GRAVITY DEFYER FOOTWEAR

WHITE PAPER
EVALUATION OF STATED BENEFITS

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Abstract

The focus of this paper is to quantify and qualify the benefits of Gravity Defyer shoes on the human body during the gait cycle and in a static position. The material sited will correlate these actions to the benefits these shoes provide to the people who wear them. Analysis of the composition of the Gravity Defyer shoe is crucial to understanding the corrective function the shoes provide and the resulting benefits. As part of this examination we will observe the piece make up of the shoes achieve a direct understanding of each part’s role in the reduction of pain and fatigue.

Herein, serious consideration is given to heel strike, forefoot strike, foot conditions and pathologies, postural alignment, and fatigue. Data relating to shoe construction, stability, and control will also be thoroughly broken down to explain the actual benefits and functionality of these shoes. A simple comparison of other shoe brands featuring similar technologies (coils or spring systems) to that utilized in Gravity Defyer shoes provides a wealth of data and further justifies the claims made by Gravity Defyer. Significant data and research was found to logically substantiate claims of pain relief, fatigue reduction, appearing taller, and an increase in additional energy.
Introduction

1.1 Establishing the Need for Biomechanically Sound Footwear

For decades shoe manufactures have discussed, marketed and produced shoes to address conditions of the human foot. Many of these manufactures make claims of comfort, yet there is nothing that makes their shoes significantly different from the rest of the industry. Shoes for centuries have followed the basic premise of a solid out sole with leather upper. The primary device used to make one brand’s footwear distinct from another was the alteration of the design and/or material of the upper and the inclusion of more and varied materials used in the construction of the sole and midsole due to advances in chemical engineering and advanced production methods (Poly-Urethane, EVA, other) Selecting a comfort shoe under these circumstances is a bit like the choice of apples or apples.

Custom shoes have long been made for people with serious foot conditions throughout the world. Some of the concepts used to produce a medical benefit have been incorporated, with varying success, into shoes produced for the general public. Typically these are considered to be just a trend shoe or a fad shoe instead of a long-term solution to an existing problem. Of those shoes produced with the medical concept built into them, most are on the market for only a short period of time before their efficacy has either been disproven or the public loses interest in them.

Gravity Defyer Inc. has produced Gravity Defyer shoes since 2005. They are unlike any other shoe on the market today. The shoes provide a direct benefit to the consumer and unlike fad products, have maintained an overall acceptance by the general public. In designing and producing Gravity Defyer shoes, the company has taken an approach uncommon to shoe manufacturers. They focus their efforts on 1) general comfort, 2) applying advances in materials and technology to best benefit the health and well-being of the consumer, and 3) style.

According to the Center for Disease Control 85% of the general public is experiencing some type of biomechanical disease, of those 85% –the vast majority– would greatly benefit from biomechanically corrective shoes: shoes designed to change, correct and alleviate the symptoms these people experience. The primary objectives of biomechanically corrective shoes are the reduction of Ground Reaction Force (GRF: The force exerted by the ground on a body in contact with it.) and the correction of body alignment. These concerns are not new, but addressing them through a shoe is. While the majority of footwear brands focus on the dispersion of force through the use of EVA or another shock absorbing material, Gravity Defyer has developed a shoe that is also a mechanical device. It has been engineered to perform two primary functions from which its benefits arise.
1. To reduce the accumulated impact damage of the GRF.
2. To balance and return the human foot to a neutral position, thereby correcting aspects of body misalignment.

Through the application of human biomechanics to shoe construction, Gravity Defyer shoes demonstrate the ability to address, change and make shoes a tool that a person can actually benefit from wearing.

1.2 Current state of shoe manufacturing industry
Shoe manufacturing has gone through vast changes from what was considered a good comfortable shoe 30 years ago. Corners are often cut for cost management; function and support are sacrificed for style, weight and production time have replaced durability. Gravity Defyer shoes fortunately do not adhere to this philosophy. Their approach in producing a shoe is to provide comfort and support while still encompassing style and functionality. Gravity Defyer shoes are constructed with the fundamental platform shared by other quality comfort shoes. What separates them from their competitors is their application of biomechanical principles that are known to benefit the consumer, yet are not incorporated in other footwear.

1.3 Contemporary standards used in shoe production.
In the shoe industry, the criteria for a good comfortable pair of shoes is considered to be composed of 5 main points: (2, 3, 4, 10, 16, 20, 22, 29).

**Shank** - The solid stabilizing support running through the middle of the shoe, under the midsole and/or upper layer of the outsole designed to reinforce the shoes strength. The Shank is (steel, plastic, or composite) used to provide additional stability to the arch as well control to the heel. (2, 3, 4, 10, 16, 20, 22, 29)

**Heel Counter** - The reinforced posterior segment of the shoe, which is designed to wrap around the heel of the foot and control movement of the heel. This additional
material creates an improved fit, feel and support of the foot. This allows for great control and stabilization during the gait cycle. (2, 3, 4, 10, 16, 20, 22, 29)

**Rounded Toe Box**- The shoes forefoot must be shaped to allow ample room for the toe area. This is accomplished by providing a deeper and wider toe box than commonly used in fashion footwear where sharp angles and close fit may cause numerous pathologies included hammer toes, claw foot, bunions and other skin irritations. (2, 3, 4, 10, 16, 20, 22, 29)

![Footwear Image](image)

**Gender and ethnic variations in foot anatomy**

**Removable Insole**- A removable insole is recommended for all footwear to allow the application of custom orthotics and corrective devices. This feature allows the wearer to modify, or adjust the interior fit of the shoe and correct for known pathologies. (2, 3, 4, 10, 16, 20, 22, 29)

**Breathability**- The ability of air to pass through the footwear is called breathability. It combines two desirable traits, Air permeability and water vapor permeability. Breathability is a desirable feature for health and comfort. Closed footwear compounds the heat generated by your body causing temperatures higher than that outside the footwear. Once combined with perspiration (moisture), these properties form an ideal environment for microbial growth. Shoes that feature
breathability are both more comfortable and advance proper foot health. (2, 3, 4, 10, 16, 20, 22, 29)

2.1 Gravity Defyer Shoes: A Summary of Their Composition and Intended Application

Breaking down the functionality of Gravity Defyers shoes starts by understanding the main component that separates this shoe from that of other manufacturers, the Trampoline system.

2.2 The Trampoline system

The Trampoline system is a shock absorbing mechanism integrated within the posterior heel region of the sole. It consists of five components: 1) a midsole with molded side-walls and a cavity located beneath the heel 2) a primary shock absorbing spring or coil, 3) two stabilizing shock absorbing springs or coils and 4) a heel plate with rubber-polymer trampoline surface. 5) the foot-bed which supports the foot and resists the action of the trampoline providing a dynamic floating support system.

2.2.1 Midsole, Molded Side-Walls, Trampoline Cavity and Shank

The midsole is considered the body of the shoe. The midsole of each shoe is made of EVA (Ethylene-Vinyl Acetate). This material is an industry standard for the dispersion of force. In Gravity Defyer shoes, the midsole provides shock protection from the mid-foot region through the metatarsals and toes. The midsole houses the shank. The shank extends to the metatarsals of the foot allowing for forefoot bend and protects the foot by limiting flexation of the arch while providing additional stability and control from the heel and arch of the wearer. The heel region is tooled to form a hollow space or trampoline cavity directly beneath the heel. The resultant semi-rigid sidewall acts as the foundation for the trampoline structure. These side walls act as a secondary stage in absorbing shock and will flex under extreme forces, further reducing GRF and allows for the transfer of force and mass through the sole of the shoe, while not impacting the wearer with the wave of force radiating through their body.

2.2.1 Primary Shock Absorbers and Twin Shock Absorbing Stabilizers
The spring (or coil) system is the primary defense against GRF and provides more energy return than EVA or other materials used in contemporary footwear. They set in a triangular configuration and integrated into the posterior heel of the outer layer of the trampoline sole. As a further benefit, the action of the shock absorbers compensates for unequal or uneven distribution of weight and pressure. If a wearer is prone to have fat pad shift (Varus or Valgum) (10, 22, 25) the springs work independent of each other to accommodate the wearer’s pressure pattern. The springs vary in resistance based on the shoe size (and presumed weight increase of the wearer). As an example, a size 10 man’s shoe uses a blue spring, with a capacity of 220psi. This spring acts as the primary shock absorber. Two red springs, each with a capacity of 60psi act as stabilizers. The combined lift of the three springs without taking into account the rubber polymer’s elastic properties is approximately 600lbs and provides optimal support for a person of average size during most common activities (standing, walking and running).

2.2.1 The Heel Plate
The heel plate is an 8mm section of sole material suspended on a plate of rubber polymer. When depressed, the heel plate retreats into the heel cavity of the molded midsole. During this action the rubber polymer is stretched adding its elastic potential energy to the shock absorbing force of the other shock absorbing elements.

2.3 The Outsole
The outsole of the shoes are tooled and composed of EVA or PU to provide the best control on various surfaces. The composition of the outsole dictates how the shoe interacts with the environment through friction (grip) and slip resistance. The soles of Gravity Defyer shoes reflect industry standards and practices for shoes in each class, whether they be for sport shoes or a casual/dress shoe. The outsoles have not yet been rated for slip resistance, oil or chemical resistance.

2.4 Heel Counter
The heel counters of the Gravity Defyer shoes are reinforced. They are in the posterior upper part of the shoe. Most manufacturers neglect this important feature in footwear. The heel counter covers the calcaneus or heel while supporting the Achilles.

2.5 Toe Box
Toe box in GD shoes are designed and manufactured for comfort. Generous room and space is given to the forefoot. The shoes are made in medium, wide, and extra wide to allow for proper fit. While the spacing in the toe box allows for variation in foot anatomy. Free movement of the toes is reinforced while still holding the foot in place with the vamp and Quarter. (10,29)
2.6 Removable Insoles

Removable Insoles are featured in all Gravity Defyer shoes. This is important because it allows the wearer to change out the insole for a medically prescribed orthotic, to adjust the shoe fit, or to extend the life of the shoe if the insole is worn down. The removable insole in all Gravity Defyer shoes is manufactured from PU. They have a built up region in the arch to provide additional support and control. An added feature of the insole is the dome pocket created in the heel of the insole, directly under the calcaneus. This feature gives additional comfort by improving heel placement, centering and cupping the heel. (2, 10, 16, 22, 29) *Image of our insole

2.6 Fit and Adjustability

Due to a lack of education and choice, the majority of people today wear ill-fitting shoes. This is an important factor relative to comfort and may contribute to the development of foot pathologies.

2.6.1 Fixed Sizes
Gravity Defyer shoes are manufactured in both full and half sizes from size 5-11 female men 7.5-15 and are available in a range of widths from medium to xtra-xtra wide.

2.6.2 Width Adjustability
Two components act to provide a proper fit and feel for your footwear.

2.6.2.1 Choice of closures.
Gravity Defyers come in a wide range of closure types including slip on, elastic and lace-up, but the most important to individuals requiring a proper fit for medical reasons is the lace-up variety. Lace-up shoes provide adjustability at several points along the arch and are recommended for persons with diabetes and other circulatory conditions.

2.6.2.2 Wide and Adjustable Widths.
Select Gravity Defyer shoes have been designed with additional width. Through the addition of an adjustment layer (dubbed the Perfect Fit insole) beneath the standard insole, one may adjust the fit and feel of the shoe to best suit their needs. This is a great feature and benefit to wearers with narrow or slim girth feet.

2.7 Ventilated Upper Construction

Gravity Defyer shoes made of leather provide industry standard venting through piercing and grommets where applicable. Athletic shoes use meshed fabric layers. This mesh is composed of
crossed grid layers to allow penetration of air in and out of the shoes through predetermined mesh air holes. This feature combines with the significant amount of room in the toe box allows for the air to move freely in and out of the shoes. The air that penetrates into the chamber from the midsole of the shoe is released through the vent opening.

2.7 AVS\textsuperscript{3} Ventilation System

Both leather and athletic shoes feature the AVS\textsuperscript{3} Ventilation System, a system that harnesses the expansion and contraction of Gravity Defyer’s unique trampoline heel to form a vacuum pump. The system consists of a heel cylinder, channels that have been molded into the midsole, open vents that allow air to pass from the shoe to these channels, and a one-way valve located in the heel cylinder. Fresh air is directly introduced from the outside of the shoes, always maintaining the same consistence with the air temperature of the surrounding area. On compression of the heel cylinder, heated air from the shoe’s interior is expelled through the one-way valve in the sidewall of the midsole. As the heel cylinder expands, the one-way valve closes forcing the vacuum system to draw air from the interior of the shoe. The vacuum creates negative pressure sucking hot air from the interior of the shoe bed and carries it toward the heel cylinder. This cycle repeats with every step. Calculations indicate that one 8\textsuperscript{th} the available volume of the shoe’s interior is expelled with each cycle. (AVS3 Technical Data)

3. Biomechanical Advantage Over Other Footwear

Gravity Defyers work based on a trampoline concept. This trampoline is located in the posterior sole of the shoes absorbing the initial contact of GFR while allowing the heel of the wearer to continue drive through the heel without feeling the impact. A secondary benefit of this shock absorbing action is the two-stage nature of its compression. As the heel platform retreats into the midsole it compensates, allowing for balanced contact of the heel. As the mid-foot and forefoot make contact with the ground at an equal and flat plane. This action with the addition of the insole, allows for the wearer to make proper transfer of weight through the metatarsals 1st-5\textsuperscript{th}, loading the 1\textsuperscript{st} MPT (Metatarsalphalangeal Joint)(2, 11, 25, 26), Sesamoids(2, 11, 25, 26), and Hallux (2, 11, 25, 26) and releasing out of the distal end of the phalange which is widely considered the ideal method of weight transfer and release in the human foot. As weight is transferred forward, the heel of the wearer is propelled up and forward by the springs.
3.1 Walking and Standing

Walking and Standing play a major part day to day activities that most of the population will perform with ease and experience little-to-no discomfort. During these actions we rarely take into consideration the duration and quantity of impact force on the human body. During the walking phase of the gait cycle, the human body is exposed to 1.5 to 3 times the body weight of the walker (1, 10, 12, 20) This significant pressure increase on joints, tissues, and alignment of the body will cause changes and alteration in functionality. This can and often does lead to the experience of pain, discomfort, and medical pathologies in a prolonged period of time. (6, 10, 12) Walking is an essential factor in maintaining or achieving good overall health. The benefits of walking have shown to be as basic as movement function but may greatly increase life span.

*Graph or Table from one of the noted sites
Gravity Defyer shoes promote walking and all the benefit attained by it. These benefits are enhanced by individuals wearing Gravity Defyer shoes in different areas. As illustrated in the image above, the natural gait cycle of the human body is very complex. There are points in the gait cycle where the human body has loaded the entire mass of the body on to an area as small as just the forefoot or toes. As we take a step our weight shifts and our legs and arms counter balance each other and our body to maintain an upright position and allow us to continue to transfer and move our bodies forward.

When we are transferring our weight we will initially load the heel or calcaneus with our entire weight. Gravity Defyer shoes reduce the impact of this weight from the ground on the calcaneus. As the weight compresses the springs the sole absorb the impact of GRF and dissipates it. The remaining impact force that does transfer up the body is again reduced by the cushioning provided by Gravity Defyer shoes’ Polyurethane insoles. By maintaining the alignment of the body throughout the gait cycle an individual will experience greater comfort, and ease of movement.

There is the benefit of the spring return or rebound effect. This is the amount of lift or bound a person will experience during heel lift or calcaneus propulsion. After each heel strike the spring system compresses, as the side walls also move into the heel and the GRF is reduced the springs load and release with the calcaneus. This sends the force up, assisting the foot and body by minimizing the amount of muscle activity and energy needed to propel the foot and leg forward. This reduction in muscle use allows for long walks and increased distances. The benefits of these results have a great effect on the physical body as well as the mental and emotional state of a person. The value of the confidence and improved results is hard to quantify for the person and their overall happiness.

3.2 Standing
When in a static posture the human body is designed to work as a loaded structure. (1,3,6,7,23) The entire mass of the body is loaded on the feet. The position or posture of the human musculoskeletal has a direct relation to the gait. Without proper posture or alignment the duration of static positioning will cause physical stressors throughout the body. Posture and positioning of the body is vital when considering conditions and pathologies that affect the structure. (4, 5, 6) Various conditions become apparent when in the static or standing position and are often experienced by the individual. Some common conditions often experienced by the majority of the general public are compression of the joints, pooling of fluids, swelling and aching, and at times numbness or tingling. These are all results of prolonged pressure on the body, specifically from the lower lumbar (back) down to the feet.

Initially Gravity Defyer shoes were designed to address the GRF experienced when walking on hard surfaces. The result of the trampoline concept when applied to standing has proven to provide great benefits to any wearer in the shoes. The amount of energy expended by the body to stand greatly strains all the muscles that hold the body in the standing position. (4, 27, 28)
Considering that fact the fatigue that sets in will eventually start to diminish the ability to hold the position in place and the amount of time the individual will be able to stand its important to allow or provide an area where they can stand with minimal amounts of contact force. We can easily deduce this by applying basic ideas and principals of alignment. (4) If a person considers that an individual standing on what is commonly known as anti-fatigue mat reduces and prolongs the duration of time that individual can remain in a standing position. (13, 14, 21, 23, 24) These mats use polymers that cushion the contact force (Contact force is the force exerted by the ground on a person’s body while in a static or standing which is equal to the individual’s weight being exerted onto the ground) and allow the standing body to increase the amount of time standing. It is reasonable to consider that the benefits received will greatly decrease the discomfort and reduce pain where conditions that cause pain exist.

A person wearing Gravity Defyer shoes will experience the ability to load fully on the calcaneus with proper alignment of the body. This is accomplished by the way the spring system interacts with the body. First they compress with the mass of the body loading directly above the springs. This gives the person the benefit of reducing the load impact on the body, joints, and the musculoskeletal structure. Because the impact is compressed in the springs and not the body, the body will not have to expend energy, muscle activity or compensate for position allowing the person to remain standing for longer periods of time. Persons having previous conditions affecting the body including, pathologies, and non-standard human development perhaps have the most to gain. (4, 7, 11, 19) Gravity Defyer shoes address alignment by first compensating for weight shift or imbalance. For example, if an individual has an overly pronated alignment of the calcaneus or inversion of the calcaneus, (19) the spring will compensate for the improper distribution of weight. (4) This correction will allow for a more balanced stance allowing the loading of the entire structure to hold a neutral posture for a longer period of time. The heel counter of the shoes and PU insole assist by keeping the entire foot in place. It redistributes the weight from solely on the heel to the arch and mid-foot area. (16) This again allows for less strain on joints, improved circulation and reduced muscle fatigue.

3.3 Impact Force
Contact force is the force exerted by the ground on a person’s body while in a static or standing which is equal to the individual’s weight being exerted onto the ground. (14, 15, 18) Contact Force is paralleled to Ground Force Reaction. (1, 9, 21) GFR is itself defined as the return of energy or force from contact with the ground surface on the body more likely applied when walking. (7,) The effects of these forces have a direct effect on the soft-tissue and skeletal components of the human body. The impact forces cause oscillations in the wobbling structures of the body, leading to instability, overcompensation, and variation of the natural frequencies in the musculoskeletal gait cycle. Studies show the firmness or rigidity of the soles of shoes directly factor into changes in the time of peak impact force. Changes or adaptations in the muscles to reduce the resonance of the impact wave haven’t conclusively ruled out soft tissue vibration within the muscle. (9, 12, 14, 15)
Illustrations • A. Peak Impact forces during the Gait cycle.
• B. The duration (shockwave) of impact force during Gait cycle.
• C. Ground Reaction force relative to Gait cycle.
4. Generalized Pain, Fatigue and Other Pathologies

4.1 Fatigue

Fatigue is a lack of energy or exhaustion of the body or mental state caused by stress. Fatigue can be considered an accumulation of multiple factors having to do with specific sources which can lead to an eventual breakdown of the individual whether physical, mental or both. In the area of prolonged standing, shoes can be an important and intricate part of reducing or enabling these stressors. (11, 19, 23) Often in the standing position the alignment of the body is the principal cause of muscle fatigue. The misalignment of the structure or bones place added stress to the muscles to hold the structure in place. Prior to the muscle system exhausting all energy there will be indicators such as soreness, aching, and simple adjustments to positioning. This is to allow a break in the stress on the muscle. (11, 19)

Gravity Defyer shoes address fatigue by acting as a load moderator and allows the musculo-skeletal system to remain relaxed for a longer period than other footwear.
4.2 Pathologies

The human body and feet are susceptible to certain specific medical conditions from prolonged walking or standing. Not all pathologies or conditions are caused by this action but the existence of them will greatly reduce or impede one's ability to perform basic necessary actions with great discomfort if at all.

4.2.1 Heel Pain

Heel Pain is or can often be attributed to 3 main sources.

4.2.1.1 Over Use

Over use of the general area afflicting the immediate and surrounding tissues and nerves. Constant use leads to inflammation of the tissues while applying pressure on the nerves leading to the uncomfortable feeling of pain. The constant inflammation of these tissues can lead to damage, sometimes permanent.

4.2.1.2 Plantar Fasciitis

Plantar Fasciitis is the tightening of inflamed thick tissues on the plantar area of the human foot and tissue. This can be a very debilitating condition which requires time to heal. Common corrections include stretching, icing, orthotics, and proper shoes. Often people in extreme cases will be given cortisone to numb and reduce the pain on the inflamed tissues and nerves. (9, 10, 24, 25)

Gravity Defyer shoes help alleviate PF in 3 basic ways. First is by reducing the pressure being applied to the inflamed area. This is accomplished by the absorption of pressure to the specific area. The trampoline system will compress into the sole of the shoe diminishing the GRF on the wearer. The second benefit is that the wearer will experience some stretching of the Plantar Fascia tissue. The stretching will give some relief because the tissue is expanding and contracting. The actions of these types of movement promote healing of the inflamed tissues. The third benefit from wearing Gravity Defyer shoes to an individual with Plantar Fasciitis is the support of the arch. This is a benefit because at times the cause of the PF is that the anterior and posterior tibial tendons are not supporting the arch and allowing for movement. Gravity Defyer
PU insoles support this structure and reduce the amount of movement in the arch and pressure on the calcaneus. This support of the arch will also stretch the Plantar Fasica, again promoting healing of the inflamed tissue.

4.2.1.3 Heel or Bone Spurs

Spurs or bone spurs are conditions that can be helped by Gravity Defyer shoes. When a person with this condition takes a step, the heel is the initial point of contact. (9, 10, 24, 25) Unfortunately for the individual this is area of the foot being effect. In Gravity Defyer shoes this impact is reduced and distributed through-out the shoes as the trampoline system absorbs the pressure and impact while not transferring it to the calcaneus or heel. This also allows the individual to walk without an altered gate. This condition is helped by the PU insoles of the shoe. The soft PU offers additional cushioning not found in other shoes as well as an arch support. The arch support in the insole partially fills in the arch and helps support the structure. The support given to the arch reduces the amount of pressure that will be loaded on the heel. The heel or calcaneus will no longer be loaded fully. This is a direct and distinct benefit and feature other shoes could not offer a person dealing with spurs.

4.2.4 Lower Back Pain

Lower back pain is one of the areas of the body where various factors come into play. When an individual is experiencing back pain the origin of the pain can come from a combination of functioning parts or from one of the components of the back. Understanding this can help narrow down the choices of the cause. The lower back is composed of the vertebra, disc, nerves, sacrum and soft tissues. Each individual area may be the cause of discomfort or areas may work in conjunction with the fore mentioned associated part.
Common Pathologies of the back are considered to be lumbar strain, trauma or injury, disc herniation, nerve compression or pitching, and or arthritis. The conditions are all addressed with consideration of each individual part. (9, 10, 24, 25) Most can and are reduced in pain severity by the simple act of reduction of pressure of the entire area.

Gravity Defyer shoes have assisted in providing aid to sufferers of back pain. The ability to align the body into a neutral corrected and load bearing position allows the back to reduce strain on the area. Gravity Defyer shoes do this by first loading all pressure and weight on the trampoline system where the calcaneus rest. The adjustment and correction of the springs for weight displacement or unbalance help stabilize the body and allow for proper lower body alignment. Once the calcaneus is in a neutral position the talus, tibia, fibula, and femur all align above them. By properly having the lower limbs aligned the pelvis region will also load and align with the lower limbs. This correction of posture will lead the sacrum and lumber vertebraes 1-5 to align directly above. With this change the pressure and strain on tissues, nerves and muscles is reduced.

4.2.3 Hip Pain
Hip pain is typically considered to be an advanced age condition. (9, 10, 24, 25) Today we are finding that hip pain is not always a result of aging but may also be caused by wear and tear on the hip joint and the surrounding tissues. The more common issues are muscle strain, tendonitis, arthritis pain, and snapping hip.

In general these conditions are created by constant use of the specific tissue, muscle or area due to misalignment or over use. (9, 10, 24, 25) In all aspects of these conditions the discomfort from the pain can lead to more serious issues if not addressed. Gravity Defyer provides the reductions of the symptoms by allowing for better movement without pain, improved alignment of the area and body, and condensing the pressure and strain being applied by use in the misaligned position.

This again is achieved by the use of the trampoline system balancing the foot into the neutral position. Once the alignment of the position is corrected, the pressure and strain are relieved on the tissues and allows tension on the muscles to be relieved. By absorbing the impact of GRF on the body and joints the hip is allowed to load and flex with greater ease and minimal compensation. The added benefit of improved muscle efficacy and reduced activity frees the area of over use.

4.2.3 Sciatica

Sciatica occurs when there is pressure or damage to the sciatic nerve. (9, 10, 24, 25) This nerve starts in the lower spine and runs down the back of each leg. It controls the muscles at the back of the knee and lower leg and provides sensation to the back of the thigh, part of the lower leg, and the sole of the foot. Sciatica pain can vary widely.

It may feel like a mild tingling, dull ache, or a burning sensation. In some cases, the pain is severe enough to make a person unable to move. This pain most often occurs on one side. Some people have sharp pain in one part of the leg or hip and numbness in other parts. The pain or numbness may also be felt on the back of the calf or on the sole of the
foot. The affected leg may feel weak. Sciatic pain often starts slowly and may get worse, commonly after standing or sitting, at night at rest, when sneezing, coughing, or laughing, and when bending or walking more than a few steps. Gravity Defyer shoes take the pressure off the low back area where the sciatic nerve is often affected. By adjusting the posture of an individual with the self-adjustment of the trampolines in Gravity Defyer shoes, a person can reduce the strain on the sciatic region, the lumbar region or alter pelvic miss alignment. The improvement of body, lumbar, and limb positioning accompanied by the relief of tension of the muscles surrounding the sciatic nerve relieves the compressed nerve. As a result, pain relief allows the individual to resume day-to-day activities with minimal discomfort and great mobility.

### 4.2.3 Pain Associated with Aging
The human body grows and ages. Joints form the connections between bones. They provide support and help you move. Any damage to the joints from disease or injury can interfere with your movement and cause a lot of pain. Many different conditions can lead to painful joints, including osteoarthritis, rheumatoid arthritis, bursitis, gout, strains, sprains, and other injuries. Joint pain is extremely common. In one national survey, about one-third of adults reported having joint pain within the past 30 days. Knee pain was the most common complaint, followed by shoulder and hip pain, but joint pain can affect any part of your body, from your ankles to your shoulders. As you get older, painful joints become increasingly more common.

![Figure 4](image.png)

**Figure 4**
Percentage of subjects experiencing pain for the past 12 months
A study performed by the University of Malaya, (18) showed that the older a person is, the greater the impact or contact force is on the body. Over a period of 12 months it was found that subjects older than 40 years of age experienced a great number of areas of discomfort or pain as compared to the subjects that were under 40 years of age during the simple act of standing. The percentages of actual pain severity also varied, the older subjects experienced anywhere from 25 to 75% more pain than did the younger subjects. This is leads us to speculate that an average person with minimal to no persisting conditions would likely feel pain and discomfort in the areas of most use during walking or standing. The causes may vary, but constant and prolonged activity generally acts as the primary catalyst.

The use of Gravity Defyer shoes for the older age demographic can be a source for freedom and a continuance of a lifestyle that is more active. With the propulsion and reduction of impact forces the elder user would feel less discomfort and have more energy to be able to walk and stand. With the population of the US and the world as a whole living longer Gravity Defyer shoes are a vital tool to freedom and movement. The benefits an individual can receive are limitless, including an addition of more years of active lifestyles without pain.

If Gravity Defyers shoes assist in the alignment of the posture and position of the body to reduce pressure and fatigue, one can conclude that a person would benefit by wearing these shoes for non-specific joint pain as well. When wearing Gravity Defyer shoes, the correction of positioning in the skeletal structure will reduce the wear on joints. This is accomplished by the body’s natural designed to use the joints in their
intend position and not out of misalignment. The trampoline system and its corrective capabilities create the corrective action necessary to pretend and alter the over use of the joints.

5. **Product Comparisons**

There have been previous attempts at creating and using a spring or coil system in a shoe that will provide a benefit to the wearer of the shoes. The more common or known brands are Spira, Z-coil, and the Novel Spring Boot. As a spring shoe, their engineering data and customer testimonials provide support to the claims both mechanical and anecdotal.

The mechanical properties of these indicates that the category of biomechanical spring shoes offers a reduction of GRF at heel strike of up to 19% with an energy return of up to 87% adding to forward motion.

5.1 **Novel Spring Boot**

Novel Spring Boots were tested and compared to an average shoe on the market. After testing on male and female subjects it was found that there was a reduction of the impact when running on the wearer. There was found to be an adjustment to the impact cost of the lower extremities when wearing the Novel Spring Boot products. (27). This Novel Spring Boot allowed the body to reduce the GRF, concluding that there is a direct benefit in wearing a shoe constructed to absorb or diminish the force of impact. The actual benefit to the body would potentially include fewer injuries to the calcaneus (fractures, spurs)(21,23), tissue damage (plantar fasciitis, Achilles tendinitis) (21,23,24), and structural impact (posture, alignment) (4,10,17). With this as a baseline, we can see that the concept of the spring shoe can have a direct benefit to the wearer.

5.2 **Z-coil**

Z-coil shoes are the shoes most often associated with a spring system. The design of a Z-coil is a shoe in the Plantar Flexed position with a 3-5 in high spring in the heel of the shoe. This shoe is designed to reduce the impact of force on the body while also equalizing the pressure on the total foot area. (28) When these shoes were tested it was found that the shoes do reduce the amount of pressure from primary impact. The effect was not conclusive for fast walking. The percentages demonstrate that there was 20% less loading of the runners during their gait cycle. This also resulted in a benefit to excessive pronation or supination. (10,24,28,29) Studies provide positive results. CSULB found that maximum mean pressure was lower by 18% in a standard gait velocity. The maximum force was reduced by a range of 13-19% in a fast velocity gait cycle. The actual benefit that could be applied to the human body from this report is that, GRF is
not causing the usual amount of damage and impact wave throughout the body as it does when wearing a standard brand of shoes.

5.3 Spira
Spira designed a shoe that placed aluminum springs into the heel and the forefoot areas of the midsole. This was accomplished by tooling into the EVA base midsole. Once the area was cleared out, a plastic bottom cover was placed into the sole. This plastic was molded to hold the springs in place with determined spring molds. With the springs in place, an additional top plastic was placed on the midsole, which is then covered with the innersole of the shoe. The design was to absorb the impact on the heel as well as on the forefoot, which was named Wave Spring Technology. Spira shoes and their Wave Spring technology studies were performed by Michigan State University, College of Engineering and Laboratory. The purpose of the study was to identify if there was an actual impact reduction of GRF on the human foot when walking and or jumping. In the report it was found that 20% of the body weight impact of an individual was reduced. The spring system also returned 87-96% of the energy to the wearer.

5.4 MBT
MBT shoes or Rocker bottom shoes are shoes designed with a rolling or rounded sole. This sole is designed to extend from the heel or calcaneus through to the distal end of the phalanges or toes. The difference with MBT produced shoes is that in the heel of the sole, there is a cushion pad or celon pad that absorbs the impact force and transfers it through the sole. This allows the wear to experience a reduction in joint pain and GRF issues. In a case study it was found that MBT shoes help reduce the impact force and pain on wears with knee joint arthritis. There was a reduction of 16.6% in the first 3 weeks (30, The effectiveness of MBT shoes...) and a total of 25.6% by the end of the 12 week study (30). There was also the additional benefit of strength increase in the lower leg muscles, improved balance and performance, and duration of workout periods. The only group that did not see the same results was the group that was obese or overweight. For this group the reduction was minimal, resulting in the continued effects of Osteoarthritis of the knee.

Though these three shoes (Novel Spring Boot, Z-Coil, Spira and MBT) differ in construction and application, it is clear that the results would be quite similar and validate their potential medical application. By reducing the force that cause pain, activating and deactivating muscle groups, and maintaining body alignment through balance and posture people can greatly benefit by wearing Gravity Defyer shoes. Shoes such as Gravity Defyer offer a mechanical advantage over standard shoes. They are biomechanically engineered for the reduction of pressure, control of the foot, and maintenance of proper alignment of the lower body benefits can be easily achieved by the wearing of the shoes alone.
6. Conclusion

Results from individual are the best gage for understanding if a product is working or not. Gravity Defyer shoes pass the eye test on comparison to the average shoe and direct competitor feature shoes on the market today. The concept of designing a shoe with biomechanics of walking and the effects of static positioning on the body greatly change what and how shoes should be made. Gravity Defyers shoes have jumped ahead of the typical shoe platform and are changing the way we see functional shoes today. Changing what a person feels and how their foot, leg and body move during the gait cycle is an undertaking that can only be achieved by creating a product that actually works and is beneficial.

Gravity Defyer shoes address a majority of conditions that the average person experiences and will face when standing or walking. If this shoes and company continue to provide the results that they currently offer the wearer, the shoe industry will have to change how shoes are designed and developed.

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