This article is a round-up of current published literature, peer-reviewed research, white papers, posters and studies that deal with causes, prevention and treatment of pain and injuries. It also evaluates and compares known interventions to SmartCells cushioning technology.

A Stable Cushioning Foundation Results in Higher Performance, Improved Productivity and Injury Prevention

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When workers are in pain, they are less productive.

Similarly, when active people, who are looking to improve performance and health, are injured or in pain, they can see their performance suffer.

For frail, at-risk folks who are most vulnerable to fall-related injuries, a fall that results in a broken bone may be a life-altering event.

The one constant among these diverse populations (workers, athletes, frail and vulnerable) is the unavoidable result of impacts stemming from the Earth's gravitational pull also known as Ground Reaction Force (GRF) -- contact with the ground. For some, it may only take a single fall to change their life. For most, contact with the ground occurs repetitively and over time, and as GRFs accumulate, so do the associated injuries, and their costs.

Injuries that are associated with GRFs are common, including: Sprains, strains, stress fractures, anterior cruciate ligament (ACL) tears, Patella dislocation, Meniscus tear (knee), bursitis, cysts, Sciatica (lower back), patellofemoral pain syndrome (AKA runner's knee), iliotibial band syndrome, patellar tendinopathy, plantar fasciitis, Achilles tendinitis, and calf-muscle strains, and osteoarthritus (OA) in the knee (the most common joint disorder in the United States).

Some activities can further increase GRFs.

Activity	Increase in body weight across the knee
Cycling	1.2 x
Walking	3.5 x
Stair Climbing	5-7 x
Squat /. Jumping	7-10 x
Running	15 x

Fortunately, properly designed products, as well as lifestyle interventions to off-load GRFs are successful. For example, losing only 10 pounds can reduce the risk of future knee OA by 50 percent. It is estimated that for every pound you lose, you remove about 4 pounds of stress from your knees. So, individuals who lose 10 lbs. would be subject to a total of 48,000 less pounds of pressure for

every mile walked. Physical therapy plays a critical role in the non-operative treatment of knee OA.

Not only are the cumulative medical costs high for dealing with GRF-related injuries but the financial impact on business is high as well. The medical costs alone for treating GRF-related injuries exceeds $300 billion per year in the U. S. In addition to direct and indirect medical costs, the financial impact to business of lost productivity from common on-the-job pain conditions among active workers, including back, knee and foot pain, costs an estimated $61.2 billion per year, with total work and injury cost exceeding $150 billion annually.

Data clearly suggest that the risk and burden of occupational lower-extremity injuries are high and that these injuries may have long-term adverse effects.

While there are many factors that affect GRF-related injuries -- BMI (Body mass Index), type of shoe, gait, strength, biomechanics, age, gender, overuse of joints, bone density, muscle weakness, joint laxity, static and repetitive movements, inactivity etc. -- pain and injuries are easily predictable outcomes of repetitive GRF's. The effects of this micro-trauma are cumulative and while they are clearly seen to increase injury risks as populations age, they are now being measured at younger and younger ages. As an example, up to 27 percent of runners in the U. S. Army report an overuse injury.

More than just feeling pain; it's about living. 41% of those experiencing pain during the last year indicate that the condition has interfered with their activities of daily living (ADL).

What to do? It's all about prevention.

The research community generally agrees that there are two categories of intervention that can effectively blunt the accumulative effect of GRFs on the body that may interfere with higher performance, improved productivity and safer environments:

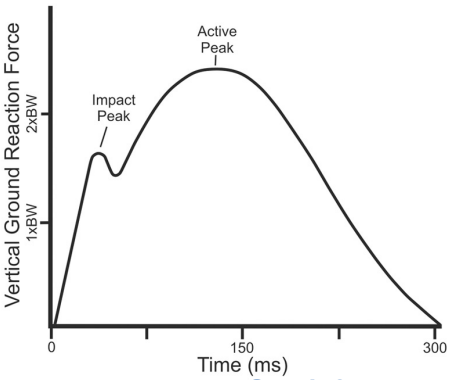
1. Reduce GRF
2. Stabilize gait

<u>Reduce GRF</u>

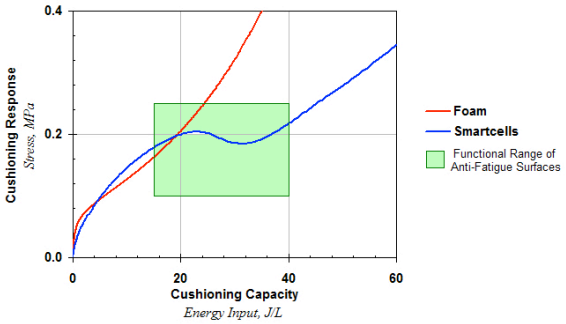
Impact-shock absorption is the key to minimize / reduce damage to soft tissue, connective tissue and bone structure.

Reducing GRFs has been clearly shown to prevent pain and disability. Various published studies indicate that peak pressure on plantar surfaces of the foot, lower back, and knee can be significantly reduced when utilizing appropriate materials and technologies. Conversely, the lack of reducing GRFs is noted as an obvious contributor to lower extremity pain and injury.

Initial contact with the ground is usually with the foot. There have been many (inconclusive) studies about the results of various foot strikes by runners -- heal first, toe first -- but the greatest take-away is that the impact forces through the foot accelerate and are transferred upward, throughout the body.



Graph 1



Graph 2

Graph 1 shows how typical forces applied to the foot, which is the only part of the body in direct contact with the ground during the gait cycle, initiate and increase the shock waves passing through the body during running.	*Graph 2 shows that within the typical activity range, as GRF load increases, the capacity to absorb the load <u>increases</u> with SmartCells cushioning, which results in lesser GRFs on the body.* *Within the typical activity range, as GRF load increases, the capacity to absorb the load <u>decreases</u> with foam-based cushioning, which results in greater GRFs on the body.*

** "At all compression levels in the functional range, the energy absorbed by the SmartCells structure is greater than that of the conventional surface material [foam]. On average, through the functional range, the energy absorbed by the SmartCells structure, per unit volume, is more than five times greater. Thus the subject structure has a substantially higher capacity to absorb impact energy...[SmartCells] achieve a surface that softens or buckles under load, while maintaining stability for walking on the surface under non-impact conditions." DECLARATION OF MARTYN SHORTEN, Ph.D. UNDER RULE 131(b), USPTO Filing*

National Athletic Trainers Association Hall-Of-Fame inductee, and 25-year former athletic trainer for the Seattle Seahawks National Football League team, Jim Whitesel, sums up this relationship between foot impact GRF and other injuries perfectly. "When you provide a stable cushioning foundation for the rest of the body (feet), you avoid injuries that will migrate through the ankles, knees, hips, back, neck and shoulders".

Stability (gait)

Overuse, *muscular fatigue* and *poor body mechanics* are the "Big 3" when it comes to lower extremity injuries caused by GRFs, but there is more to consider than cushioning alone. Pain and injury make us move differently, causing us to modify the way we walk or run, "tweaking" our normal biomechanics which resonates throughout the body. There is plenty of evidence that this *gait impairment* increases injury risk during locomotion (walking, running), including fall-related acute injuries as well as overuse damage to lower limb joints.

The urgent challenge is to find dual-purpose standing, walking, running surfaces that are optimized for BOTH maximum cushioning **AND** stability that will prevent gait disorders. Additionally, it needs to be cost effective as well as easily and willingly utilized.

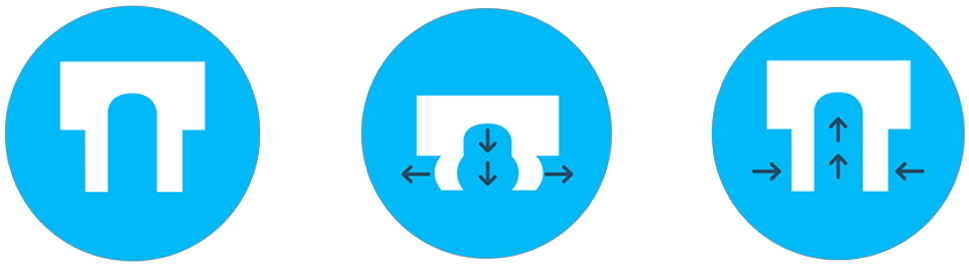
SmartCells

Softer is not better.

Most surfaces used to attenuate GRF tend to be thick, soft and squishy, or so thin as to be of limited functional use as a cushion. There is a direct correlation between the height of a material and its effectiveness to cushion, referred to as the densification strain. Generally this means that if a material compresses more than 50% of its height it will tend to act as though it is bottomed out, becoming hard (losing its ability to compress) and less and less able to cushion as pressure / force is increased. To accommodate for this, a typical cushioning material, like foam, must become thicker and thicker, which leads to instability, akin to standing on a mattress. Similarly, gel just squishes to the side with only limited ability to cushion, and is also entirely unstable. Like a domino effect too much instability causes muscular fatigue, which causes changes in body position and gait, which leads to changes in body biomechanics, which leads to pain and injury. A material that starts out thin (like foam or gel in an insole) has very little height to compress, especially as it wears out from repetitive use, and therefore has only a short life of very limited cushioning.

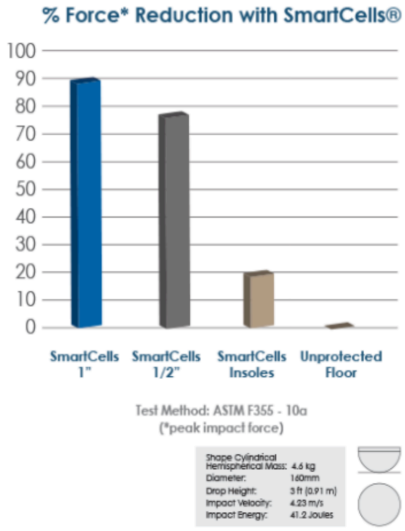
Consider SmartCells Cushioning.

The SmartCells rubber structure has been optimized for human performance and reacts the exact opposite of foam and gel. Where foam becomes harder as it is compressed, SmartCells become softer as they are compressed. As the stable surface of SmartCells receives increasing pressure or force, the walls of its cellular structures soften and collapse. Designed for the typical range of normal human activities, the greater the force, the softer it becomes.



Consider SmartCells Stability.

When surface pressure is reduced or eliminated, the dynamic SmartCells structures actively “push back” with a resilient upright force, like miniature springs, as they return to their stable, supportive resting state, working “in phase” with body movements, and returning their stored energy.



SmartCells insoles, mats and flooring offer between 20% - 90% reduction in GRF, with measured stability that is statistically indistinguishable from a standard, rigid floor.

SmartCells products range in thickness and cushioning capacity, but all SmartCells solutions are designed to:

- Significantly reduce GRF for their application
- Become softer as compressed
- Not bottom out
- Respond to movement with resilient and dynamic functionality
- Provide a stable standing, walking, running, impact surface that will not affect gait
- Last a long time
- Help with infection-control issues

SmartCells solutions:

- Custom and standard-sized Anti-fatigue Mats, Runners and Flooring
- Fall Protection Flooring

- Performance Training Mats and Flooring
- Insoles for various applications

For more information please contact…

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DOI 10.1186/s13047-016-0176-z
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