Efficacy of Core Stabilization Training Utilizing Low Plank Exercises on a Bosu Ball

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Abstract

Core stability training is a main component in any sports training or rehabilitation program. The core muscles of the body include the pelvic floor muscles, transversus abdominis, multifidus, internal and external obliques, rectus abdominis, erector spinae, and the diaphragm.

Methods: 50 students were asked to participate in this study. The students were not selected based on body type or athletic ability. Participants were screened using a McGill side bridge to determine their initial core stability endurance. These participants then underwent a four week core strengthening program, using low plank exercises. The participants were randomly divided into two groups. One group performed these planks on a stable surface (the ground) while the other group performed these planks on a Bosu® ball. The participants were screened again after this protocol to determine an increase in core stability.

Results: Many participants dropped out of the study during the four-week training protocol. Group 1 showed an overall average increase in McGill side bridge endurance of 1.34 seconds whereas Group 2 showed an overall average increase in McGill side bridge endurance of 5.77 seconds.

Conclusion: An unstable surface has a less affect on the strengthening and endurance of the core musculature based on the McGill side bridge test and the strengthening protocol used in this study. Many factors could have influenced these results including examiner biases as well as the training program may have been too short.

Introduction

The purpose of this study was to determine the difference between core stability training using a stable surface versus an unstable surface. Training of the core musculature has been proven very important in both the reduction and prevention of low back pain both in athletes and the average population. A major objective of core training is to exercise the abdominal and lower back muscles in unison (Clark, p. 200). Increasing the strength and flexibility of the core to increase trunk flexion and extension has also shown to decrease the amount of pain that chronic low back pain sufferers report (Donchin – abstract p. 1). The core muscles must function synergistically in order to stabilize the lumbar spine of an individual. “Research confirms that in healthy individuals, activation of the core muscles occurs before any movement of the body or a body segment. This confirms that the core muscles are essential for optimal stabilization…” (Aaberg, p. 45). It is evident that these muscles are critical in the rehabilitation progress of individuals who have suffered a lumbar spine injury and also important in the prevention of lumbar spine injuries. Many different exercise protocols have been developed to strengthen the core muscles, but it is unclear which exercise alone is the most beneficial to target each muscle. Plank exercises have been proven beneficial in targeting multiple core muscles. “This exercise works all the muscles in your torso – this includes the deeper abdominal muscles called the transversus abdominus, the muscles of the spine, and also the muscles that support the shoulder girdle” (Green p. 77). This study utilizes plank exercises both on a stable and unstable surface to determine which surface was more beneficial in order to train these core muscles.

Methods

50 students were selected from Logan College to participate in this study. The participants were asked to volunteer for this study for extra credit in a particular course. The inclusion criteria for this study were that the participants be between the ages of 20

and 30 years old. No discriminations were made based on the participants' physique or athletic ability. Participants read and signed an exclusion criterion prior to participating in the study. Exclusions include: 1) Anyone who has been diagnosed with a current muscle weakness disease or illness, 2) Anyone diagnosed with injuries resulting in instability of joints or muscles of the core or spine, 3) Any previous injury or surgery that may affect the muscles or joints of the core or spine, 4) Any vestibulocochlear disease or syndrome, which may affect balance or coordination, 5) Any prescription or over the counter medicine that may affect balance and/or coordination, 6) Current pregnancy, or 7) Anyone diagnosed with hypertension and/or osteoporosis.

It was also included that the participants must have a physical on file in the student health center at Logan College that had been performed in the past year. Participants who were eligible for the study were asked to read and sign a consent form prior to participation.

Participants were divided randomly into two groups of 25, based on the order in which they signed the participation sheet. Participants numbered with odd numbers will be assigned to group 1 and participants numbered with even numbers will be assigned to group 2.

Group 1 was determined to be the group that would perform the exercises on an unstable surface. Performing the exercises on a Bosu Ball provided this unstable surface. Group 2 was assigned to perform the exercises on a stable surface. A hard floor provided this stable surface.

Prior to beginning the exercise protocol, participants were asked to perform a McGill side bridge endurance test to determine a base reading. The participants were asked to lie on their right side and perform a side bridge exercise while supporting their own bodyweight with an elbow on the ground. Examiners instructed these participants on the correct way to perform this test, making sure that the elbow is bent at 90 degrees, the elbow is directly under the shoulder, the body is in a straight position and the feet are stacked on one another. Participants were instructed to hold this position for as long as possible, or until the examiner informed them to relax. The examiner observed this position and used a stopwatch to record the time of how long the participant could hold this position. Time was started when the participant reached the correct starting position and was stopped when the participant either was not able to maintain the position or was observed as being unstable or shaking during the exercise. This test was performed 3 times on the right side and times were recorded on a record sheet. An average of these 3 measurements was then recorded on the same record sheet.

Next, the participants were required to return each week, 2 times per week for 4 weeks to perform an exercise protocol. The exercise protocol included the participants performing a low plank exercise to activate the core musculature. The participant performs a low plank exercise by laying prone and bridging up into a plank position while supporting their body weight on their elbows. Examiners instructed the participants on how to perform this low plank and indicated the form as the elbows bent at 90 degrees with shoulders directly over the elbows, toes on the floor and body straight and parallel to the floor while avoided arching or swaying of the low back. As stated previously, Group 1 performed these low plank exercises on a Bosu ball and Group 2 performed these low plank exercises on the floor. As a group, the participants were informed to "bridge up" and hold this position for 30 seconds. The examiners timed these exercises with a stop-watch and informed the students when 30 seconds was reached. The participants were then told to rest for 1 minute. This was repeated 3 times a day, 2 times a week for 4 weeks.

After the 4-week exercise protocol, the participants were asked to perform the McGill side bridge again on the right side. Three measurements were again taken and then an average was found and recorded again.

The averages of the McGill side bridge tests collected before and after the 4-week exercise protocol were then compared to determine if the participants increased their ability to perform the McGill side bridge by holding the position correctly for a longer period of time. Group 1 averages recorded of the McGill side bridge test results from before the 4 week exercise protocol were then added to the averages of the McGill side bridge test results recorded after the 4 week exercise protocol and a new average was found for each participant. All participants' final averages were then added together and averaged again to find a final average of the test results. This procedure was repeated for Group 2 to determine Group 2's final averages. The final averages from Group 1 were then compared to Group 2 to determine which group showed the greatest increase in ability to perform a McGill side bridge test, thus indicating which type of plank exercise is more effective in training the core musculature.

Results

During the course of the 6-week study (4 weeks of training), many of the subjects fell out of the study due to time constraints. These subjects were contacted multiple times but were not able to continue the study. At the end of the 4-week training program, 13 participants from group 1 and 10 participants from group 2 remained for the final evaluation.

Group 1 (Bosu ball) showed an overall average increase in the ability to properly perform and maintain a McGill side bridge of 1.34 seconds. Group 2 showed an overall average increase in the ability to properly perform and maintain a McGill side bridge of 5.77 seconds. The averages were calculated by taking the difference between the average measurements of the initial and the final results of the McGill side bridge. These figures were then averaged again for the entire group depending on the amount of participants who completed the study.

Discussion

The current study found that a 4 week supervised strengthening program utilizing low planks both on a stable and unstable surface showed an overall increase in the ability of the participant to properly perform a McGill side bridge test. The hypothesis that the unstable surface would show a greater increase in core control and stability was found incorrect, however. Results show that the group who performed the low plank exercises on a stable surface (Group 2) increased their ability to perform the side bridge by 5.77 seconds whereas the group performing the low plank exercises on the unstable surface (Bosu ball) only increased their ability to perform a McGill side bridge by 1.34 seconds; a difference of 4.43 seconds. These results show that core stability training on an unlevel surface is less beneficial than core stability training on a stable surface. One hypothesis for these results is that performing these low plank exercises while elbows are on the Bosu ball may create a greater angle of the torso to the floor compared to the angle of the torso to the floor when performing these planks with the elbows placed directly on the floor. This increase in angle may cause an activation of different muscle of the core than does a plank of a lower angle may activate. Another hypothesis is that the unlevel surface may cause an increase in the activation of the upper body musculature involved in performing a plank, such as the shoulder girdle, trapezius, rhomboid muscles, etc.

There is no doubt that a strong core is critical for overall strength. In anatomy the core refers to the body minus the legs and arms. Practitioners no longer treat the "abs" or the low back region as separate entities of the training culture. They now target and collectively coin the core as several of the muscle compartments that emanate from approximately mid-torso to mid-thigh (Mannie, 8). As people become more sedentary, the core muscles are used less often causing them to weaken and provide less spinal support. This weakness opens the door for a possible injury, which may lead to low back pain (Kuhlenberg, 8). Functional movements are highly dependent on the core, and lack of core development can result in a predisposition to injury.

The major muscles of the core reside in the area of the belly and the mid and lower back (not the shoulders), and some include peripherally the hips, the shoulders and the neck. Major muscles included are the pelvic floor muscles, transversus abdominis, multifidus, internal and external obliques, rectus abdominis, erector spinae, especially the longissimus thoracis, and the diaphragm. Minor core muscles include the latissimus dorsi, gluteus maximus, and trapezius. Improved understanding that the core is composed of the entire lumbo-pelvic-hip complex (LPHC) has resulted in an increase in popularity of core stability routines focused on recruiting the anterior, medial, lateral and postural musculature that supports the LPHC (Oliver, Gretchen, etc. al 910).

Core stability training is a generic description that describes the training of the muscles of the abdominal and lumbopelvic region. A combination of global and local stability systems have been used in an attempt to define core stability. The global stability system refers to the larger, superficial muscles around the abdominal and lumbar region, such as the rectus abdominus, paraspinals, and external obliques. All of these muscles are labeled as the prime movers for trunk or hip flexion, extension, and rotation. Local stability then refers to the deep muscles of the abdominal wall, such as the transverse abdominus and multifundus. These internal muscles are then associated with stability of the lumbar spine during whole body movements when postural adjustments are required (Kahle, 65). Many of the major muscles of your shoulders, arms, and legs are attached to the pelvic bones or the spine, which help to constitute the core (Gatorade Sports Science Institute, 72). One of the most important components of any exercise program is core strength. Known as the "powerhouse," the core is the foundation—or center—of the functional kinetic chain. Similar to the foundation of a house, the core supports and stabilizes the spine during static positions and movement. Core stability is defined as the ability to control the position and motion of the trunk over the pelvis to allow optimal production, transfer and control of force and motion to the terminal segment in integrated athletic activities. In day-to-day terms, core stability is necessary for efficient and injury-free movement patterns (Sonnemaker, 2010).

The abdominal muscle group is a main component of this “power house”. This group consists of four muscles, divided into two groups. The deep (anterolateral) abdominals are transverse abdominis and internal oblique; the superficial abdominals are the rectus abdominis and external oblique (Norris, 51). The rectus abdominis and lateral fibers of external oblique are the prime movers of trunk flexion; the internal oblique and transverse abdominis are the major stabilizers. The rectus and external oblique are superficial muscles that often dominate trunk actions. The transversus and internal oblique are more deeply placed, and patients often are unable to contract these muscles voluntarily (Norris, 52). The internal oblique and transversus abdominis are the major back stabilizers compared to the more superficial (Norris, 59). The transversus abdominis seems to contract during posture not simply to bring the body back closer to the posture line, but to increase the stiffness of the lumbar region and enhance stability (Norris, 58). The transversus acts at the initiation of movement to stabilize the trunk in overhead and lower-limb actions (Norris, 52). The attachment of multifidi muscles to the spinous processes of the lumbar spine results in an effective lever arm for lumbar stabilization (Sung, 1318).

Local muscles are small, deep muscles that control intersegmental motion between adjacent vertebrae and act as stabilizers (Parkhouse, et al., 518). Global muscles are large, superficial muscles that transfer force between thoracic cage and pelvis and play a role in creating movement (Parkhouse, et al., 518). The anatomical core will be defined as the axial skeleton and all soft tissues with a proximal attachment originating on the axial skeleton, regardless of whether the soft tissue terminates on the axial or appendicular skeleton (Behm, et al., 92).

Sufficient spinal stability requires involvement of all muscles in the torso. When muscles contract, they create both force and stiffness. Force may or may not be stabilizing, whereas stiffness is always stabilizing (McGill, Karpowicz, 2009). These subsystems work together to stabilize the vertebral column.

There are both active and passive subsystems present in the human body that help to stabilize the skeleton and spine. Chronic low back problems may occur when one of the subsystems becomes deficient, which places greater compensatory stress on other subsystems (Behm, et al., 94). Passive subsystem is a system made up of ligaments, discs, and facet joints. It is important toward the end point movement in the neutral zone, at which point the vertebral ligaments tighten and develop reactive tension to resist motion (Behm, et al., 94).

When considered independently, the passive subsystem has limited potential to stabilize the vertebral column. For example, in vitro experiments have demonstrated that the osteoligamentous lumbar spine buckles under compressive loading of approximately 90 N. The mass of the body in a standing position exceeds this level of support (Behm, et al., 94). The importance of proper muscular support and function is evident when considering this study.

The active muscle subsystem is local and global in regards to the axial skeleton stabilizers. The transversus abdominis, diaphragm, and levator ani are particularly important for increasing intra-abdominal pressure, which may reduce compressive forces between the lumbar vertebrae (Behm, et al., 94), thus reducing the risk for intradiscal herniation leading to back pain.

Active neural subsystem controls the recruitment of the core musculature via feed-forward and feedback mechanisms. During performance of motor skills, anticipatory postural adjustments (feed-forward) take place immediately prior to or simultaneous with movement to maintain whole-body stability (Behm, et al., 94). The transversus abdominis muscle is the first core muscle activated during arm and leg raising tasks. Proprioceptors embedded within the intervertebral discs, vertebral ligaments, and facet joint capsules provide sensory feedback regarding position and movement of the vertebral column. Sensory feedback from muscle spindles is also utilized to meet spinal stability requirements. The smaller deep vertebral muscles (multifidus) have the greatest spindle density. These muscles are less effective in stiffening the spine; thus, their primary role is in providing sensory feedback that facilitates coactivation of the larger superficial muscles. When people engage in repeated movements, their bodies anticipate the predictable load and the muscles brace themselves accordingly. When back stability is controlled in advance this way, it is known as feed forward control (Norris, 57).

The central nervous system (CNS) must analyze the present state of stiffness (stability) in the spine and reduce it to allow unimpeded movement or increase it to reduce unwanted motion. The CNS receives continuous signals from nerve sensors in the spinal tissues including the joints, discs, ligaments, and muscles (Norris, 57). When the CNS recognizes a familiar movement pattern, it is able to use feed-forward motion control to plan ahead and contract the stability muscles by just the right amount to optimally stabilize the spine, without stiffening the spine so much that free movement is compromised (Norris, 58).

The human spine is inherently unstable without its surrounding musculature (Norris, 58). McGill suggests that the first step towards protecting the spine is to detect and correct unsafe body mechanics, then to develop spine position awareness (Sanders, 74). Dysfunction in activation and performance of body mechanics can lead to injury of the spine and surrounding musculature. Dysfunction is defined by Dorland's Illustrated Medical Dictionary as a disturbing, impairment, or the abnormality of function. Low back dysfunction is often the cause of low back pain, and clinicians may seek to relieve pain to lessen the dysfunction, which may remain the primary focus (Sung, 1314).

Defined spinal instability is a significant decrease in the capacity of the spine's stabilizing system to maintain intervertebral neutral zones within physiologic limits (Sung, 1314). Decreased muscular endurance of the low back musculature is strongly associated with low back pain (Behm, et al., 93). Consider an overhead lifting action performed with an unstable spine: If the pelvis tilts forward, lumbar lordosis increases and the abdominal muscles overstretch as the lumbar spine moves into full extension. What trunk stability is present, it comes from facet joint approximation and elastic recoil of noncontractile tissues rather than from muscle action (Norris, 54). Of the deep intersegmental muscles, the multifidus is most important for stabilizing the spine by helping to control lordosis and neutralizing spinal flexion. Following low back injury, exercise therapy is required to restore multifidus function (Norris, 59). Stability forms the foundation of all trunk exercise. People should train for trunk stability before training for muscle performance (Norris, 54).

The type of training necessary to train for muscle stability and performance is based upon the type of muscle fibers located in a particular muscle group. Aerobic-type muscle fibers (Type I) compromise the majority (>80%) of the erector spinae, multifidus, and longissimus thoracis muscles in healthy males and females. The combination of exercises with low force requirements and core muscles with high fatigue resistance may necessitate a high volume, and even with relatively low force will gradually increase muscle fiber recruitment by inducing fatigue of the lower-threshold motor units, thereby recruiting higher threshold motor units…(Behm, et al., 102)." "…based on the relatively high proportion of type I fibers, the core musculature might respond particularly well to multiple sets that involve many repetitions (Behm, et al., 102)."

A study by Hodges and Richardson demonstrated how the use of limb musculature which was originally thought to be independent of the core muscles, indeed had a great affect on the core. Using fine-wire electrodes, Hodges and Richardson (1996) assessed abdominal muscle action during 10 repetitions of shoulder flexion, extension, and abduction. They found that the transversus abdominis contracted before the shoulder muscles by as much as 38.9 ms. The reaction time for the deltoid was on average 188 ms, with the abdominal muscles (except transversus) following the deltoid contraction by 9.84 ms. With the subjects who had a history of low back pain, however, the contraction of the transversus failed to precede that of the deltoid, indicating that the subjects had lost the anticipatory nature of stability (Norris, 57). This reveals a uniform dysfunction in the motor control of the transversus abdominis in people with low back pain – the problem is not simply one of muscle strength (Norris, 58).

Core stability is the ability to control the position and motion of the trunk over the pelvis, thereby allowing optimum production, transfer, and control of force and motion to the terminal segment in integrated athletic kinetic chain activities (Parkhouse, et al., 518).

The stability of the vertebral column, and thus the effective transfer of torque and angular momentum through the kinetic chain is dependent on sequential activation patterns in the core musculature. The appropriate combination and intensity of muscle activation is dependent on factors such as posture, external forces, movement velocity, and fatigue (Behm, et al., 95).

Many studies have proposed that optimal core stability is vital for injury prevention. Poor core stability, weakness in a specific group of core muscles (e.g., hip abduction) is predictive of ACL injury, patellofemoral pain, IT band syndrome, low back pain, and improper landing kinematics (Behm, et al., 98). Thus, when assessing the role of the core musculature during sports tasks, it is important to consider the demands at all joints and muscles in the kinetic chain, including those distal and proximal to the core (Behm, et al., 98). Core training has advanced significantly as biomechanists like Stuart McGill, PhD, have used their models to show that strengthening the muscles of the core to brace and resist movement can stiffen the spine, thus efficiently transferring forces between the upper and lower extremities, and also to demonstrate protection of the spine from buckling. Biomechanical models do show that the larger core muscles are capable of stabilizing the spine by increasing compressive forces, and have become the foundation for many lumbar stabilization programs. More recently we have been introduced to the motor control model of spinal stability that incorporates the central nervous system (CNS) and the ability of certain core muscles to reflexively stabilize the spine. The research has shown there to be a "feed forward" mechanism of deep core muscle contraction to stabilize the spine just prior to extremity movement. This model accounts for segmental stability through resistance of translational and shearing forces during high and low load activities (Heiler, 2010).

In order to protect the spine and train the core, there are many exercise programs that have been developed. The McGill side bridge is an exercise designed to train the quadratus lumborum, transverse abdominis, and abdominal obliques as spine stabilizers. The McGill side bridge has become the optimal technique to maximize activation of the core but minimize the spinal load. Maintaining the side bridge position ensures constant muscle activation while the brace introduces new combinations of muscle recruitment to ensure stability. Muscle endurance, as opposed to strength, has been shown to be protective against future back troubles. It is almost impossible for the spine to become unstable while performing a side bridge with a neutral spine.

There are three stages of performing a McGill side bridge. These stages are beginners, intermediate, and advanced. Beginners bridge from the knees. In the beginning position, the exerciser is on his side, supported by his elbows and hip. The knees are bent to 90 degrees. Placing the free hand on the opposite shoulder and pulling down on it will help stabilize the shoulder. The torso is straightened until the body is supported on the elbow and the knee, with some input from the lower leg. This stage can be slightly advanced by placing the free arm along the side of the torso.

The intermediate exerciser is on his side, supported by his feet and elbow. Placing the free hand on the opposite shoulder and pulling down on it will help stabilize the shoulder. The torso is straightened until the body is supported on the elbow and the knee, with some input from the lower leg. This stage can be slightly advanced by placing the free arm along the side of the torso.

The advanced technique is designed to enhance the motor challenge of the side bridge and to transfer from one elbow to the other while abdominally bracing rather than repeatedly hiking the hips off the floor into the bridge position. This ensures that the rib cage is braced to the pelvis. The contraction speed of the abdominals is more critical than their strength when they react to a force tending to displace the lumbar spine. The ability of a patient to dissociate deep abdominal function from that of the superficial abdominals is important (Norris, 54)."

Abdominal hallowing is another important exercise for core training. Hallowing works the transversus abdominis and internal obliques (deep abdominals) (Norris, 54)." "People with low back pain tend to favor the more external abdominal muscles (Norris, 59). Patients with chronic low back pain were not able to fire the internal oblique as well the rectus abdominis and external oblique (Norris, 54). The transversus abdominis is active in trunk movements in all directions. Its activity always precedes that of the other abdominal muscles in normal subjects (Norris, 55)." Abdominal hallowing will cause the contraction of the transversus abdominus and the internal obliques, therefore strengthening these muscles. Abdominal hallowing resulted in 32% less stability than abdominal bracing (Behm, et al., 95). Drawing in the abdominal wall during abdominal hollowing reduces the momentum for the internal and external obliques and rectus abdominis, thus reducing their potential to stabilize the vertebral column. The generation of intra-abdominal pressure through co-contraction of all major abdominal muscles appears to better stabilize the spine.

Another important idea in core stability training is the consideration of whether a unstable surface provides a more proprioceptive form of muscle training than does training on a stable surface. Proponents of using unstable devices have hypothesized that the greater instability elicited during exercise may stress the neuromuscular system to a greater extent that ground-based training methods (Behm, et al., 93). Unstable devices promote postural disequilibrium or imbalance, as postural sway may project the center mass beyond the device's area of support. They also promote postural disequilibrium, as the surface distorts (Behm, et al., 92). A BOSU ball is a hemispherical physioball with an inflated dome side and a hard rubber flat side (Behm, et al., 92). It is unclear when these devices began to be used as training and rehabilitation tools, but physical therapists were using physioballs prior to WWII (Behm, et al., 92). Generally, findings have indicated that as the degree of instability increases, the degree of core muscle activity increases proportionally (Parkhouse, et al., 518).

Since motion for physical tasks, such as sports skills, fitness activities, occupational tasks, and activities of daily living, occur on relatively unstable surfaces, training must attempt to closely address the demands of the sport (Behm, et al., 92). The unstable nature of the ball forces one to make postural adjustments to increase coordination, which requires activation of the appropriate core musculature to stabilize the lumbar spine. The deep postural muscles of the trunk have a primary purpose to ensure this lumbar stabilization and to maintain the body's center of gravity within its base of support to minimize loss of balance (Parkhouse, et al., 523). Research shows, however, that some of the instability devices such as Bosu ball may not provide a sufficient amount of challenges to the highly resistance-trained individuals. A moderate amount of instability on the Bosu ball did not produce significant changes in activation of the muscles tested (Wahl, Michael J et. Al, 1369).

The use of static balance exercises performed while supported on unstable devices might be viewed as a preliminary training step in improving balance and the strength and endurance of the core musculature, prior to the implementation of dynamic and ballistic resistance exercises (Behm, et al., 92). This may provide a slower introduction for the participant to core stability training, thus reducing the risk of injury. A program that incorporates both static and dynamic exercises may provide these benefits if the dynamic exercises are then performed with increased velocity (Parkhouse, et al., 524).

Improvements in the ability to stabilize the spine may occur naturally in conjunction with the development of other characteristics (e.g., balance) (Behm, et al., 98). In patients with chronic low back pain, there is known dysfunction of the transverse abdominis and atrophy of the multifidus (Behm, et al., 102). These two muscles, as discussed earlier, are extremely important in both spinal movement and movement of the limbs; all of which movements are involved in balance.

Gender is another factor that must be addressed when introducing core stability training into an exercise program. A study conducted by Sung indicates that spinal stabilization exercises intervention may have been more efficacious for women than for men because women showed a slight gain in endurance, whereas men showed a significant loss of endurance (Sung, 1318). Back fatigability was significantly more prevalent in men than in women after a modified Sorenson test. The thoracic and lumbar regions of the back muscles from the muscle biopsy analyses suggested that the ratio of type I to type II muscle fiber cross-sectional area is significantly greater in women than in men (Sung 1318).

There are studies that have been conducted that question the ideas previously stated in this discussion. Firstly, in our body all structures are profoundly connected in many different dimensions, including anatomically and biomechanically. One would need a knife to separate them from each other. It is not difficult to emphasize a connection that would fit the theory. For example, in breast reconstruction after mastectomy, one side of the rectus abdominis is used for reconstruction of the breast. The patient would then be left with only one side of rectus abdominis and weakness of abdominal muscles. Such alteration in trunk biomechanics would also be expected to result in profound motor control changes. Despite all these changes there seems to be no relationship to back pain or impairment to patient's functional/movement activities, measured up to several years after the operation. (Mizgala et al., 1994) and (Simon et al., 2004). In this case, damage to abdominal musculature does not seem to be detrimental to spinal stability or contribute to low back pain. Also, a person would have to lose substantial trunk muscle or force control before it will destabilize the spine.

Secondly, It is doubtful that there exists a core group of trunk muscles that are recruited operate independently of all other trunk muscles during daily or sport activities (McGill et al., 2003). Such classification is anatomical but has no functional meaning. The motor output and the recruitment of muscles are extensive (Hodges et al., 2000), affecting the whole body. To specifically activate the core muscles during functional movement the individual would have to override natural patterns of trunk muscle activation. This would be impractical and next to impossible and potentially dangerous, as stated by Brown et al. (2006).

Training focused on a single muscle is even more difficult. Muscle by muscle activation does not exist (Georgopoulos, 2000). Single muscle control is regulated in the hierarchy of motor processes to spinal motor centers – a process that would be distant from conscious control (interestingly even the motor neurons of particular muscles are intermingled rather than being distinct anatomical groups in the spinal cord) (Luscher and Clamann, 1992). It has been demonstrated that when tapping the tendons of rectus abdominis, external oblique and internal oblique the evoked stretch reflex responses can be observed in the muscle tapped but also spreading extensively to muscles on the ipsilateral and contralateral sides of the abdomen (Beith and Harrison, 2004). It is well documented that other muscles are involved – multifidus (Carpenter and Nelson, 1999), psoas (Barker et al., 2004), diaphragm (Hodges et al., 1997) pelvic floor muscles (Pool-Goudzwaard et al., 2005), and gluteals (Leinonen et al., 2000). Basically in core in relation to low back pain, we see a complex and wide reorganization of motor control in response to damage or pain.

Conclusion

The study indicates that short term training may only improve core strength by reducing fatigue in the core musculature and allowing the athlete more neuromuscular control during balance. It is possible that an exercise period of more than four weeks might be necessary to determine a clinically relevant difference in these muscle endurance measures. Also, there could be discrepancies in the research between individual examiners as to the observation of a properly executed side bridge performance. Core stability has been a growing theme in sports training and rehabilitation over the past few years and will continue to grow as a major factor in the rehabilitation and prevention of low back pain.

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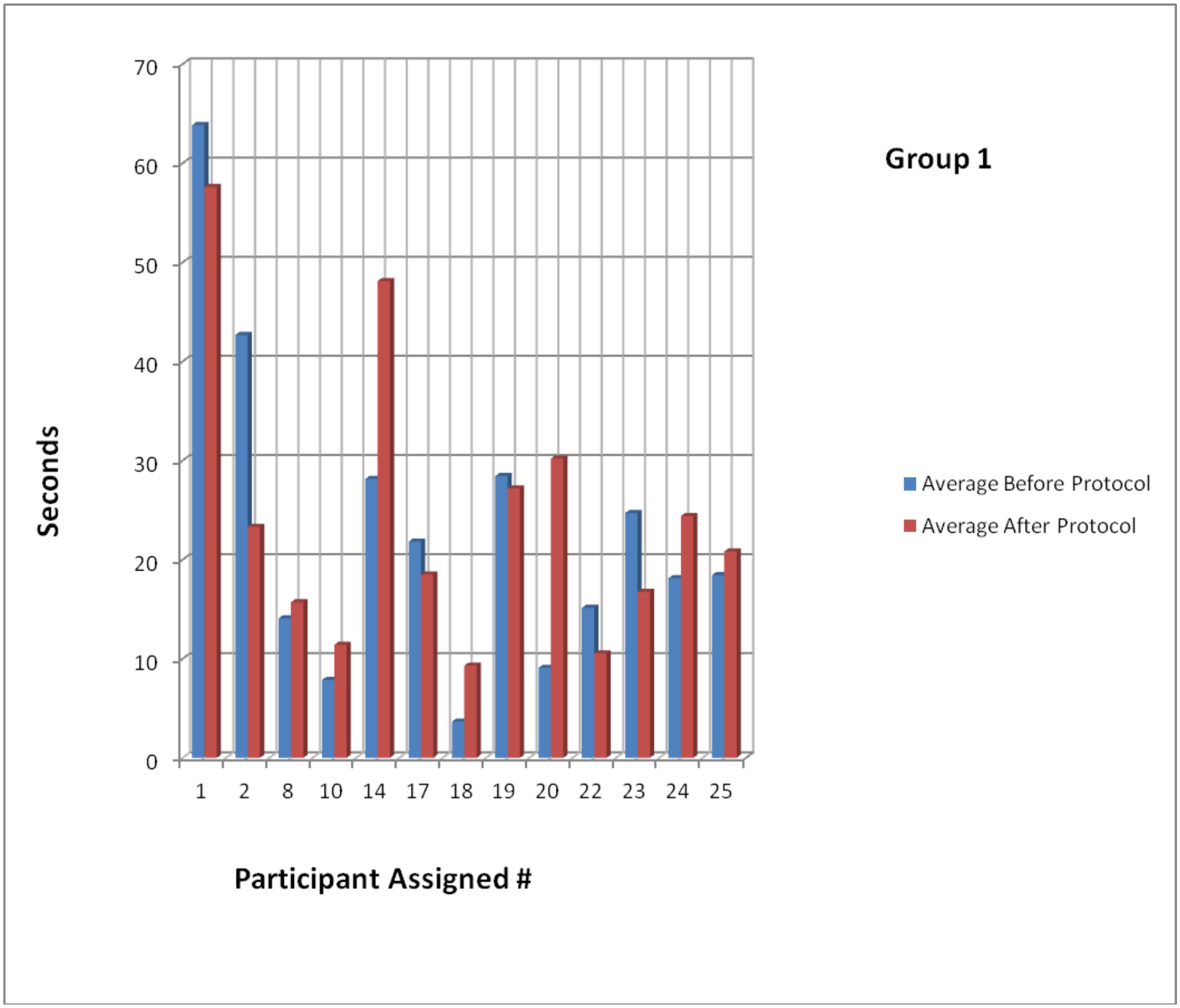
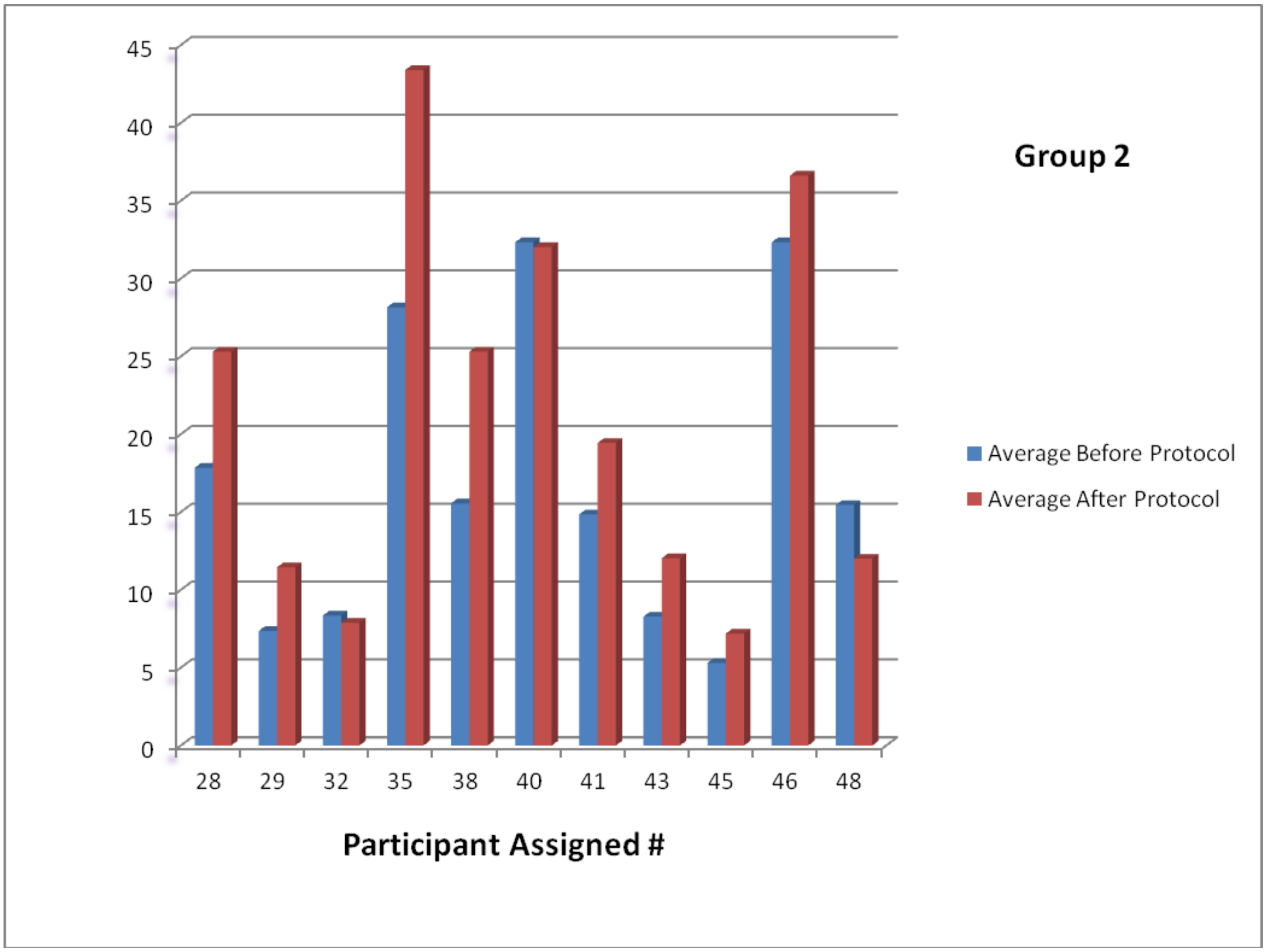
Figures

Figure 1: Results of group 1. Blue lines indicate the average seconds the McGill side bridge was performed before the 4 week training program. Red lines indicate indicate the average seconds the McGill side bridge was performed after the 4 week training program.

Figure 2: Results of group 2. Blue lines indicate the average seconds the McGill side bridge was performed before the 4 week training program. Red lines indicate indicate the average seconds the McGill side bridge was performed after the 4 week training program.



Group 1
Seconds
70
60
50
40
30
20
10
0
1
2
8
10
14
17
18
19
20
22
23
24
25
Participant Assigned #
Average Before Protocol
Average After Protocol


45
40
35
30
25
20
15
10
5
0
Group 2
Average Before Protocol
Average After Protocol
28
29
32
35
38
40
41
43
45
46
48
Participant Assigned #