The Versatile Benefits of Body Core Strengthening with HITS® Technology - a Review

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ABSTRACT

Body core strengthening is essential for maintaining musculoskeletal health, particularly in the lower back and pelvis, and for preventing lower extremity injuries. Core muscles play a central role in core stability, which is the ability of the lumbopelvic hip complex to resist collapse and regain balance. Core strengthening is a vital component of therapeutic exercise programs, including aerobic, anaerobic, and resistance training, all of which improve muscle strength and endurance. Since neuromuscular magnetic stimulation has proven to be an effective alternative to physical training programs, the HITS® method of core strengthening offers promising potential in clinical settings, providing a new therapeutic approach to treating a variety of musculoskeletal problems.

I. INTRODUCTION

Body core strengthening offers numerous benefits for the musculoskeletal system, including supporting lower back and pelvic health, increasing core stability, and reducing the risk of injuries to the lower extremities. Consequently, physical therapists, athletic trainers, and musculoskeletal researchers are highly focused on the development and upkeep of core stability. Core stability refers to the ability of the lumbopelvic hip complex to resist collapse and quickly regain balance after a disturbance. While static structures like bones and soft tissues play a role, core stability is primarily driven by the dynamic action of muscles.

a) Body Core muscles anatomy

The core muscles are a group of muscles in the trunk that support the spine, stabilize the body, and facilitate movement [1]. Key core muscles include the rectus abdominis (front, "six-pack" muscle), transverse abdominis (deep abdominal layer for stability), abdominal oblique muscles (internal and external, for twisting and side bending), erector spinae (back extensors), diaphragm (for breathing), and the pelvic floor muscles [1]. Gluteus and hamstring muscles also contribute to core stability [2]. Core muscles are crucial for maintaining posture, balance, and protecting the spine during physical activities. A strong core enhances athletic performance and reduces the risk of injuries.

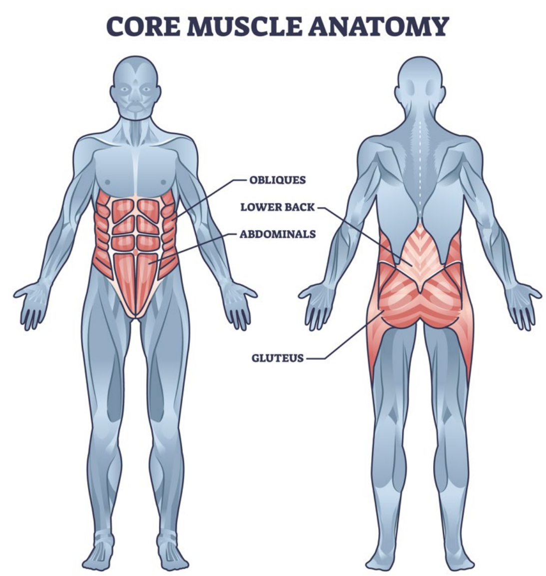

Figure 1. Anatomic diagram of body's core muscles

b) Body Core function

The body operates as an integrated system, where different layers of muscles, fascia, and connective tissues work together to produce movement [3]. Muscle contractions create motion, with extremities moving freely away from the trunk, while the core anchors the body. This anchoring occurs through the proximal attachment of muscles in the trunk or limbs, enabling the body to function as a unified unit. Movement in one part of the body affects other areas, as forces generated by muscle contractions travel both distally and proximally. Key areas of force transition include the spine, pelvis, and hips. For example, when force is generated in the lower extremity, it travels upward through the trunk, providing stability by securing the position of the core. Additionally, studies show that the core muscles contract before limb movement to stabilize the trunk and spine, facilitating smooth energy transfer between limbs and trunk. This is central to the concept of the kinetic chain theory [3], which explains the connection of muscle activation and force translation within the musculoskeletal system.

The core muscles are considered the centre of the kinetic chain [4], as they initiate motion and stabilize the spine and abdomen. During this process, the abdominal and back muscles contract to stabilize the trunk before and during locomotion, enabling efficient force transfer. In a well-functioning system, there are no weak points where forces can be lost due to instability or weakness. However, a weak core creates an imbalance, leading to compensations by other muscles. In athletes with a weak core, muscles outside the kinetic chain work harder to compensate for the lost stability, often resulting in increased strain and risk of injury. These issues are evident in cases of extremity pain or low back pain, where dysfunction in the kinetic chain can lead to decreased postural control, proprioception, and overall movement efficiency.

The core also has a built-in neuronal protection system that helps control muscle firing patterns and maintain proprioceptive feedback about body position. Before any limb movement occurs, the core, particularly the transverse abdominis and multifidi, contracts to stabilize the trunk and prepare for motion. These muscles contract first, increasing intra-abdominal pressure and tightening the thoracolumbar fascia, which provides stability to the lumbar spine.

The active, muscular elements of the core contribute to the stability of the system through three mechanisms: intra-abdominal pressure, spinal compressive forces (axial load), and hip and trunk muscle stiffness. The contribution of intraabdominal pressure to core stability is primarily a consequence of abdominal muscle activity [2]. However, simultaneous contraction of the diaphragm and pelvic floor muscles also raises intraabdominal pressure and increases global trunk stiffness [5].

The body core regulates internal pressure changes in the thoracoabdominal-pelvic cavity and modulates its volumes and shape. This function of the core not only underlies breathing and postural control but also a range of other functions e.g. functional expiratory patterns - vocalization, singing, laughing, sneezing; and acts of elimination - coughing, nose blowing, vomiting, defecation, birthing etc.; while also maintaining continence during impact activities like running and jumping [6].

c) Body Core dysfunction

When the core is weak or lacks endurance, motion becomes inefficient, and power generation is reduced, increasing the risk of injury. A disruption in the kinetic chain results in delayed or improper activation of core muscles, causing compensatory firing from other muscle groups. For example, individuals with low back pain often experience inhibited activation of the multifidi and transverse abdominis. In healthy individuals, the transverse abdominis contracts first, stabilizing the trunk to prevent unwanted movement and facilitating energy transfer through the kinetic chain. However, in those with low back pain, the transverse abdominis may activate too late, leading to disrupted movement patterns and inefficiency in force transfer.

A strong, balanced core is not only crucial for the kinetic chain but also for providing stability to the spine, pelvis, and sacrum. It supports the spine, gives the postural control to counteract gravity and balance while at the same time, also co-coordinates important functions such as breathing and continence [6].

d) Body Core muscle training

For healthy people, core muscle training is theorized to improve sports performance by enhancing the stiffness of the trunk, thereby providing a platform that enables greater torque production in the upper and lower extremities [7]. The main purpose of basic core strength training is to increase stability and to gain coordination and timing of the deep abdominal wall musculature, as well as to reduce and prevent injury. Core training seeks to coordinate the kinetic chain (muscular, skeletal, and nervous systems) to enhance the synergism and function of the core musculature.

i) Muscle Strength and endurance

Training the core for an emphasis in strength would include high load, low repetition tasks, while endurance enhancement requires longer, less demanding exercises [1]. When the core is conditioned with both strength and endurance, spinal motion is better controlled, reducing excessive shear forces and preventing injury[8]. Proper control of segmental motion allows for more powerful, efficient movement, with energy smoothly transmitted from the core to the limbs. This coordination improves athletic performance and reduces the likelihood of joint dysfunction, ultimately making the body more resilient and less prone to injury [8].

ii) Endocrine muscle function

The importance of regular physical activity to prevent and treat chronic and degenerative diseases is widely accepted [9]. The active skeletal muscle and the maintenance of muscle mass are essential for good health, wellness and disease prevention and treatment. Among the beneficial biological effects of physical exercise is the recently [10] documented endocrine muscle function. Exercise stimulates the release of proteins with autocrine, paracrine, or endocrine functions produced in skeletal muscle, termed myokines. Based on the current state of knowledge, the major physiological function of myokines is to protect the functionality and to enhance the exercise capacity of skeletal muscle. Myokines control adaptive processes in skeletal muscle by acting as paracrine regulators of fuel oxidation, hypertrophy, angiogenesis, inflammatory processes, and regulation of the extracellular matrix [9].

e) Body Core muscle stimulation with HITS® technology

HITS® stands for High Intensity Tesla Stimulation. HITS® employs a rapidly changing magnetic field to stimulate peripheral nerves and trigger repeated contractions of the skeletal muscles [11].

HITS® is available in Fotona's StarFormer® magnetic stimulation devices, enabling the stimulation of several body regions during the same sessions using either handheld applicators, or applicators embedded in the IntimaWave® magnetic chair. IntimaWave® chair is unique in having the applicator embedded in both the chair's seat, enabling stimulation of pelvic floor, and backrest, enabling the stimulation of back muscles.

Figure 2. Fotona's StarFormer® magnetic stimulation device with IntimaWave® chair**.**

With the CoreRestore™ program, handheld applicators are held in place of the patient's abdomen while the patient sits on the IntimaWave® chair [11]. This allows all components of the core - the pelvic floor muscles, back muscles and abdominal muscles to contract during a single treatment session, effectively strengthening and stabilizing the body's core. This is enabled by the system's Quattro™ modality, enabling treatment of up to 4 body regions at the same time. For smaller patients, a single applicator in addition to the IntimaWave® chair is used, while for larger patients, two applicators or a single extra-large applicator are placed on the abdomen.

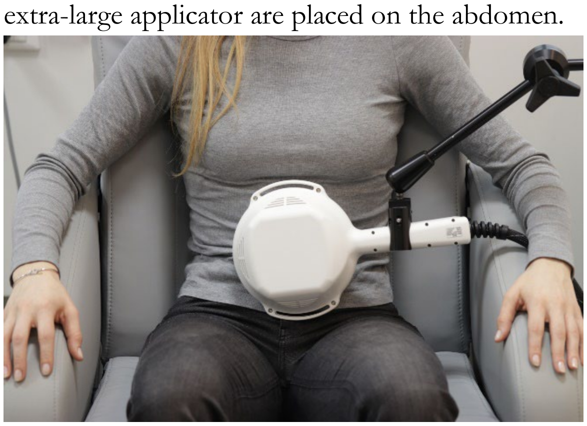

Figure 3. Body Core Strengthening with HITS® Technology - CoreRestore™.

II. REVIEW OF CLINICAL STUDIES

Available clinical studies demonstrate the benefits of Body Core Strengthening in various clinical fields. Below we summarize the role of Body Core strengthening in a) Physical fitness, prevention, and rehabilitation of injury, b) Low back pain, c) Pelvic floor dysfunction and d) Inflammation.

a) Physical fitness, prevention, and rehabilitation of injury

Core muscle strength is an important prerequisite for several sport (e.g., running, climbing, soccer), and everyday activities (e.g., sitting, standing, walking in an upright position). As the core functions as a kinetic link that facilitates the transfer of torques and angular momentum between the lower and upper extremities, it is of vital importance for sport-specific and everyday activities in different age groups. The core serves as a muscular corset that works as a unit to stabilize the body and spine, with and without limb movement. A comprehensive strengthening or facilitation of these core muscles has been advocated as a way to prevent and rehabilitate various lumbar spine and musculoskeletal disorders and as a way to enhance athletic performance (Akuthota and Nadler 2004). Results of clinical studies illustrate that core strength training is a feasible and safe (i.e., no injuries reported) training modality that produces marked increases in health (i.e., strength, flexibility) and skill-related (i.e., balance, coordination, speed) components of physical fitness (Granacher et al. 2014).

Core strengthening has become recognized as an integral part of rehabilitation in athletes and an important part of their training programs. The core acts as the stabilizer of the spine and trunk, the generator of power when initiating movement of the limbs, and a point of transition of forces from the lower limbs to the upper limbs, and vice versa, via the abdomen and spine [2].

Current theories on the link between core stability and lower extremity function, performance, and injury [2] propose that postural support must be established before voluntary extremity movements begin. This is based on the finding, that the transversus abdominis, the deepest abdominal muscle, is always the first to activate in preparation for movement, followed closely by the multifidus. Moreover, the central nervous system creates a stable foundation for lower extremity movement through the coactivation of the transversus abdominis and multifidus muscles [12]. This underscores the importance of core stability in initiating and coordinating lower extremity movements. Several studies investigated the effect of core stability training on lower extremity muscle strength and postural stability. A randomized controlled study on 40 healthy participants demonstrated that a Pilates core stability training enhanced motor performance skills by increasing lower extremity muscle strength and improving postural stability and concluded it prevent musculoskeletal disorders and improve quality of life [13]. Another study performed in 120 male and female athletes concluded that core stability has an important role in injury prevention [14].

Core stability has been suggested to influence lower extremity functioning and might contribute to the development of lower extremity overuse injuries. A clinical cohort study in athletes identified measures for dynamic postural control, core muscle strength, and core muscle endurance as significant risk factors for the development of overuse injuries [15], with decreased abdominal core muscle endurance being significantly associated with lower extremity overuse injury.

Results of another study clearly support the core stability concept as an important consideration for preventing core and lower extremity injuries, including an ankle sprain [16]. Poor core stability is believed to increase vulnerability to uncontrolled joint displacements throughout the kinetic chain between the foot and the lumbar spine [16]. Performing core stability exercises accelerated rehabilitation of the ankle in another study[7] which concluded that core stability training is recommended as a therapeutic option for individuals with chronic ankle instability [7].

Magnetic stimulation physiotherapy of the core's abdominal muscles has been also demonstrated to result in significant inspired volume generation and as well in significant expired pressure production [34], which is of particular interest in view of the shortness of breath as a common symptom of COVID-19.

b) Low back pain

People with chronic low back pain (LBP) exhibit a delayed or decreased activation of lumbar multifidi and transversus abdominus and loss of physiologic tonic activation of transversus abdominus during gait and extremity movement [17]. Dysfunction of these muscles may determine loss of lumbar spine support, increased stress and load on the joints and ligaments of lumbar spine. The purpose of core stability exercises is to recreate normal muscle function in order to increase spinal stability, neuromuscular control within the lumbopelvic region, induce intersegmental stiffness and prevent shear force that causes injury to the lumbar spine [17].

One form of strengthening exercise that has received increasing attention recently is core stability exercise [18]. This type of exercise is defined as any exercises that strengthen spinal musculature or specifically as those that emphasize the deep lumbopelvic musculature (eg, transversus abdominis, multifidus). A recent systematic review [18] concluded that the exercises that target these deep muscles are effective in treating chronic LBP in the general population.

Several clinical studies investigated the role of core muscles training in LBP. High grade evidence from randomized controlled studies point to clinically important improvements in pain intensity [19, 20], favoring the core stability intervention group over conventional treatment group. In the short term, core stability exercise is more effective than general exercise for decreasing pain and increasing back-specific functional status in patients with LBP [21].

Through core strength training, patients with chronic low back pain can strengthen their deep trunk muscles. A systematic review of studies exploring the effectiveness of various core strength training strategies for patients with chronic low back pain concluded that core strength training is more effective than typical resistance training for alleviating chronic low back pain, specifically when focusing on training the deep trunk muscles [22].

c) Pelvic floor dysfunction

The pelvic floor is a complex structure made of muscles and connective tissues, which plays a crucial role in maintaining urinary and bowel continence and normal sexual function by enabling a proper support of pelvic organs. Dysfunction of the pelvic floor muscles (PFMs) may lead to structural problems such as stress urinary incontinence (SUI), fecal incontinence, and pelvic organ prolapse as well as functional problems such as sensory and emptying abnormalities of the lower urinary tract, defecatory dysfunction, sexual dysfunction, and chronic pain syndromes [23]. There is strong evidence that pelvic floor muscle training improves the function of the pelvic floor and symptoms of urinary incontinence and is thus recommended as a first line treatment for pelvic floor dysfunction symptoms [24].

The pelvic floor forms the bottom boundary of the abdominopelvic cavity and an integral part of the body's core muscles. Pelvic floor muscles work synergistically with abdominal and back muscles to support the spine and maintain core stability, the ability to control position and movement of the trunk. Strong and stable core muscles are also important for ensuring the production and transfer of forces involved in maintaining continence. Co-activation of the abdominal muscles contributes to the generation of a strong PFM contraction [25]. Several clinical studies concluded that an addition of abdominal and core stability training to the PFM training results in significantly better improvement of SUI symptoms compared to PFM training alone [24, 26-29].

d) Inflammation

Chronic, sub-clinical inflammation can arise from long-term infections, autoimmune diseases, or lifestyle factors such as physical inactivity, unhealthy diets, and obesity, overwhelming the immune system's anti-inflammatory processes. Symptoms like fatigue, joint stiffness, muscle pain, gastrointestinal issues, and persistent infections may persist for months or years. Treatments for chronic inflammation include anti-inflammatory drugs and lifestyle changes, with exercise playing a crucial role by enhancing muscle function and blood circulation. Skeletal muscle, comprising 30-50% of body weight, not only supports movement and posture but also stimulates blood flow and metabolic activity. During contraction, muscle fibers release myokines—cytokines such as myostatin, irisin, and interleukin-6—that create an anti-inflammatory systemic environment, benefiting organs like the brain, liver, and skin. These myokines explain many of the systemic health benefits of regular physical activity [11].

Core training may contribute to anti-inflammatory responses through several synergistic mechanisms. Besides strengthening deep stabilizing muscles, which improves posture and reduces mechanical strain, it was also shown to lead to increase in anti-inflammatory cytokines [30]. Enhanced circulation and oxygenation from repeated core exercises help with reinforcing the antioxidative capacity and reducing oxidative stress [31]. Additionally, intensive muscle activity can reduce visceral fat, a known source of inflammatory adipokines [32]. Exercise can also reduce neuroinflammation by decreasing microglial activation, increasing neurotrophic factors like BDNF, and lowering systemic inflammation, thereby supporting brain health and function [33]. Together, these effects suggest that exercise, including core training, supports reduced systemic inflammation and enhanced overall health.

While most studies on the effects of muscle exercise on the release of myokines have focused on aerobic exercise, it has been found that anaerobic exercise through externally stimulated involuntary muscle contraction can exert positive effects on the release of various myokines, too, as has been demonstrated by electrically stimulated contractions of rat muscles [35].

For efficient anaerobic treatment a large enough muscle area needs to be stimulated. Consequently, using electrical stimulation is not suitable for controlling inflammation, as electric stimulation requires direct skin contact. In particular, electrical stimulation would require an unpractically large direct skin contact area that would be very uncomfortable for the patient at the required electrical stimulation intensities. Therefore, using a time-varying magnetic field is advantageous over electrical stimulation as no direct skin contact is required. In fact, the time-varying magnetic field can pass any medium, even a vacuum, without attenuation of energy and thereby provides the patient with a powerful, effective, comfortable, non-invasive, motivating, painless fast and safe method to obtain high muscle contraction activity. In particular, as no directs skin contact is needed, magnetic stimulation therapy is also accessible for patients with extreme hypersensitivity or allodynia to skin touch.

Contraction of at least one large muscle or muscle group of the patient is required because the production of anti-inflammatory myokines depends on the amount of contracted muscle mass and is therefore strongly related to the amount of muscle mass exercised/contracted. Therefore, in order to maximize the production of myokines, large muscle groups, such as those located in the arms, thighs, abdomen and buttocks, are to be targeted for effective control of inflammation.

HITS® magnetic muscle stimulation activates muscles in a similar way to electrical stimulation [36], but with the added benefits of deeper penetration, enabling stimulation of a larger muscle volume, and enhanced patient comfort. Recent study by Gaspar et al. has demonstrated that HITS® stimulation of large muscles reduces serum TNF-α levels and lowers the impact of chronic inflammation symptoms on quality of life, mimicking the effects of physical exercise [37].

III. DISCUSSION

Body core strengthening is an essential component of various therapeutical exercise programs. Physical exercise (aerobic, anaerobic, resistance) is the gold standard modality for increasing muscle strength and endurance. Neuromuscular magnetic stimulation presents a well-accepted alternative option to physical exercise, with a comprehensive body of evidence demonstrating that magnetic stimulation leads to enhanced muscle performance by improving strength endurance, muscle power/exercise capacity, quality of life related to muscle function, and an improvement in musculoskeletal pain and motor control [11].

Table 1. CoreRestore™ recommended treatment parameters and treatment schedule

Program	Sessions	Duration / treatment frequency	Stimulation	Active applicator
CoreRestore™ – abs, back and pelvic floor	4-10	30 mins / 2-3 times per week	Maximum intensity up to patient tolerance, multi-step treatment at 30-45 Hz frequency	Chair seat and back applicators + Handheld applicators

Body Core strengthening with HITS® therefore holds great potential in clinical practice treating in areas outlined in this review. CoreRestore™ treatment is especially suitable for individuals with weakened core muscles, post-partum women and everyone that wish to improve their performance of their core muscles.

IV. CONCLUSIONS

Improving muscle performance by core training and stabilization offers a wide range of health benefits, supporting the rehabilitation of lower extremities, alleviating lower back pain, addressing pelvic floor dysfunction, and managing chronic inflammation. HITS® core rehabilitation, utilizing the CoreRestore™ protocol, presents an innovative approach to enhancing core strength and stability. It serves as both a standalone treatment and an adjunctive therapy, expanding therapeutic options for a diverse range of patients. It is generally known that (regular) physical activity helps control inflammation, reduces the risk of chronic degenerative illnesses and improves life quality in the adult aging population. While other approaches are available (e.g., drugs of different kinds), these other approaches are generally less effective and/or entail severe side effects. Meanwhile, a regime of (regular) physical activity is often hard to implement in practice. The biggest obstacle remains in the patient's willingness to adopt and adhere to them, especially when considering the need to sustain them for prolonged periods of time during which the effects are not immediately perceived. The HITS® magnetic stimulation technology thus offers a welcome alternative approach for improving and prolonging the life of adult aging population.

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