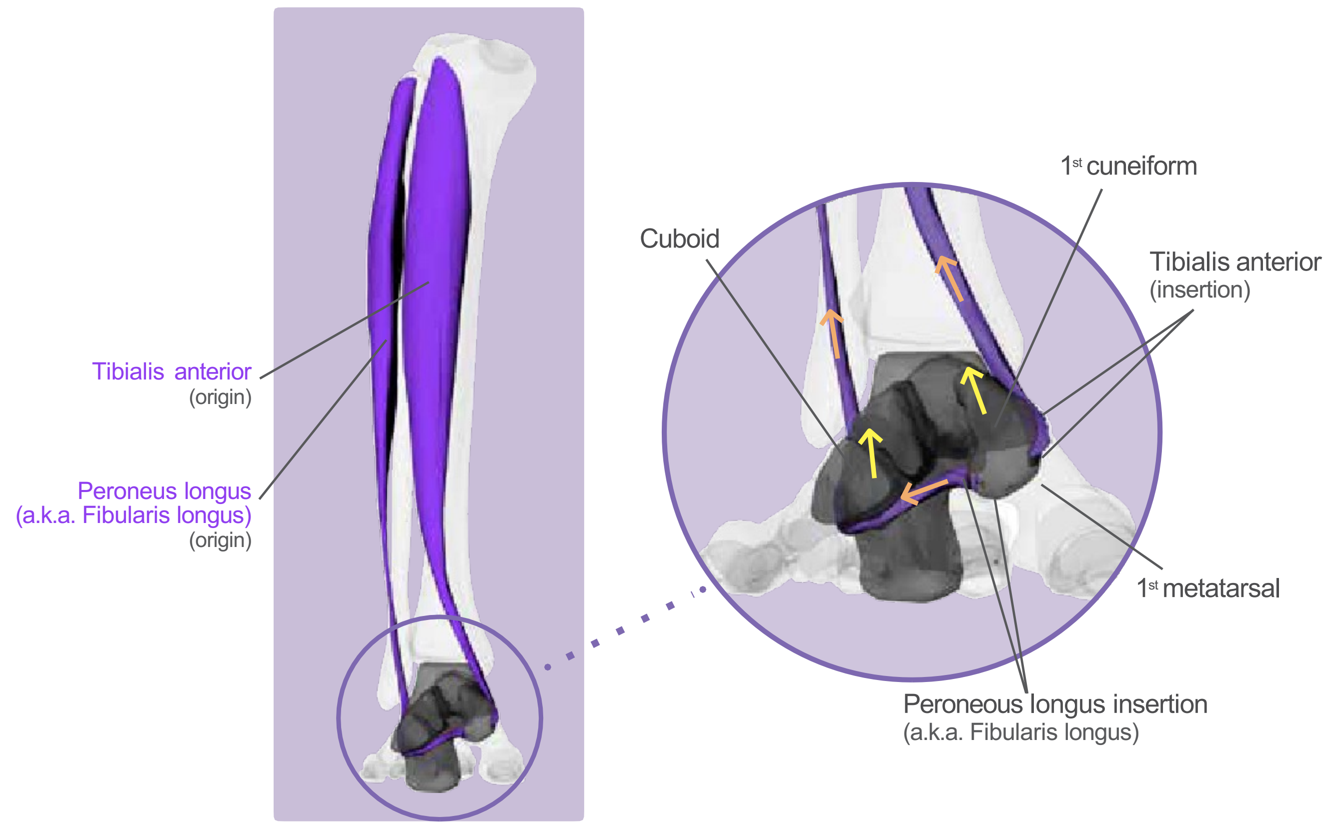

Figure 2.10.

the tibialis anterior, establishes the 1st metatarsal/1st cuneiform joint not only as the "conceptual" transverse arch keystone, but as the foundation of the entire kinetic chain, regardless of activity levels and terrain.

The function of the interosseous muscles (i.e., adduction of the 3rd to 5th toes toward the 2nd toe, and abduction of the 2nd to 4th toes) establishes the 2nd ray as the longitudinal axis of the foot's dome-like functional configuration.

Another important contribution to the dome-like alignment and ideal longitudinal arch apex in the pre-contact phase, is contraction of the extensor hallucis longus; this results in the Windlass Effect of the great toe and plantar flexion of the first metatarsal (Figure 2.10). In addition, simultaneous contraction of the extensor digitorum longus causes dorsiflexion of the corresponding digits and plantar flexion of the related metatarsals. The Windlass Effect is further enhanced, regarding the 2nd to 5th digits, by passive to active tension within the lumbricals, which (via their dorsal insertion points) also contribute to dorsiflexion of the interphalangeal joints.

Of great significance, with a synergistic effect toward optimal arch apex formation, is the role played by the hallux and the sesamoid bones. Together they stabilize and lock into place the Windlass Effect through the 1st ray. Prior to ground contact, simultaneous to the Windlass and Cuboid Pulley activations, the hallux dorsiflexes and the sesamoids glide forward up and distal to the 1st metatarsal head, thus maximizing the tension on the flexor hallucis longus. Once the 1st metatarsal becomes weight bearing, the sesamoids' location (distal to the 1st metatarsal head) is such that the Windlass Effect is locked in place. This mechanism assures that the optimal arch apex cannot collapse during the entire stance phase of gait (Figure 2.11).

As the digits dorsiflex, the mechanical dynamic that causes plantar-flexion of the metatarsals corresponds to a passive tension or preloading of the following:

- the tendons of flexors hallucis longus (and slip) and digitorum longus, muscle body of quadratus plantae and the lumbricals – the second layer muscles
- abductor hallucis, flexor digitorum brevis, and abductor digiti minimi – the intrinsic first layer muscles, and
- the plantar fascia.

The opposing active tension created between the extrinsic extensors and 1st and 2nd layer muscles cinches the interlocking bones into a dynamic dome-like structure that is capable of handling enormous force with minimal muscular contribution (Figure 2.12). The preloaded intrinsic 1st and 2nd layer muscles and plantar fascia provide a resilient tie beam of optimal tensile strength.

Figure 2.11.

As already described, natural healthy foot function and ideal gait mechanics should demonstrate optimal neuromusculoskeletal function (timing of muscle firing and alignment) throughout the kinetic chain as a dynamic response to activity levels and terrain. That is, subtle variable stimuli to the sole of the foot produces:

- tactile and nociceptive reflex activations of the foot and ankle related muscles and
- proprioceptive reflex activations in the muscles throughout the lower limb, hip, and back kinetic chain.

Together, they optimally align the bones to most effectively manage the forces generated during varying activities and terrain while promoting optimal neuromusculoskeletal function and little or no degenerative stress. Tactile, nociceptive, mechanoreceptive, and proprioceptive sensory stimuli of the first step and/or optimal proprioceptive conditioning triggers a protective reflex response during the swing phase of gait prior to the second step ground contact. This continuous, step-by-step, nociceptive/mechanoreceptive/proprioceptive reflex activity results in a pre-ground contact cinching of the interlocking bones of the foot and ankle to:

- form a strong yet adaptable dome-like shape in the foot (i.e., Optimal Arch Apex [OAA]), and
- lock the foot and ankle to inhibit eversion or inversion at ground contact (i.e., stabilize the subtalar region for optimal mechanical positioning through the knee and hip in line with the arch apex).

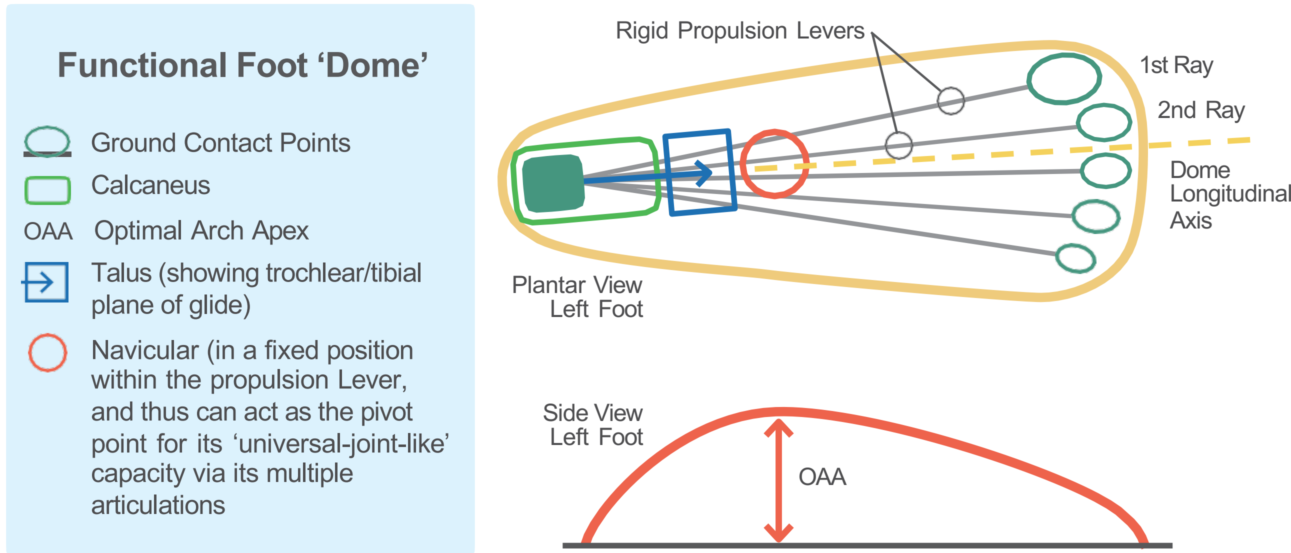

Figure 2.12.

The reflexive pre-ground contact musculoskeletal cinching is a dynamic response to activity levels and terrain. Functioning in this ideal manner, the foot's neuromusculoskeletal structure is capable of providing optimal structural integrity, alignment, and shock management throughout multidirectional ground contact, weight-bearing, and toe off, while forming a spring-loaded rigid lever when in the propulsion mode.

When the ankle is locked against eversion and inversion at heel contact, the roundness of the heel initiates a smooth, stress-free transition, naturally aligning the forefoot to the ground. This is consistent in multidirectional activity through varying angles of impact.

In short, to paraphrase sports training concepts, the barefoot environment promotes Proper Technique toward the creation of optimal foot function. Over time, with repetition, the body adapts to the diversified stimuli and optimal neuromusculoskeletal mechanics and ultimately becomes the conditioned norm or "optimal reflexive condition." This can be "reconditioned" or "retrained" to become a maladapted reflexive condition through Poor Technique activities of sufficient intensity and duration.

15
KEY TAKEAWAY

The Windlass Effect and Cuboid Pulley systems are the means by which the foot (via muscle activation) simultaneously creates stability, adaptability, and a rigid lever system for propulsion, and is "locked" in place by the sesamoid bones (via sufficient hallux elevation). The Windlass Effect and the Cuboid Pulley systems assist both functional performance and injury prevention.

3 SECTION

Gait-related Pathologies

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SECTION 3

Gait-related Pathologies

(For more detailed coverage of this topic, refer to The Future of Foot Care monograph, Section 4, "Footwear's Relationship to Lower Limb Biomechanics and Resulting Pathologies," pages 26-43.)

Sections and Keywords:

- Maladaptive foot function and resultant gait-related pathologies
- Ideal state = "Right Stimulus" and "Right Movement" as observed in barefoot populations
- Protective reflex in unshod
- Lower limb kinetic chain
- Weight-bearing "sweet spot"

To fully grasp the many manifestations of maladaptive foot function and resultant gait-related pathologies, it is helpful to understand the "ideal state" of a bipedal human being. That "ideal state" can only exist when the feet function in an environment that facilitates both Right Stimulus and Right Movement, as observed in barefoot populations with few debilitating foot-related pathologies.

The innate protective reflex and optimized neuromusculoskeletal function and alignment of the habitually unshod are a direct result of the minimal tissue stress and/or degeneration that occurs throughout the lower limb kinetic chain during day-to-day activities. This dynamic weight-bearing "sweet spot" function/alignment provides us with a model of optimal gait technique.

Generally speaking, the quality of the function and alignment of an individual's kinetic chain is a predictor of future weight-bearing degeneration and resultant gait-related pathologies.

To understand the tissue-specific pathophysiology of gait-related pathologies, it is useful to think of a shod foot as a fettered structure. When viewed this way, it is easy to conclude that the shod foot has significant total foot immobilization or regions of significant immobilization. There are several basic principles (listed below) that define the development of pathologies.

In the words of R. Gotlin, author of Sports Injuries Guidebook, "Simply put, function is the outcome of any activity."[1] Physiologically speaking, our body function is governed by Wolff's Law of Bone Transformation, Davis's Law (of soft tissue adaptation), and neuroplasticity (the adaptive capabilities of the nervous system).

The Effects of Immobilization

Immobilization can have significant effects on muscle, the synovial joints, periarticular soft tissues, and the nervous system. Following are some of those effects:

- Muscle: loss of strength, more rapid fatigue, and atrophy
- Synovial joints: decreased water content, increased collagen cross-links, loss of collagen mass, increase in fibro-fatty CT in joint space, synovial fold adhesions, adhesions of fibro-fatty CT to cartilage surfaces, cartilage atrophy, ulceration of cartilage contact sites, disorganization of ligament components, and weakened ligament insertion site
- Periarticular soft tissues: joint stiffness, restricted movement, intra-articular adhesions, poor collagen orientation, significant water loss (thus, less resilience), increased collagen cross-links (thus, a loss of elasticity)
- Nervous system: loss of muscle function and proprioceptive sense and atrophy

[1] R. Gotlin, editor. Sports Injuries Guidebook (Champaign, IL: Human Kinetics, 2008).

Common forms of immobilization

- Casts
- Braces
- Orthotics
- Regular Footwear

The effects of immobility in the creation of pathology

- Immobility can be the cause of many pathologies,
- Immobility can lead to functional maladaptations.
- Functional maladaptations can lead to acute and chronic pain.

The Relationship of Footwear to Lower Limb Biomechanics and Resultant Pathologies

Functional and anatomical maladaptations

Maladaptive neuromusculoskeletal function and related maladapted reflex function are typically observed in shod populations. For shod populations, the cushioning, restrictive, and supportive characteristics of footwear can create these consequences:

- Proprioceptive sensory input and tactile stimuli are dampened, resulting in insufficient stimuli.
- The natural, dynamic "Right Movement" throughout the feet, ankles, legs, hips, and lower back is restricted or encumbered.
- The result is that the "safe" force management capabilities of these areas are impaired throughout the demands of three-dimensional activities.

During maladaptive neuromusculoskeletal function, impairment occurs in the movement being generated, the proprioceptive input, the sensory input, and the tactile stimulus from ground contact by each foot. This is caused by:

- artificial cushioning, which dampens the tactile sensory ("Right Stimulus") input required to initiate an adequate protective reflex response during reflex-activated anticipation (or preparation) for the next step (while the foot is off the ground)
- artificial support and restrictions to musculoskeletal "Right Movement" that impede the dynamic three-dimensional movement of the musculoskeletal structure, leading to instability.

As a result, the following can happen:

- Muscles do not receive the signals required for effective alignment and stability of the bones in the foot, ankle, and leg (prior to ground contact).
- The bones of the foot, ankle, and leg cannot dynamically align and stabilize because of the "support" or "restrictions" throughout all skeletal and neuromuscular gait phases.

As a result, the neuromusculoskeletal structure becomes incapable of safely managing the forces that are generated and its performance capabilities are impeded by compensatory, imbalanced, and inefficient muscle use.

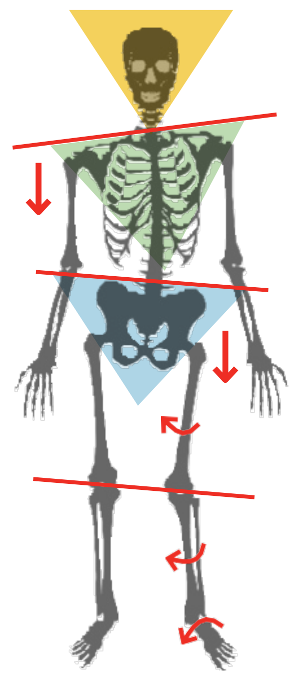


Figure 3.1. Poor skeletal alignment due to maladapted neuromuscular function.

The stressors that are generated cause damage and contribute to the creation of a less robust neuromusculoskeletal structure (i.e., weaker and less flexible), significantly increasing the risk of injury.

In short, the shod environment promotes Poor Technique.

Over time and after much repetition, maladaptive neuromusculoskeletal mechanics become the "Maladapted Reflex Condition," which can be reconditioned or retrained to become the "Habitual Optimal Functional Condition" by employing Proper Technique activities of sufficient intensity and duration.

For example, the Maladapted Reflex Condition is observed when a limb is placed in a splint or cast. Even after a relatively short period of two weeks, atrophy, joint stiffness, loss of soft tissue resiliency, and diminished protective reflex capabilities will be noticeable. In cases like this, rehabilitative therapies (e.g., exercise programs) are commonly employed to regain optimal function.

16
KEY
TAKEAWAY

When shod, individuals experience adverse maladaptive neuromusculoskeletal mechanics as a result of:

- Artificial cushioning and control that inhibits "Right Stimulus"
- Artificial restrictions that inhibit "Right Movement."

Footwear design characteristics and gait-related pathology

It is commonly accepted that poor foot biomechanics play a significant role in the development of pathologies that include metatarsalgia, plantar fasciitis, hallux valgus, heel spurs, neuromas, Achilles tendonitis, shin splints, patello-femoral syndromes, and hip and back pain. Although it is often argued that genetics plays a key role in dysfunctional foot biomechanics, there is very little science to support this hypothesis. Conversely, there is abundant scientific evidence that points to footwear as the leading cause of foot dysfunction and most associated foot-related pathologies.

Most conventional footwear designs affect the feet much like a cast or splint affects an arm or leg. Chronic restrictions imposed by footwear cause muscle atrophy, loss of bone mass, less-than-ideal bone geometry (through remodeling), and joint stiffness. Wearing shoes can actually weaken the feet and legs, increasing their susceptibility to injury.

Shoes insulate the soles of the feet from the subtle varied stimulus required for optimal neuromuscular function throughout the lower limb-hip-back kinetic chain. This dampened nociceptive stimulus impairs the timing and intensity of optimal proprioceptive muscle activity throughout the kinetic chain, effectively destabilizing its dynamic load-bearing and propulsion capabilities (i.e., the dynamic mechanical capabilities – alignment and muscle efficiencies – are impaired). This dynamic instability results in degenerative stresses in the muscles and at joints that cause or contribute to various “arthritic-like” problems (pathologies) in the feet, legs, hips, and back.

In addition to improper sizing, there are many ways in which footwear design characteristics contribute to poor foot function. (See Table 3.1.)

CAUSE Footwear design characteristic	EFFECTS
Rigid soles Cushioning properties (underfoot) Arch supports	• Dampen the varied sensory stimulus to the sole of the foot needed to trigger the proper muscle function that aligns the bones for optimal dynamic stability • Inhibit nociceptive and proprioceptive reflex musculoskeletal activity
Restrictive toe box height or width Rigid soles that prevent dorsiflexion of great toe Restrictions over arch area (by design or tight lacing) that prevent optimal apex height Narrow width through metatarsal area	• Restrict the natural dynamic nature of the foot (i.e., full foot mobility involving the natural raising of the arch and dorsiflexion of the toes) necessary to effectively manage varying loads (impact stresses) and terrain changes • Rigid soles inhibit natural walking and running dynamics and increase the forces the foot must manage • Shallow rigid toe boxes restrict the natural toe movement required to form a strong stable arch • Tight lacing inhibits natural raising of the arch in response to increased loads, causing the foot to flatten (promoting inefficient bone alignment and structural instability), which weakens the restricted muscles and causes others to fatigue from overwork • Enclosed footwear with rigid soles and tight lacing condition “poor” proprioceptive reflex muscle activity
Wide or flared heels or midsoles Rigid soles or midsoles Stiff uppers	• Increase lever arm mechanics and accelerate forces during gait – premature plantar flexion and excessive pronation • Inhibits balanced stance and equal distribution of weight during walking or standing – poor structural alignment through feet and entire kinetic chain • Tight lacing inhibits natural raising of the arch in response to increased loads, causing the foot to flatten (promoting inefficient bone alignment and structural instability), which weakens the restricted muscles and causes others to fatigue from overwork. Enclosed footwear with rigid soles and tight lacing condition “poor” proprioceptive reflex muscle activity • Increases lever arm mechanics and accelerate forces during gait – premature plantar flexion and excessive pronation
Increased heel height	• Inhibits balanced stance and equal distribution of weight during walking or standing – poor structural alignment through feet and entire kinetic chain

Table 3.1. How footwear design characteristics contribute to poor foot function.

Each design characteristic imposes singular negative effects on lower limb, hip, and back neuromuscular function; when combined, their negative effects are magnified significantly. Most footwear on the market today features many of these characteristics, which shoe manufacturers actually promote as beneficial for their customers. In reality, damaging degenerative stresses increase relative to the amount of cushioning, support, and restrictiveness and inherent restrictions of the footwear.

Lack of nociceptive and proprioceptive sensory feedback

A shoe that is rigid and supportive, or one that features abundant cushioning greatly diminishes the subtle varied sensory feedback required for optimal "natural" nociceptive and proprioceptive reflex muscle-firing sequences that stabilize the arch. According to Robbins, "Wearers of expensive running shoes that are promoted as having additional features that protect (e.g., more cushioning, pronation correction), are injured significantly more frequently than runners employing inexpensive shoes (costing less than US $40)."[2]

Modern footwear – running shoes, in particular – substantially diminishes sensory feedback but does not diminish injury-inducing impact. That is a dangerous situation.

Supportive cushioning features are widely promoted as essential for safety when walking or running to mitigate chronic overload on the lower extremities due to modern man's purported inherent fragility. This is inconsistent with reports that indicate habitually unshod humans are not subject to chronic overloading when running and are virtually free of foot-related pathologies.

[2] Robbins SE, Gerard GJ. Athletic Footwear: Unsafe Due to Perceptual Illusions. Medicine and Science in Sports and Exercise 23(2): p. 217, 1991.

Considerable research indicates that the lower extremities of predominantly barefoot populations are inherently durable and that chronic overloading is a consequence of wearing footwear. Studies on barefoot populations indicate that, because of the intrinsic properties of biomechanically sound feet unfettered by the constrictions of footwear, they can effectively manage the forces and stresses generated during most rigorous activities on the hardest surfaces. Manmade cushioning and motion control designs pale in comparison.

Restrictions in structural alignment

Footwear for women that features narrow pointed toe boxes and high heels has generated criticism from foot care professionals. It is commonly understood that improper footwear (by design or size) contributes to a host of foot pathologies, yet there are conflicting opinions about what constitutes appropriate footwear and its effect on the foot's structure and the dynamics of gait.

Maladaptive bone remodeling

The ancient Chinese practice of foot-binding and the use of Lotus shoes are excellent examples of the ways in which negative environmental influences can restructure the foot. The practice of foot-binding in China spanned more than a thousand years, with millions of women enduring and suffering severe lifelong disabilities from this extremely painful process. Even though it was banned in 1911, it continued until the New China was founded in 1949.

Similar deformities are also common in today's modern society. The environmental influences of the toe box design characteristics of restrictive footwear clearly demonstrate their negative physiological impact. Not only does footwear impede healthy optimal neuromuscular function, it actually contributes to maladaptive bone remodeling.

According to Wolff's Law, because bone is living tissue and constantly undergoing cellular regeneration, it has the ability to change and adapt. For example, this adaptation is observed when unhealthy repetitive stress results in the formation of heel spurs at the insertion of the plantar fascia to the calcaneus. In this case, the bone remodels toward the source of repetitive tension as a means of mitigating the stress. Bunions and "pump bumps" also demonstrate the ways that unhealthy repetitive stress affects bone. By contrast, healthy repetitive stress generated by moderate exercise, such as running or lifting weights, helps build and maintain bone density.

Unhealthy Neuromusculoskeletal Mechanics

The most damaging footwear design characteristics are those that inhibit subtle variable sensory input to the soles of the feet, those that prevent structural integrity of the domed arch dynamic and those that increase the forces and stresses on the musculoskeletal structure.

In addition to dampening subtle varied sensory feedback, rigid soles and restrictive toe box areas exert the most damaging influence by inhibiting dorsiflexion of the toes, which is necessary for alignment and stabilization of the strong, functional dome-like dynamic of the interlocking bones in the foot and ankle. Chronic interruption of this dome-like dynamic can actually condition improper muscle-firing sequences and result in either compensatory overuse or a failure to fire at all. The dynamic is further hampered by restrictions over the arch area that prevent the formation of the optimal arch apex, which is necessary for efficiently managing specific loads. These restrictions may be inherent to the footwear design, and may result from improper shoe size or from overtight lacing. These dampening and restrictive influences negatively impact all types of developed foot function albeit in slightly different ways.

While a rigid high arch is structurally capable of managing greater loads, without adequate muscular activity to maintain its domed integrity, the arch system will abruptly fail mechanically when loads exceed its structural capacity. This results in more "acute-like" degenerative stresses and a diminished capacity to effectively manage "shock."

A hypermobile or flat foot is structurally capable of managing lesser loads. In both instances, the foot's load-bearing capacity is notably diminished without appropriate muscular activity to maintain the integrity of the arch system. A functional arch system is either not present (flat) or fails immediately (hypermobile) at forefoot/ground contact and results in more "chronic-like" degenerative stresses and compensatory muscle imbalances throughout the closed kinetic chain.

Individuals exhibiting pes cavus feet typically demonstrate less midfoot flexibility and excessively supinate, invert, and toe-in through heel strike to toe off, thus rolling off the 4th and 5th metatarsal heads during propulsion. During normal walking gait, the foot and leg are abducted excessively at heel contact. As the body's center of mass moves forward over the foot through heel strike, full weight-bearing, propulsion, and toe off, the abducted foot and abducting leg cause a diagonal rolling about and over the lateral side of the 4th and 5th metatarsal heads. The propulsion stride is inefficient, directing the body's mass laterally and forward relative to the foot's positioning, generating tremendous torsional stresses on the 4th and 5th metatarsal heads.

While the high rigid arch is structurally capable of managing greater loads than the hypermobile foot, when its load-bearing capacity is exceeded (without appropriate nociceptive and proprioceptive muscle activity), the structural integrity fails more acutely, resulting in more traumatic (sudden) degenerative stress. In addition, the foot generates a tremendous amount of torque and friction within the shoe. Depending on the shoe design, these stresses often result in excessive calluses, bunions, bunionettes, and metatarsalgia. Accelerating torsional stresses are also generated at the knee, contributing to conditions that include ligament and cartilage damage, chondromalacia, and patello-femoral syndrome.

Regardless of foot type, habitual use of footwear that dampens somatosensory stimulus and/or creates a restrictive environment will condition improper (maladapted) muscle-firing sequences throughout the supporting musculature of the lower limb, hip, and back. Muscles will cease to fire completely or fire at inappropriate intervals. This can lead to muscle atrophy (from lack of use) or hypertrophy (from overwork) and to muscles becoming easily fatigued. Pathologies, such as plantar fasciitis, heel spurs, or shin splints typically develop when these dynamics are present.

When the supporting musculature of the foot fails to provide structural stabilization, the resulting inefficient alignment negatively affects the mechanical geometry of the smaller and deeper levels of intrinsic musculature. Poor mechanical geometry leads to compensatory and inefficient (overworked) muscle function, increased stress, and fatigue. These smaller muscles are best suited for fine motor control and dexterity and are not able to effectively manage the forces generated by an unstable and poorly aligned structure.

As the unstable structure enters first into the weight-bearing phase of gait, followed by the propulsion phase, the poorly aligned and unlocked bones are unable to effectively manage the forces and stress that are generated. Intensifying as they migrate up through the musculoskeletal structure, these forces and stresses can lead to chronic or acute pathologies at the sites of the weakest links in the kinetic chain, depending on activity levels. Conditions such as Achilles tendonitis; patello-femoral syndrome; and knee, hip, and back problems are commonly associated with these poor structural dynamics.

Unfortunately, the stresses generated by poor structural dynamics are exacerbated by footwear design characteristics, some of which were actually engineered with the intention of stabilizing the unstable foot.

From a mechanical perspective, the effects of various footwear characteristics (e.g., midsole and heel height/flare) are synergistic in their resultant accelerating velocities of plantar flexion, pronation, supination, inversion, and eversion. In varying combinations (due to design geometry), they impact significantly on structural loads, magnify the horizontal tie beam and torsional stresses throughout the foot and ankle, and negatively affect structural integrity. These design geometries directly influence the location and degree of poor structural alignment and the relative increase in degenerative stress at the joints throughout the kinetic chain, particularly the knees, hips, and lower back. Clearly, footwear design characteristics play a major role in the development and exacerbation of musculoskeletal pathologies throughout the gait-related kinetic chain.

Each of the signs, symptoms, and diagnoses listed below is a net consequence of the maladapted mechanisms, excessive stresses, compensatory muscle activities, footwear restrictions – or any combination – that result from the maladaptation of kinetic chain function discussed above.

Foot Dysfunction Indicators (FDIs)

The presence of any of the following conditions directly indicates that foot function has maladapted and that related neuromuscular mechanics are in need of rehabilitation and are the cause of nontraumatic lower limb symptoms and/or pathologies.

Bunions	External hip rotation	Fifth toe “flail”
“Pigeon-toed”	Bony protuberances of foot	Pes cavus
Supinated forefoot/Everted	Hammer toes	Loss of toe gaps
calcaneus	Forefoot splay	Excessive ankle plantar flexion
Bunionettes	Pelvic torsion	Genu valgus
Hallux valgus	Claw toes	Misaligned subtalar joints
Inverted calcaneus	Longitudinal toe rotation	Genu varus
Callus and corns	“Pump bumps”	High iliac crest
	“Flat” feet	
	Overlapping toes	

Table 3.2. Indicators of foot dysfunction.

Common foot-related pathologies caused or exacerbated by footwear use. Symptoms manifest at the weakest link in the kinetic chain, as influenced by activities and footwear characteristics.

Feet:
Intertarsal muscle fibrosis
Tarsal tunnel syndrome
Metatarsalgia or sesamoiditis
Plantar fasciitis
Tib Ant & Per L insertion fibrosis
AbHL muscle fibrosis
Dorsum subcu tissue fibrosis
Cuboid fixation pain
Morton's neuroma
Tendonosis ant to subtalar joint
Med talo/navic ligament fibrosis

Lower Leg:
Fib head fixation and fibrosis
Gastroc-soleus myotend fibrosis
FHL belly/myotend fibrosis
Tib Post belly/myotend fibrosis
Shin 'splints'

Knee:
Patello-femoral syndromes
- VLO or VMO distal fibrosis
- Quad fascia fibrosis at patella
- MCL & Jt line fascia fibrosis

Illio-Tibial Band Syndrome
Infrapatellar tendonosis
Hamst tend fibrosis, M or L
Adductor tubercle fibrosis

Ankle:
M or L ligament fibrosis
Tib Post & FHL tend at M malleol
Peroneii myotend fibrosis
Subtal EHL TibA EDL tend fibrosis
Tib-talus joint fixation
Achil tend or calc bursa fibrosis

Hip/Buttock:
Greater troch bursitis
Glut/Hams/Isch tub fibrosis
Glut/ITB interface fibrosis
Iliopsoas myotend fibrosis
Deep glut fibrosis/contracture

Low Back:
Recurrent SI Jt fixation
SI Jt ligament fibrosis
Ilio-Lumbar lig fibrosis
Iliac crest/QL/Erector fibrosis
Glut fibrosis at iliac crest

Other Conditions:
Diabetes
Fibromyalgia

Table 3.3. Common foot-related pathologies.

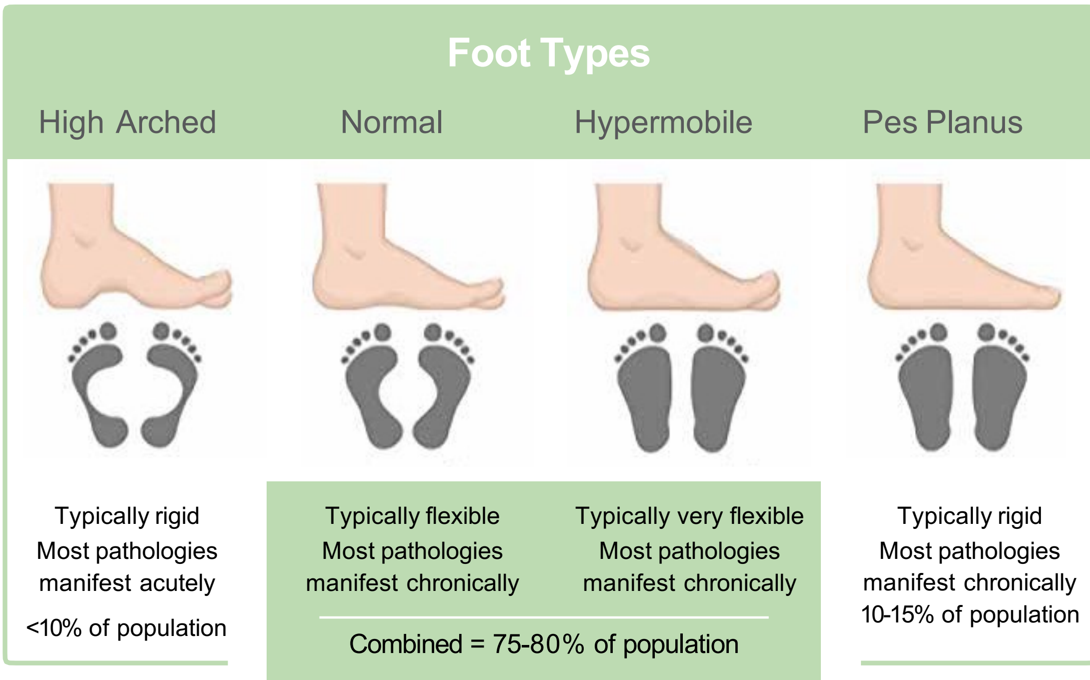


Figure 3.2. Four primary foot types. Each presents pathologies in distinct ways.

18 KEY TAKEAWAY

There is a fundamental absence of signs or symptoms of kinetic chain dysfunction and accompanying gait-related pathologies when ideal neuromusculoskeletal mechanisms are consistently in effect. Less than 3% of habitually barefoot populations exhibit foot-related pathologies. However, there is a plethora of kinetic chain dysfunction and gait-related pathologies within the shod community. More than 66% of the North American population currently experiences some type of foot-related discomfort, and 85% will see a medical professional for one or more foot-related problems over their lifetimes.

4 SECTION

Neuromuscular Pathology Treatment Options

biopods®

SECTION 4

Conventional Treatment Methods

(For more detailed coverage of this topic, refer to The Future of Foot Care monograph, pages 44-52.)

Palliative Treatment Methods

Examples of the least effective (in the long term) attempts to relieve presenting symptoms are the following (strictly palliative) means:

- Electrotherapy
- Compression wrap and braces
- Heat
- Ice
- Oral anti-inflammatories and analgesics
- Topical creams, ointments, and rubs

Therapeutic Treatment Methods

Therapeutic treatment methods, while a step up in the pursuit of symptom relief, often still do not alleviate the underlying causes of pathology. The following is a list of common therapeutic treatment methods:

- Acupuncture
- Chiropractic manipulation
- Corticosteroid injection
- Deep tissue massage
- Hands-on soft tissue mobilization
- Instrument assisted soft tissue mobilization
- Laser treatment
- Shockwave therapy
- Therapeutic ultrasound

Figure 4.1. Some common treatment methods.

Surgery

Perhaps the most aggressive treatment method for relieving symptoms is surgery to remove or alter the structures or tissues from which pain is emanating. It may be argued that, in the long term, this is the worst option of all because it alters essentially normal anatomy, potentially reducing the possibility of future, optimal rehabilitation.

All treatment methods will result in some symptomatic relief and, perhaps, even complete relief. However, without addressing the actual cause of the underlying maladaptive neuromusculoskeletal mechanics of a pathology, the ultimate long-term net outcome of any of these treatment methods will be future pain, suffering, degeneration, and ever-diminishing functional capacity.

Common Gait-Related Treatment Methods

The most common treatments for the host of pathologies that result from poor foot biomechanics focus on cushioning, supporting, or bracing the foot and ankle – often in combination. While exercise and rehabilitation programs are sometimes recommended, the focus is usually on the toe flexors as opposed to the toe extensors and compliance is usually poor.

Cushioning

Cushioning treatment options include foam, gel, and felt-based insole products, and footwear that incorporates cushioning midsoles. Cushioning often presents a “comfortable” feeling initially, but it provides a false sense of security by offering benefits that are superficial at best. In reality, cushioning spreads the ground contact forces to the sole of the foot over a wider surface area and optimal subtle varied stimulus becomes attenuated uniform stimulus.

Cushioning products are purported to dissipate the vertical shock that results from chronic overloading, thereby reducing the stress to the foot. Contrary to common perceptions, cushioning products mitigate vertical shock by less than 10%, at best. Unfortunately, studies show that horizontal forces – rather than vertical forces – contribute most significantly to foot pathologies. Research demonstrates that the control of initial pronation is of greater importance than shock absorption. Studies indicate that cushioning the foot isolates the plantar surface from the sensory feedback it requires to induce its protective adaptations – essential for effectively managing the forces generated at impact. It has been demonstrated, in vivo, that impact remains unchanged whether the runner uses soft running shoes, hard running shoes, or is barefoot (without a barefoot adaptation period).

Long-term use of cushioning products results in lower limb maladaptations – the loss of the neuromuscular system's functional robustness.

Supportive Orthotics (Bracing)
Custom orthotics and similar products attempt to stabilize the subtalar joint by supporting the arch, claiming to "correct" the poor biomechanics of the foot. This claim of correction is misleading. In reality, orthotics by their very nature, spread the ground contact forces to the sole of the foot over a wider surface area – optimal subtle varied stimulus becomes attenuated uniform stimulus.

Subtalar neutral position (the mechanical relationship between the talus and navicular) is often thought of as the key to proper structural alignment in the foot. Contrary to the conventional view, this mechanical relationship is dynamic in nature rather than static; that is, the relative positioning of the subtalar joint is determined by the nociceptive and proprioceptive reflex muscle activations (or lack thereof) in response to activity levels and terrain.

All too often, excessive pronation is incorrectly identified as the cause of these problems, when it has been demonstrated herein to be merely a clinical sign of inefficient nociceptive and proprioceptive reflex muscle activity. Orthotics mask these neuromuscular inefficiencies by artificially supporting or bracing the dysfunctional structure (or the structure that is exhibiting poor bone alignment) along with its inherent muscle imbalances, by simply introducing a new angle of ground interface to the foot.

In addition, by artificially supporting the foot, the orthotic manages the vertical loads in place of the arch system. As a result, over the long term, the arch system of the foot and the neuromuscular mechanics of the lower limb remodel in response, leading to a weakened structure and an increased dependency on the artificial support.

Exercise (Rehabilitation)

Exercise as a means of rehabilitation is a common therapy throughout musculoskeletal medicine. In fact, exercise, where appropriate, is usually the first treatment of choice, prior to more radical options, such as surgery. Many orthopedic surgeons recommend a regimen of exercise, both before and after surgery, as a means to speed recovery times. Mobility braces are commonly used after reconstructive ligament surgeries (i.e., at the knee) to reduce scar tissue formation and maintain mobility at the joint.

The most commonly recommended exercises for foot pathologies focus on rolling a ball or cylinder with the sole of the foot, plantarflexing the toes, or using them to grasp an object. These exercises may provide some benefit, but the muscular sequences involved have very little relevance to gait mechanics.

19
KEY TAKEAWAY

Current treatment methodologies are primarily focused on symptomatic relief and often are ineffective at addressing the cause of adverse maladaptive neuromusculoskeletal gait mechanics.

The most beneficial foot exercise would involve multidirectional barefoot activity on diversified terrain to enhance neuromuscular function and develop a balance of strength and flexibility throughout the lower limbs, hips, and back. However, this type of activity is impractical for most individuals.

Regardless of the exercises involved, the amount of time spent to achieve some positive benefit would be in direct proportion to the amount of time the person wore restrictive footwear. While exercise is promising for most individuals, it is limited by time constraints; hence, the typically poor compliance.

Biopods™ Technologies and Related Complementary Treatment Modalities: The New Gait-Related Paradigm

(For more detailed coverage of this topic, refer to The Future of Foot Care monograph, pages 52-85.)

The revolutionary premise of "foot rehabilitation" – capable of restoring an individual's maladapted neuromuscular gait mechanics (as found in the shod community) to optimally align and muscularly control gait mechanics (as found in the traditionally unshod community) – is the mission of Biopods technology.

To that end, Biopods, has developed a patented Stimsoles® technologies, which are incorporated into Biopods insole and and footwear products. Biopods products create the "Right Stimulus" and facilitate the "Right Movement" required for healthy barefoot-like (protective) neuromuscular response throughout the lower limbs, hips and back. This protective reflex response triggers the Windlass and Cuboid Pulley Effect mechanisms that are fundamental to the formation of a strong stable dome-like arch system. This dome-like arch system is the foundation for the safe and efficient lower limb kinetic chain "Right Movement."

20 KEY TAKEAWAY

When the soles of the feet receive "Right Stimulus" (disparate, variable stimulus) during the ground contact phase of gait, the protective reflex muscle activity required to create the "Optimal Arch Apex" is activated during swing phase of gait.

This protective reflex activity is a natural occurrence in unshod communities and is necessary for optimal foot, leg, hip, and back alignment/dynamic function.

This natural protective reflex can now be initiated in footwear by Biopods Stimsoles.

Clinical Concepts and Modalities

1. Footwear design features that affect optimal foot mechanics

(a) Inner sole cushioning, for 'user comfort':

i. dampens any possible stimulus to tactile, mechanoreceptive, proprioceptive, and pressure sensory input that would positively influence (i.e., stimulate) proper neuromusculoskeletal alignment of the foot

ii. has been shown mathematically to create a net increase in the rate and severity of injury-causing forces experienced by the foot during weight bearing and propulsion

iii. provides no 'useful' sensory input for central processing, and, perhaps worse

iv. 'insulates' the nerves of the foot from detecting useful stimuli external to the shoe, via which optimal protective reflexes would otherwise be initiated, toward the creation of ideal foot alignment.

SOLUTION... footwear design that incorporates an inner sole with such an ideal firmness that it acts as an inert, neutral platform that provides the optimal metatarsal head-to-inner sole interface for maximally efficient propulsion. Introduce a 'variable' stimulus into the inner sole that will mimic the stimulus received by an unshod foot while walking on natural terrain.

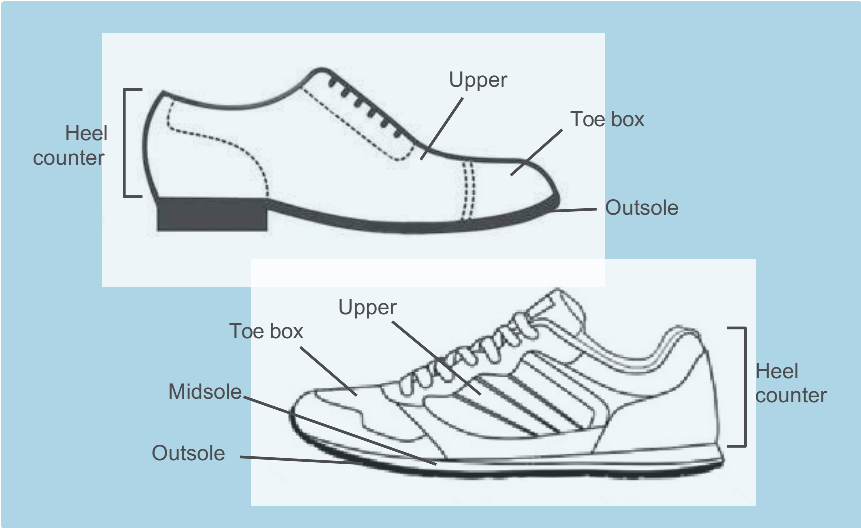


Figure 4.2. Footwear design characteristics.

(b) Rigid outsoles constructed of hard and/or excessively thick materials:

i. inhibit an efficient toe-off during propulsion via their rigidity

ii. attenuate varied ground contact stimulus

iii. inhibit the ideal sequence of adaptive heel-to-toe foot contact during the stance phase of gait

iv. create accelerated longitudinal heel contact to forefoot contact loading forces (i.e., "foot slap") and accelerated medial to lateral/lateral to medial loading forces during ground contact. These accelerated forces can be up to 400% greater than those experienced when barefoot. These increased forces create unnecessary strain and significantly increase the likelihood of injury.

SOLUTION… footwear design that incorporates soles capable of bending freely in every transverse plane, and that allow torsional positioning of the foot as it reacts to the stimulus of the previous stance phase

(c) Hard rigid materials enclosing the toe boxes:

i. prevent the adequate hallux extension necessary for the 'Windlass Effect' to have been effectively stimulated before heel strike, beginning the stance phase of gait

ii. prevent the adequate hallux extension necessary for ideal first ray configuration, thus hampering an efficient, linear toe-off for propulsion

iii. prevent the adequate hallux extension needed for the sesamoid bones to glide distal to the 1st metatarsal head point of ground contact. This is necessary for the 'locking-in-place' of the Windlass Effect required for the stability and alignment needed for optimal propulsion.

SOLUTION… footwear design that incorporates soft, non-restrictive materials above all the toes, but in particular, above the hallux

(d) Narrow "pointy" toe boxes:

i. compress all the metatarsal heads toward the foot's central axis, shifting the ideal vector of propulsion away from the first ray, diminishing the efficiency of propulsion and increasing tissue stress that can contribute to tissue injury

ii. prevent the adequate hallux extension needed for the sesamoid bones to glide distal to the hallux point of ground contact, necessary for the 'locking-in-place' of the Windlass Effect needed for optimal stability and alignment that create ideal propulsion, and minimizes the potential for tissue stress and injury.

SOLUTION… footwear design that incorporates a wide, roomy, deep toe box region

(e) Widely flared heels (intended to 'stabilize' the foot at heel strike):

i. prevent, or at least, inhibit the capacity of the calcaneus to roll, at heel contact, which is needed to most correctly react to the encountered terrain as sensed at the previous stance phase

ii. create a pivot point, other than at the center of mass of the calcaneus, that creates an inappropriate lever arm, thus generating abnormal stress that increases the risk of tissue overload.

SOLUTION… footwear design that incorporates outsoles that have the plantar surface of the heel region curved convexly (without any medial or lateral 'flare') to most closely match the natural, convex curve of the calcaneus. This minimizes the length of the lever arm so that, at the point of ground contact, there is an efficient and easy adaptability to the muscle stimulation that resulted from the terrain and activity level sensed during the previous stance phase of gait.

(f) Uppers constructed with excessively rigid materials:

i. prevent, or at least, inhibit torsional adaptive foot alignment relative to the stimulus received from the previous heel strike, regarding environment, terrain, and angles of activity

ii. prevent, or at least, inhibit the optimal skeletal alignment for the Windlass Effect and the glide of the sesamoid bones past the hallux point of ground contact, needed for optimal propulsion and minimized tissue stress

iii. prevent the peroneii muscles from efficiently exerting their 'pulley-like' effect through the Cuboid, thus inhibiting the formation of the 'optimal arch apex'.

SOLUTION… footwear design that incorporates uppers constructed of materials with sufficient suppleness and malleability so as to not hinder any degree of motion or alignment adaptations the foot may require as it responds to the stimulus from the previous stance phase

(g) Excessive Heel Height:

i. creates a position of plantar flexion that, beyond a tolerable minimal amount, makes it difficult to achieve sufficient dorsiflexion during swing phase to effectively create the Windlass Effect, leading to an unstable foot alignment in stance phase

ii. at the extreme (i.e., stilettos), causes the body's center of gravity to shift, ankles to become overly plantar-flexed, and knees to become hyper-extended – which creates multiple regions of abnormal tissue strain.

SOLUTION… footwear design that incorporates minimal heel height

21 KEY TAKEAWAY

Ideal footwear construction should incorporate:

- Maximally flexible outersole, capable of considerable torsion and easy dorsiflexion (uniformly, throughout the entire forefoot)
- Uniformly firm and dense innersole
- Rounded heel of minimal height
- Deep, roomy, broadly shaped toebox
- Supple uppers (materials and or construction)

These characteristics create an environment that optimizes "Right Movement," as initiated by the "Right Stimulus" of the contralateral foot, during the ground contact phase of gait.

2. Soft tissue treatment options

i. Arch Supports – as an attempt to passively create the 'fallen' or diminished foot arch – limits movement of the foot causing atrophy and weakening of the boney and soft tissues

ii. Joint and Soft Tissue Manipulative treatment – is a form of manual treatment to influence joint and neurophysiological function, such as: improve joint biomechanics, improve joint neurological input and output, break up joint and soft tissue adhesions, reduce swelling with increased joint motion, etc.

iii. Cushioned Insoles – as a means to absorb forces, construed to be the cause of tissue symptoms – causes atrophy and weakening of the boney and soft tissues
iv. Custom and Contoured Insoles – as an attempt to improve foot function with a presumed ideal, preconfigured shape – limits movement of the foot causing atrophy and weakening of the boney and soft tissues

v. Exercise Therapy – as an attempt to lengthen contractured muscles, restore contractility to and strengthen wasted muscles and otherwise mobilize all soft issues in a currently maladapted region

vi. Heat Therapy – as an attempt to temporarily increase blood flow to the symptomatic region such that oxygen and healing nutrients can flood the damaged tissues

vii. Ice Therapy – as an attempt to temporarily reduce blood flow to the symptomatic region as a means to diminish inflammation and swelling, also as an attempt to create a concurrent analgesic benefit

viii. Immobilization – external braces, tensor wraps, and taping are used as a means to 'stabilize' the symptomatic areas – causes atrophy and weakening of the boney and soft tissues

ix. Instrument assisted soft tissue mobilization – as an attempt to break down adhesions and scar tissue (via the application of an instrument and precise body movements and specific tension, applied to the problem tissue), in essence, to "free up" proper tissue motion, elasticity, and contractility of muscles, tendons, and ligaments

x. Medication – (i) as an attempt to prevent, or reduce, the inflammatory response produced by tissues that naturally occurs following trauma or concurrent to an RSI process; (ii) as an attempt to inhibit the brain's perception of nociceptive input… in essence 'masking' the ongoing damaging process' warning signal, potentially risking further damaging activity, unabated

xi. Topical Ointments and Creams – a wide variety is available, as an attempt to offer ice benefits, heat benefits, healing compound benefits, and direct nutrient benefits

xii. Ultrasound, Shock-Wave, and Laser Therapies – as an attempt to eliminate the fibrotic build up and adhesions from symptomatic tissues; also as an attempt to stimulate/increase the rate of tissue healing

3. Assessment protocols: How to identify those who will benefit from Biopods

Q: "Who will benefit from the use of Biopods Technology?"
A: "Everyone who walks on two feet and wears shoes."

a) Clinical Indications of Maladapted Gait Mechanics

I. Visual Signs: [a.k.a.: (+) Foot Dysfunction Indicators (FDI)]

1. Bunions
2. Bunionettes
3. Callus &corns
4. Hammer Toes
5. Claw Toes
6. "Flat" Feet
7. Pes Cavus (excessively high arch)
8. Genu Valgus
9. Genu Varus
10. "Pigeon-Toed"
11. Hallux Valgus
12. External Hip Rotation
13. Forefoot Splay
14. Longitudinal Toe Rotation
15. Overlapping Toes
16. Loss of Toe Gaps
17. Misaligned Subtalar Joint Alignment
18. Pronated Forefoot with Inverted Calcaneus
19. Supinated Forefoot with Everted Calcaneus
20. Everted Calcaneus
21. Inverted Calcaneus
22. Bony Protuberances of the Foot (multiple sites possible)
23. High Iliac Crest
24. Pelvic Torsion
25. "Pump Bumps"
26. Fifth Toe "Flail"
27. Excessive Ankle Plantar flexion (when non-weight-bearing)

II. Nontraumatic Complaints of:

1. Toe Pain
2. Heel Pain
3. Ankle Pain
4. Shin 'Splints'
5. Peripatellar Knee Pain
6. Metatarsal Heads Pain
7. Achilles Tendon Pain
8. Hip Flexor Pain
9. Buttocks Pain
10. Lateral Knee Pain
    (fibula ligaments and ITB insertion)
11. Posterior Knee Pain
    (at hamstring tendon insertions)
12. Morton's Neuroma
13. Tarsal Tunnel Syndrome
14. Low Back Pain (including those
    with radiated pain to knee level)
15. Lateral Thigh Pain (ITB)
16. Trochanteric Bursitis
17. 'Sciatic' Leg Pain
18. Sesamoiditis

III. Recurrent Symptoms from Previous Trauma:

1. Recurring Hamstring Pulls
2. Recurring Groin Pulls
3. Recurring Quadriceps Strains
4. Recurring Ankle Sprains
5. Episodic Low Back Pain
6. Recurring Hip Flexor Pulls
7. Episodic Limping Gait

IV. Discovery by Palpation:

1. Intertarsal Muscle Fibrosis
2. Shin Muscle/Fascia Fibrotic 'Lumps'
3. Tender Achilles Tendon
4. Tender Fibrotic Regions within the Peroneii (Fibularis), Flexor Hallucis Longus, Tibialis Anterior or Posterior Muscle
5. Tender Fibrotic Regions within the Plantar Fascia
6. Tender Fibrotic Regions of the Tibialis Anterior, Peroneus (Fibularis) Longus, or Peroneus (Fibularis) Brevis Insertion Points
7. Joint Fixations within the Foot and Ankle

The presence, history, detection, or palpation of any of the above represents a positive indication for the use of Biopods Technology as a means to correct the maladaptive neuromusculoskeletal gait mechanics that are responsible for the development of each of these observations/findings.

22
KEY TAKEAWAY

We see Biopods technologies as an actual panacea for the treatment of virtually all nontraumatic lower limb conditions of:

- Pain
- Degeneration
- Maladapted tissue
- Dysfunction

All due to a maladapted mechanical gait pattern (as the singular cause)–as found consistently in the shod community.

V. Other Possibilities:

1. Diabetic Patients
2. Fibromyalgia Patients
3. Post-surgical Rehab Patients (regarding the lower limb)
4. Incomplete Recovery from Surgery or Injury (for lower limb)
5. Children (to promote optimal foot function, during growth, that leads to an optimal 'environment' for ideal bone development and antagonistic muscle balance)

How to Select the Optimal Biopods Stimulus Intensity Level

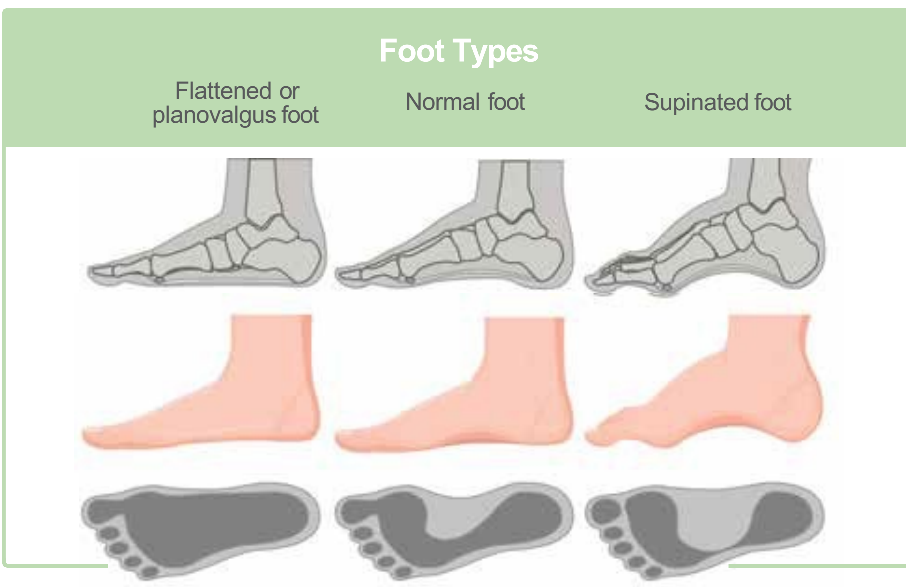


Figure 4.3. Three foot types. Each type can be regarded functionally as either rigid (difficult hallux elevation) or mobile and each will be best suited to a specific stimulus intensity level.

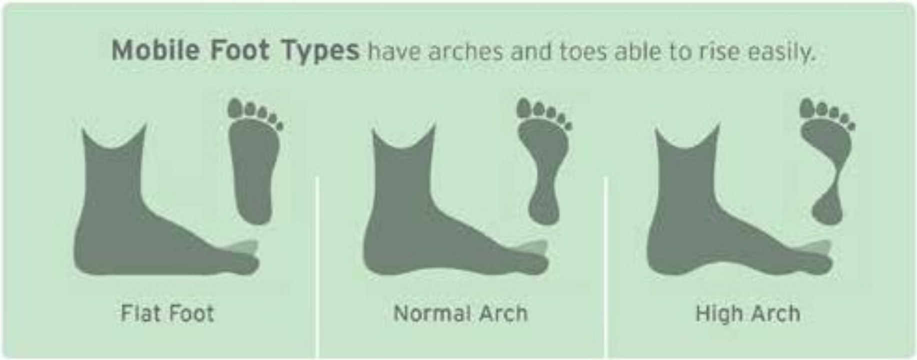


Figure 4.4. Mobile foot types: The toes and arches are able to rise easily.

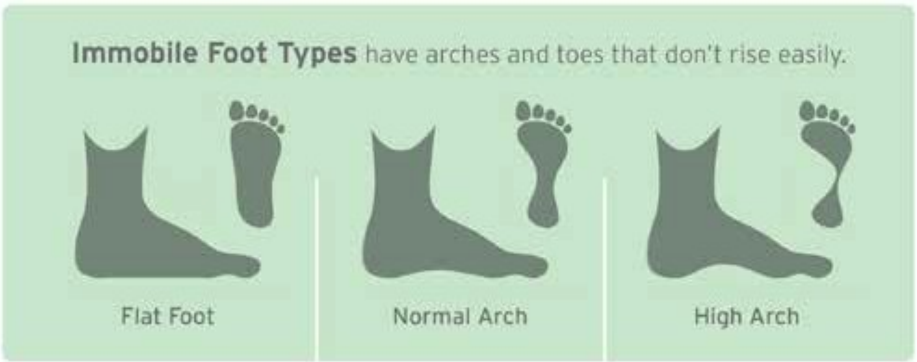


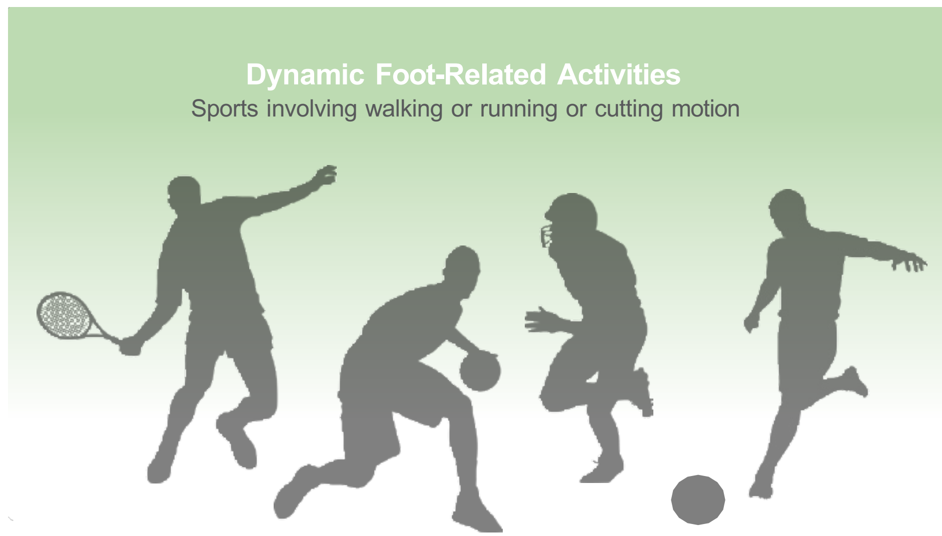
Figure 4.5. Immobile foot types: The toes and arches are unable to rise easily.

Absolute contraindication for Biopods implementation: Hallux rigidus (complete immobilization of the hallux of any cause – genetic, arthritic, traumatic, or surgical).

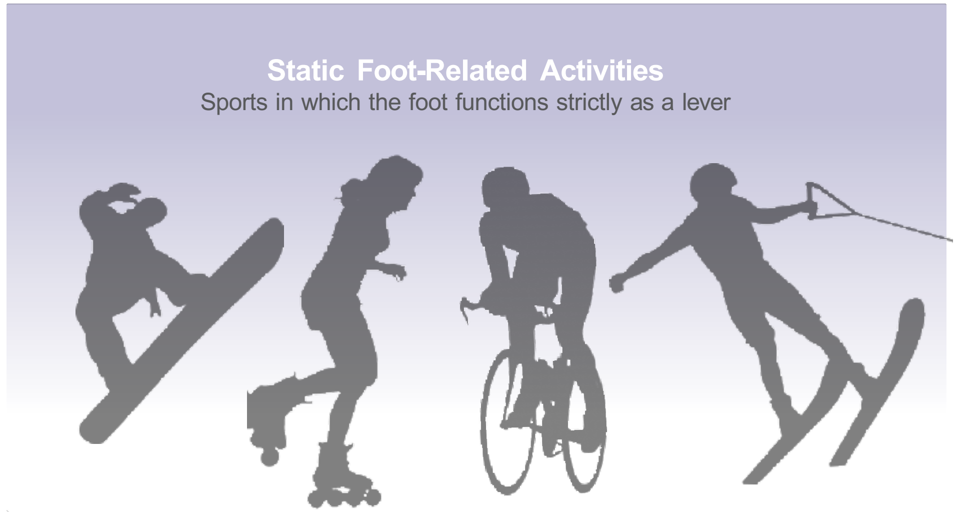
b) Habitual Footwear Use and Activity-Related Parameters
Biopods Footwear provide the user with the option of varying the Pods' stimulus intensity. Typically, the optimal Pods stimulus level is determined, first, by comfort or by starting with the stimulus most suitable for specific foot types (see Figures 4.4 and 4.5).
A more aggressive stimulus may be preferred for higher-intensity "Dynamic Foot-Related Activities". A moderate degree of stimulus may best suited to everyday use. The least aggressive stimulus may best suited ror standing or lower-intensity activities. Lower stimulus intensities are also preferred for "Static Foot-Related Activities" in tighter fitting footwear. The user should always let comfort be their guide in selecting the most appropriate stimulus level.

Amore aggressive stimulus level does not necessarily produce better or faster results. The brain is more alert to subtle varied stimulus.

Dynamic Foot-Related Activities:
Sports involving walking or running or cutting motion (e.g., soccer, baseball, basketball, tennis, football).



Static Foot-Related Activities: Sports in which the foot functions strictly as a lever (e.g., waterskiing, cycling, snow skiing, rowing, skating).



Dynamic and Static Blended Activities: Activities requiring prolonged standing and moderate amounts of walking (e.g., retail sales jobs, warehouse workers, cashiers, production line workers, hospital workers).

4. Conservative Treatment Modalities

a) Overall Concepts

The singular intent of Biopods Technologies is Foot-Related Function Rehabilitation. This intent implies that the optimal rehabilitation of all weight bearing mechanics and the entire kinetic chain that rely on optimal foot function will follow. True rehabilitation (to be equivalent to the approach taken regarding every other body region) cannot be achieved via palliative treatment (i.e., simply providing comfort) modalities.

23 KEY TAKEAWAY

The optimal Biopods Stimsole selection will be determined using several criteria foot type and mobility capacity, activity levels, style of intended footwear. and components of construction and/or materials within the footwear to be used.

The use of specific-purpose, therapeutic measures is necessary for true rehabilitation. From the table below, it is apparent that 4 therapeutic options are implicated as components of a truly effective foot (and related gait issues) rehabilitation program.

i) Table of Treatment Options

TREATMENT	TYPE	EXAMPLES
Pain Control and/or Anti-inflammatory	Palliative	Ice, Heat, Acupuncture, Oral Medication, Electrotherapy, Topical Creams/Rubs
Passive Alignment Control/Stability	Palliative	Tensor Wrap, Brace, Supports, Orthotics
Surgery	Palliative	————
Corticosteroid Injection	Pall/Therap	————
Specific Exercises	Pall/Therap	Stretch, Strengthen, Coordinate, Balance
Non-instrument assisted soft tissue manipulation	Therapeutic	FAKTR (Functional And Kinetic Treatment with Rehab)
Damaged Tissue Breakdown	Therapeutic	Ultrasound, Laser, Active Release Technique (ART), Graston, Shock Wave Therapy
Joint Manipulation	Therapeutic	Chiropractic Treatment
Stimulated Alignment Control	Therapeutic	Biopods Technologies

ii. Factors Affecting the Treatment Plan and Prognosis

Assuming constant use of Biopods Technologies during all weight bearing activities

1. Age:

(a) [< 20 yrs: Biopods effect is quick and easy; for damaged tissue, Rx~4 sessions]

(b) [20-40 yrs: Biopods effect is 1 weeks; for damaged tissue, Rx~6-8 sessions]

(c) [40-60 yrs: Biopods effect is 2 weeks; for damaged tissue, Rx~8 sessions]

(d) [> 60 yrs: Biopods effect is 3-4 weeks; for damaged tissue, Rx~8 –many sessions]

2. General Health:

(a) Poor nutritional status: Results in a slower rate of tissue healing whether from adapting to Biopods stimulus or emergence of latent tissue damage revealed by adaptation to Biopods

(b) Diabetic patient: If a long history, or severe symptoms, it will result in a much slower rate of tissue healing; if secondary therapy is needed, adaptation to the Biopods stimulus may be (but not necessarily) slower

(c) Poor fitness level: No effect on rate of adaptation to the Biopods stimulus; low fitness usually shows slower rate of response when secondary therapy is needed

(d) Neurologic disorders: The presence of MS, ALS, Parkinson's, etc., unpredictable outcomes; neuropathy often has rapid, efficient adaptation to Biopods stimulus (but max results are usually not expected); response to tissue therapy, when it has become needed, can be prolonged

3. History of Significant Lower Limb Trauma:

(a) Knee instability (due to traumatic ligament damage): The Biopods stimulus cannot stabilize the loss of internal knee ligaments, but will create optimal alignment, thus decreasing prior degenerative patterns

(b) Fused hallux (via surgery, advanced arthritis or congenital): This condition predictably shows the poorest response to Biopods stimulus; without the Windlass Effect foot rehab cannot occur

(c) Recurrent ankle sprains: The response to Biopods is usually excellent but, depending on the amount and severity of lateral ankle ligament and tendon damage present, much secondary therapy may be needed

(d) Fractures: If healing has occurred with perfect bone alignment there is a minimum of, or nil, tissue damage to rehab; but often, and especially if bone has healed with poor alignment, there can be secondary tissue damage to repair; if a femur, tibia, or fibula has healed "short," a heel lift may be needed beneath the Biopods insole for optimal rehab

(e) Achilles tendon rupture/repair: If optimal length has been surgically restored, there is usually no complication to ideal adaptation to the Biopods

(f) Torn hamstring: A belly tear may, or may not, require secondary tissue therapy to adapt to Biopods stimulus; however, tears at either of the insertion regions usually require secondary therapy to accommodate the (usual) shift in knee alignment that accompanies kinetic chain rehabilitation, via Biopods stimulus

(g) Myositis ossificans: The difficulty in alleviating this condition does not, typically, interfere with the Biopods rehabilitation

4. Daily Activity Levels:

(a) Running sport athletes: The high performance demands of such individuals implies a very high likelihood of the emergence of even tiny pre-existing sites of tissue damage, via the Biopods adaptation process

(b) Weight bearing fitness participants will have a slight increased likelihood of emergence of pre-existing tissue damage, via the Biopods adaptation process

(c) Jobs requiring constant weight bearing: The likelihood of latent symptom emergence, via Biopods use, is moderate
(d) Jobs requiring constant sitting: The likelihood of latent symptom emergence, via Biopods use, is minimal
(e) Weekend warriors will often show dramatic inflamed aggravations of their pre-existing tissue damage sites during adaptations to the Biopods insoles

All the above generalizations are magnified (for the worse), for those who utilize the Biopods Technologies only intermittently during their weight bearing activities

b) Common Sites of Presenting Symptoms, Emerging Symptoms, their Pathomechanics and the Biopods Treatment Methodologies

***The following table justifies the description of Biopods** Technologies as a panacea
(i.e., the dysfunctional foot, as per the previous discussion, is the singular basis for each emerging, or already symptomatic, site of tissue damage)*

Diagnosis of Current Sx, or Rx-Program – Emerging Sx	Diagnosis Made via (FDI = Foot Dysfunction Indicator)	Tissue Specific Pathomechanics, via Gait and/or Footwear (RSI = Repetitive Strain Injury)	Treatment/Therapy
Intertarsal Muscle Fibrosis	Site Pain/ Confirm Tissue Palp/Correlate (+) FDI	Compression/Friction in Narrow Toe box with Inhibited Windlass Effect	Utilize Biopods Tech/Use footwear with greater toe box room/flexibility/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Tarsal Tunnel Syndrome	Radiated Sx/Site Pain/ Correlate (+) FDI	Rigid Footwear Upper Material/Talus Pronation Friction on & Strain of FHL & TP Tendons	Utilize Biopods Tech/Employ Flexible Footwear/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Metatarsalgia	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Prolonged use of cushioning under the forefoot/Concave footwear supporting surface under metatarsals/Compression of Inner-sole, with Shallow Toe Box & Inhibited Windlass Effect	Utilize Biopods Tech/Use footwear with flexible yet firm flat supporting surface under metatarsals/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional

Diagnosis of Current Sx, or Rx-Program – Emerging Sx	Diagnosis Made via (FDI = Foot Dysfunction Indicator)	Tissue Specific Pathomechanics, via Gait and/or Footwear (RSI = Repetitive Strain Injury)	Treatment/Therapy
Plantar Fasciitis	Heel Pain at Calcaneus/ Correlate (+) FDI	Ineffective Windlass – Lengthened Plantar Tissues – RSI at PF Insertion on Calcaneus	Utilize Biopods Tech/ Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Fibrosis of Tib Ant & Per Long Insertion Point	Arch Pain/Confirm with Tissue Palpation/ Correlate (+) FDI	Lack of "Right Stimulus" – Inefficient Nerve Signals – Unbalanced 'Pulls' of Antagonistic Muscles – RSI	Utilize Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
AbHallLong Muscle Fibrosis	Pain at Medial Foot Border/Confirm Tiss Palp/Correlate (+) FDI	Rigid Footwear Uppers – Inefficient 1st Ray for Propulsion Lever – Friction & Torsion	Utilize Biopods Tech/Employ flexible footwear/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Dorsum Subcu Tis Fascia Fibrosis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Excessively Tight Lacing/Inefficient Windlass/Friction – RSI	Utilize Biopods Tech/Employ loosely laced flexible footwear/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Per Brev Tendon Insert. Fibrosis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Tight Lacing, Rigid Uppers, Lack of "Right Stimulus" – Friction & RSI	Utilize Biopods Tech/Employ loosely laced flexible footwear/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Cuboid Pain Via Joint Fixation	Site Pain/Joint ROM Challenge Confirm/ Correlate (+) FDI	Tight Lacing, Rigid Uppers, Inefficient Peroneii (Fibularis) by lack of "Right Stimulus"	Utilize Biopods Tech/Employ loosely laced flexible footwear/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Dorsi-Flexor Tendons at Tib-Talus Jt	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Tight Rigid Uppers Resist DF's Participation in Windlass/ High Heel Strains DF Tendons	Utilize Biopods Tech/Employ flexible footwear/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Medial Ankle Lig Fibrosis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Chronic Position of Calc Ever/ Pronation Strain/Rigid Uppers/ Inefficient Windlass	Utilize Biopods Tech/Employ flexible footwear/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional

Diagnosis of Current Sx, or Rx-Program – Emerging Sx	Diagnosis Made via (FDI = Foot Dysfunction Indicator)	Tissue Specific Pathomechanics, via Gait and/or Footwear (RSI = Repetitive Strain Injury)	Treatment/Therapy
Lateral Ankle Lig Fibrosis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Recur Inversion Sprains/ Unstable due to Inefficient Windlass/ Unstable 1st Ray as a Lever	Utilize Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Med Talo-Nav Lig Fibrosi	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Unstable Arch Apex/ Inefficient Windlass/RSI Med Ligament	Utilize Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
TP & FHL Tendons at Medial Ankle	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Rigid Upper Material/Talus Pronation/ Friction on & Strain of FHL & TP Tendons	Utilize Biopods Tech/Employ flexible footwear/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Peroneii Myo-Tend Region Fibrosis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Strain, Overuse, RSI of Peroneii (Fibularis) Muscles Against Unstable-Pronated Midfoot/ Due to Inefficient Windlass	Utilize Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Tendonosis of EHL, TA & EDL in Subtalar Region	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Rigid Uppers/Inefficient Dorsiflex of Ankle/Inefficient Windlass	Utilize Biopods Tech/Employ flexible footwear/Mandatory Therapy to Eliminate Fibrous Tissue/Palliative Optional
Pain of Tib-Talar Joint Fixation	Site Pain/Joint ROM Challenge/ Correlate (+) FDI	Unstable 1st Ray due to Inefficient Windlass/Stressful Propulsion/ Repeated Joint Compression	Biopods Tech/Chiropractic Manip/ Palliative Optional
Fibular Head Fixat and Fibrosis	Site Pain/Joint ROM Challenge/ Correlate (+) FDI	Inefficient Windlass/Ankle Pronat/ Med Knee Torsion/Tib-Fib Jt Stress	Biopods Tech/Chiropractic Manip/ Palliative Optional + Eliminate Fibrous Tiss
Achil. Tendonosis Retrocalc Bursitis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Rigid Heel Material/ Unstable Heel Strike/Inefficient Windlass	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional
Gastoc-Soleus Myotendon Fibrosis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/ Everted Calc During Stance Phase/ Torsional Contraction for Propulsion	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/ Palliative Optional

Diagnosis of Current Sx, or Rx-Program – Emerging Sx	Diagnosis Made via (FDI = Foot Dysfunction Indicator)	Tissue Specific Pathomechanics, via Gait and/or Footwear (RSI = Repetitive Strain Injury)	Treatment/Therapy
Hamstring Tendon Fibrosis (M or L)	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/ Knee Torsion & Hyperextension at Heel Strike	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional
Vastus Lateralis Fibrosis Distally	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/ Med Torsion Knee/ Strain of all Peripatellar Fascia	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional
Fibrosis of Quad-Patella Fascia at Sup Pole of Patella	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/ Med Torsion Knee/ Strain of all Peripatellar Fascia	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional
Fibrosis of MCL & Med Knee Fascia	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/ Med Torsion Knee/ Strain of all Peripatellar Fascia	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional
Infrapatellar Tendon Fibrosis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/Med Torsion Through Patellar Tendon/RSI	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional
FHL Belly & Myo-Tendon Fibrosis	M or L Calc Pain/ Confirm Tissue Palp/ Correlate (+) FDI	Decreased Arch Apex/Elongated Tie-Beam/Strain of Myo-Tend Region/RSI	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional
TP Belly & Myo-Tendon Fibrosis	M or L Calc Pain/ Confirm Tissue Palp/ Correlate (+) FDI	Decreased Arch Apex/Elongated Tie-Beam/Strain of Myo-Tend Region/RSI	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional
Adductor Tubercle Fibrosis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/ Femur Internal Rotation/ RSI of Adductor Insertion	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional
Iliopsoas Insertion Fibrosis or Contracture	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/ Pronation/Femur Internal Rotation/ RSI of Iliopsoas Insertion in Gait	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional and/or Deep Massage of Iliopsoas/Check SI's

Diagnosis of Current Sx, or Rx-Program – Emerging Sx	Diagnosis Made via (FDI = Foot Dysfunction Indicator)	Tissue Specific Pathomechanics, via Gait and/or Footwear (RSI = Repetitive Strain Injury)	Treatment/Therapy
Greater Trochant Bursitis/Fibrosis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/ Femur Internal Rotation/RSI of ITB-Bursa Tissues in Gait	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional
Glut-ITB Interface Fibrosis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/ Femur Internal Rotation/ RSI of Gluteal-ITB Interface Fascia	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/Palliative Optional
Recurrent SI Jt Fixation (LBP #1)	Site Pain/Joint ROM Challenge/ Correlate (+) FDI	Inefficient Windlass/Pronation/ Femur Internal Rotation/ Drops Level of Iliac Crest/Compress SI	Biopods Tech/Chiropractic Manip/ Palliative Optional
Fibrosis of SI Jt Ligaments (LBP #2)	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/ Femur Internal Rotation/ Drops Level of Iliac Crest/RSI Ligs	Biopods Tech/ Mandatory Therapy to Eliminate Fibrous Tiss/ Check SI Jt ROM/Palliative Optional
Ilio-Lumbar Lig Fibrosis (LBP #3)	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/ Femur Internal Rotation/ Pelvis Torsion/RSI Ilio-Lumbar Lig	Biopods Tech/ Mandatory Therapy to Eliminate Fibrous Tiss/ Check L5 Vert ROM/Palliative Optional
Fibrosis of Iliac Crest Fascia-Erector or QL Muscles Insertion (LBP #4)	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/Femur Internal Rotation/Pelvis Drop & Torsion/ RSI of Erectors and QL Muscles	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/ Check SI Jt ROM/Palliative Optional
Fibrosis of Gluteus Muscles at Iliac Crest (LBP #5)	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/Femur Internal Rotation/Pelvis Drop & Torsion/ RSI Gluts at the Iliac Crest	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/ Check SI Jt ROM/Palliative Optional
Deep Gluteal Fibrosis and/or Contractures (LBP #6)	Site Pain/Leg "Tingle"/ Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/Femur Internal Rotation/ Pelvis Drop & Torsion/RSI Gluts	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/ Check SI Jt ROM/Palliative Optional
Low Gluteal & Hamstring/ Ischial Tuberosity Fibrosis	Site Pain/Confirm Tissue Palp/Correlate (+) FDI	Inefficient Windlass/Pronation/ Femur Internal Rotation/Pelvis Drop & Torsion/RSI Hamstring Origin/ Ischial Tuberosity Fascia	Biopods Tech/Mandatory Therapy to Eliminate Fibrous Tiss/ Check SI Jt ROM/Palliative Optional

Foot Dysfunction Indicator (F.D.I.)	Pathomechanics of the F.D.I.'s
Bunion	Non-rigid lever propulsion, with inefficient Windlass, and a consistently restricted toe box creates a valgus/compressive force onto the distal joint of the hallux; over sufficient time, bone, joint, and connective tissues remodel themselves according to the prevailing forces applied
Bunionette	Rigid upper material, compressing the 5th metatarsal, during toe off that has a torsional component; due to inefficient Windlass and 1st ray non-rigidity for propulsion; varus stress over sufficient time will induce bone and soft tissue remodeling with a varus angle, upon the distal joint of the 5th ray
Callus & Corn	Tight rigid footwear, combined with inefficient Windlass and non-rigid 1st ray lever, results in non linear propulsion; torsional stress will induce multiple opportunities for friction – the cause of callus and corn
Hammer Toe	When the absence of "Right Stimulus" fails to activate proper firing of many muscles of the foot and/or when footwear restricts toe movement (dorsiflexion), the toe flexor muscles can overpower their extensor counterparts, thereby causing "hammer toe"
Claw Toe	Absence of "Right Stimulus" fails to activate proper firing of many muscles of the foot; inappropriate flexor muscle activity with no extensor muscle activity to balance the forces, causes the "claw toe"
"Flat Feet"	Habitual, inefficient, Windlass Effect cannot create any functional arch (let alone an Optimal Arch Apex) and eventually stays flat (i.e., habitually pronated)
Pes Cavus	Tight rigid footwear, from a very young age, creates an environment in which the tibialis anterior and the peroneus longus are in simultaneous contracture, a permanent state of a high, rigid Windlass Effect results
Genu Valgus	A chronic state of pronation, due to inefficient Windlass Effect, will readily lead to internal rotation of the tibia and femur with contracture of the iliopsoas, and will put the ipsilateral knee into a valgus position

This table is intended to demonstrate the relationship between Foot Dysfunction Indicators and the maladapted foot mechanics that created each indicator.

Each example here, begins with the assumption of an absence of "Right Stimulus" and demonstrates a possible, chronic manifestation of "Wrong Movement"

Foot Dysfunction Indicator (F.D.I.)	Pathomechanics of the F.D.I.'s
Genu Varus	A chronic state of pes cavus, due to simultaneous contractures of tibialis anterior and peroneus longus, but with tibialis anterior in a dominant, overpowering state; the ipsilateral knee will be put into a varus position
Pigeon-Toed	If both feet have similar degrees of pronation, due to inefficient Windlass Effect, and bilateral internal tibial rotation occurs, then to internally rotate the femurs, the iliopsoas muscles will become contractured; thus each leg notably rotates internally – "pigeon-toed"
Hallux Valgus	Non-rigid lever propulsion, with inefficient Windlass Effect, creates torsion at toe-off that, via much repetition, develops into a valgus deformation of bones and joint of the hallux
External Hip Rotation	A chronic state of inefficient Windlass Effect, creating pronation, internal rotation of tibia and femur, strains the iliopsoas to a position of weakness and the antagonist gluteal muscles develop and display dominance, which becomes an externally rotated hip joint, affecting the entire leg
Forefoot Splay	A non-rigid lever for propulsion, with an inefficient Windlass Effect, in a moderately loose toe box, can have the effect that multiple, deep muscles attempt to stabilize the foot, for propulsion, by abducting the toes (i.e., 'splaying' them)
Longitudinal Toe Rotation	Absence of "Right Stimulus" allows random and inappropriate muscle activity; a metatarsal influenced by a chronic state of (moderate) dorsiflexion with either contractured adduction or abduction, will (in time) result in the longitudinal rotation of that metatarsal
Overlapping Toes	Absence of "Right Stimulus" allows random and inappropriate muscle activity; a chronic state of either adduction with dorsiflexion, or abduction with dorsiflexion, adjacent to a metatarsal affected by mildly contractured flexion, will (in time) result in one toe crossing another

This table is intended to demonstrate the relationship between Foot Dysfunction Indicators and the maladapted foot mechanics that created each indicator.

Each example here, begins with the assumption of an absence of "Right Stimulus" and demonstrates a possible, chronic manifestation of "Wrong Movement"

Foot Dysfunction Indicator (F.D.I.)	Pathomechanics of the F.D.I.'s
Loss of Toe Gaps	The use of tight fitting shoes, especially with a narrow toe box, in the presence of an inefficient Windlass Effect and absence of "Right Stimulus" (thus poorly stimulated deep muscles of the foot), contractures of the adductor muscles can occur, thus approximating all of the metatarsals
Misaligned SubtalarJoint Region	Inefficient Windlass Effect cannot create the optimal arch apex, and: (a) with lack of "Right Stimulus," and a common lack of tibialis anterior activity, the midfoot pronates, shifting the subtalar joint region medially; or (b) with lack of "Right Stimulus," and a rare, but possible, increased tibialis anterior activity, will shift the subtalar joint region laterally
Pronated Forefoot & Inverted Calcaneus	With lack of "Right Stimulus," a rare combination of inappropriate muscle activities can occur… such as: less of tibialis anterior/more of peroneus longus = pronated fore-foot, and contractured medial longitudinal region of the gastroc-soleus = inverted calcaneus
Supinated Forefoot & Everted	With lack of "Right Stimulus," a rare combination of inappropriate muscle-calcaneus activities can occur, such as: less of peroneus longus/ more of tibialis anterior = supinated fore-foot, and contractured lateral longitudinal region of the gastroc-soleus = everted calcaneus
Everted Calcaneus	With lack of "Right Stimulus," a contracture of the lateral longitudinal region of the gastroc-soleus muscle is possible to develop, which will evert the calcaneus
Inverted Calcaneus	With lack of "Right Stimulus," a contracture of the medial longitudinal region of the gastroc-soleus muscle complex is possible to develop, which will invert the calcaneus
Bony Protuberances of the Foot	Inefficient Windlass Effect allows a poorly aligned lever system and very poor arch formation, that can result in bones 'jammed' into each other in such a way as to stimulate abnormal bone growth to mitigate the forces; visible bumps can occur externally; this can occur at a variety of sites
High Iliac Crest	Inefficient Windlass Effect leads to pronation and inefficient arch stimulation, that 'shortens' that leg, which lowers the ipsilateral iliac crest; the contralateral ilia then appears higher

This table is intended to demonstrate the relationship between Foot Dysfunction Indicators and the maladapted foot mechanics that created each indicator.

Each example here, begins with the assumption of an absence of "Right Stimulus" and demonstrates a possible, chronic manifestation of "Wrong Movement"

Foot Dysfunction Indicator (F.D.I.)	Pathomechanics of the F.D.I.'s
Pelvic Torsion	Inefficient Windlass Effect, can induce internal rotation of both the tibia and femur, which when asymmetric, will create an anterior shift of the ipsilateral ilia, appearing as pelvic torsion
"Pump Bumps"	Rigid and hard edged heel counters, especially combined with high heels, with a poor ability to dorsiflex, will react to the constant friction in the form of thickened/hypertrophied tissue at the Achilles'/calcaneal region
Fifth Toe "Flail"	Absence of "Right Stimulus," and resultant ineffective Windlass Effect, which creates forefoot pronation, can allow such inappropriate muscle activities as excess extension of the 5th metatarsal, as an inefficient attempt to induce a partial Windlass at the least resistant region
Excessive Ankle Plantar Flexion (when non-weight-bearing)	Absence of "Right Stimulus," while wearing shoes with tight, rigid uppers (especially if high heels are frequently worn), the ability of the tibialis anterior, peroneus longus and extensor hallucis longus to collectively dorsiflex the ankle becomes greatly diminished, to the point at which, in a non-weight-bearing situation, the plantar flexors hold the ankle in a position of plantar flexion

This table is intended to demonstrate the relationship between Foot Dysfunction Indicators and the maladapted foot mechanics that created each indicator.

Each example here, begins with the assumption of an absence of "Right Stimulus" and demonstrates a possible, chronic manifestation of "Wrong Movement"

24 KEY TAKEAWAY

"The foot is a masterpiece of engineering."
(Leonardo da Vinci)

To rectify the effects of traditional footwear (ie; all the pain, deformity, degeneration, and suffering), simply unfetter the foot and stimulate it. This emulates the 'barefoot experience' and restores the foot to its rightful capacity as a "masterpiece of engineering."

Addendum: Contraindications and Challenging Applications that may require additional considerations

There are several contraindications and pathology symptoms that may require additional considerations.

a) Contraindications

One absolute contraindication for implementation of Biopods products is hallux rigidus, or complete immobility of the hallux due to genetics, arthritic, traumatic, or surgical fusion.

The healthcare practitioner should verify complete immobility by attempting to move the great toe by passively challenging the hallux into its extended position. If the great toe is fused (i.e..completely rigid), Biopod products will have little or no benefit and may be uncomfortable for the user. (Figure 4.6.)

If the healthcare practitioner can demonstrate at least moderate, passive extension in the great toe, Biopods products may be employed. (Figure 4.7.)

Figure 4.6.

Figure 4.7.

b) Challenging Applications

While most patients will adapt to Biopods products with minimal issues, there are a number of potentially difficult applications that, despite initial indications of less-than ideal applicability, can be overcome with the use of complementary therapies. These situations may also indicate an exception to the criteria for selecting the appropriate Biopods stimulus level.

i. Absence of voluntary neurologic control of extensor hallucis longus muscle activity offers an unpredictable outcome. (Figure 4.9., page 14)
Success will likely depend on the specific cause of the loss of voluntary extensor hallucis longus activation (e.g., peripheral neuropathy, MS, ALS, Parkinson's). In some instances, Biopods products may induce reflex activation of the extensor hallucis longus; therefore, it is a clinical trial worth pursuing. In these instances, the practitioner may want the patient to test various Biopods stimulus levels to determine which will produce optimal results, depending on the patient's condition and footwear type.

25 KEY TAKEAWAY

The vast majority of dysfunctional feet (excluding those with hallux rigidus) can be rehabilitated with Biopods usage.

ii. Inability to dorsiflex one of both of the talonavicular joints beyond the 90° position due to mechanical joint fixation indicates that mobilization or manipulation would be of benefit. (Figure 4.8.) The practitioner should select the therapy they believe will be most applicable and recommend self-therapy (e.g., heel walks and/or repetitive, active, full-range dorsiflexion with the heel resting on the floor) concurrent with regular Biopods usage during gait.

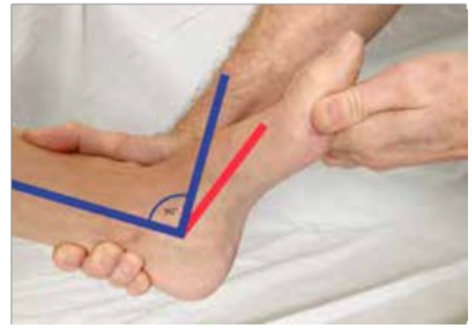


Figure 4.8.

iii. Neurologic loss of voluntary control of either or both tibialis anterior or peronei (fibularis) muscles offers an unpredictable outcome. (Figure 4.9.) Success will likely depend on the specific cause of the loss of voluntary tibialis anterior and/or peronei muscle activation (e.g., peripheral neuropathy, MS, ALS, Parkinson's). In some instances, Biopods may induce reflex activation of the tibialis anterior or peroneii; therefore, it is a clinical trial worth pursuing. In these instances, the practitioner may want the patient to test various Biopods stimulus levels to determine which will produce optimal results, depending on the patient's condition and footwear type.

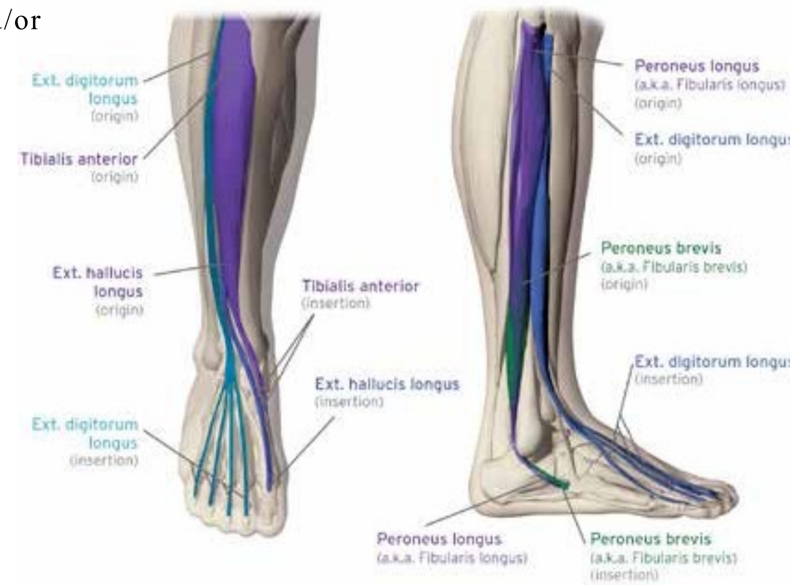


Figure 4.9.

iv. Ballerina ankle configuration is a condition in which there is a virtual straight line down the tibia and foot dorsum when lying supine. (Figure 4.10.)

This may indicate that the muscles of ankle dorsiflexors are much weaker than their antagonist plantar flexors and may also demonstrate insufficient dorsiflexion at the talonavicular joint due to a mechanical fixation. In this case, the practitioner should employ one of the following strategies, depending on the severity of muscle imbalance:

1. Mobilization or manipulation therapies concurrent with Biopods use – to restore sufficient mobility to the talonavicular joint. In addition, recommend self-therapy that includes heel walks and/or repetitive, active, full-range dorsiflexion with the heel resting on the floor.
2. When a significant muscle imbalance is observed, the aforementioned therapies may be needed as a "pre-therapy" before a justifiable positive outcome can be expected and Biopods can be put to use.

Figure 4.10.
Ballerina ankle configuration.

v. Notably fibrotic regions, especially at the myotendonous junction and/or insertions of the tibialis anterior and/or peroneii may become painful as a result of the stimulus intensity of Biopods Stimsoles. (Figure 4.11.) After evaluating the severity, thickness, and chronicity of the fibrotic regions, you may opt to employ one or more soft tissue mobilization therapies (e.g., therapeutic ultrasound, A.R.T., Graston Technique®, deep tissue massage) to reduce or eliminate the fibrotic tissues prior to or during implementation of Biopods products. In these cases, the patient may initially require a lower Biopods stimulus level until the fibrotic tissue has been sufficiently reduced or eliminated.

Figure 4.11.

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KEY TAKEAWAY

There are several types of foot dysfunction that require pre-therapies or concurrent therapies (with respect to Biopods usage) for optimal foot and kinetic chain rehabilitation.