Original Article

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Rectus Abdominis Muscle Activity on Different Surfaces

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Abstract

Background: Abdominal exercises (AE) are one of the most popular exercises used in fitness and training programs. Exercising on an unstable surface as opposed to exercising directly on a hard flat surface may enhance the body respond to the instability. To remain balanced the muscle recruitment patterns may change and enhanced muscle response may be required. **Methods:** Thirty three normal healthy male and female subjects with age between 18-25 years were included in the study. Subjects were asked to perform abdominal crunches on four different surfaces (plinth, Swiss ball, 2-dimensional wobble board and 3-dimensional wobble board) and electromyographic activity of the upper and lower rectus abdominis was noted. **Results and Conclusion:** Average as well as the peak activity of upper and lower rectus abdominis muscle was found to increase as subject performed on progressively more unstable surface.

Key words: Abdominal exercises; Swiss ball; 2-Dimensional wobble board; 3-Dimensional wobble board.

Introduction

In recent years, health and fitness practitioners have given greater and greater emphasis to core stability for injury prevention, rehabilitation and performance enhancement. The concept of developing strong muscles in the trunk is believed to reduce the risk of both acute and chronic injury.[1]

The "core musculature" can be defined generally as the 29 pairs of muscles that support the lumbo-pelvic-hip complex in order to stabilize the spine, pelvis, and kinetic chain during functional movements.[2] The core is also commonly referred to as the "powerhouse"or the foundation of all limb movement.[3] To ensure stability of the spine in order to produce force and to prevent injury, trunk muscles must have sufficient strength, endurance, and recruitment patterns.[4]

A well developed muscle of the abdominal is an essential ingredient to the type of complete physique for any sports performance. The anatomical and kinesiological studies have revealed that abdominal muscles are the stabilizer of the pelvis, the lumber spine and the thorax and are prime mover for the trunk flexion and rotation.[5]

The most well known and prominent abdominal muscle is rectus abdominis. It is a long flat muscle that extends vertically between the pubis and the fifth, sixth and seventh ribs.[6] It helps to flex the spinal column, narrowing the space between the pelvis and the ribs. It is also active during side bending motions and helps stabilize the trunk during movements involving the extrimities and head.[7]

Core stability exercise can be defined as "any exercise that channels motor patterns to ensure a stable spine through repetition.[8] However, the current trend toward core stability training

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in commercial fitness centers may have originated from physical therapy methodology. When performed in this setting, core stability exercises are different from the a fore mentioned free weight lifts in that the emphasis is on isometric muscle actions (e.g. prone or supine bridging) performed with body mass or relatively light loads . Furthermore, these exercises are often performed while lying, seated, or standing on unstable equipment such as a Swiss ball, wobble board, low density mat, or air-filled disc.

Abdominal exercises (AE) are one of the most popular exercises used in fitness and training programs. The main goal of AE is to strengths the thoraco-lumbar flexor muscles. Research shows that weakness of the rectus abdominis (or any anterior abdominal muscle: pyramidalis, transversus abdominis external or internal oblique abdominal) can cause chronic instability of the pelvis due to abnormal pelvic rotation and movement.[9]

The use of unstable equipment has increased in popularity among healthy athletes. Various forms of unstable equipment have been claimed effective training tools for improving strength and power.[10] Surface instability is a common addition to traditional rehabilitation and strength exercise with the aim of increasing muscle activity and increasing exercise difficulty.[11]

The swiss ball exercises are believed to activate the trunk musculature to a greater extent than more traditional resistance execises. The unstable surface of ball is thought to provide a greater challenge to the core muscles than a solid bench or standing on a stable surface. The swiss ball stability and balance exercises increases the torso balance and electromyographic activity compared to conventional floor exercises.[12]

A primary benefit with an exercise ball as opposed to exercising directly on a hard flat surface is that the body responds to the instability of the ball to remain balanced.[13] Swiss balls are unstable surface which may result in an increased need for force output from trunk muscles to provide adequate spinal stability or balance. They increase the muscle isolation, improved balance, greater dexterity and enhanced strength.[14] Swiss ball exercises are the key to effective improvements in trunk strength, as actions performed on the ball involve greater stimulation of the neuromuscular system.[15]

The correct alignment required to stabilize and accommodate movements of the pelvic girdle depends on adequate strength and endurance of abdominal musculature.[16] Swiss balls have been incorporated into strength training regimes and touted as a means to train musculoskeletal system effectively.[13]

The other most commonly used unstable surface is the wobble board. It is however possible to use the wobble board in a wide variety of exercises, such as balanced push ups and sit-ups or to improve balance on one leg. Balance board training can help to build core strength and stability, increase the range of motion in lower extremities, and improve posture. All these physical benefits can engender greater body awareness and confidence that will positively affect our athletic performance.[17]

The use of electromyography has been an important tool in understanding the muscles activity. Experimental research uses electromyographic (EMG) methods to characterize the activation of muscles.[18]

Methodology

Thirty three normal healthy male and female subjects with age between 18-25 years were included in the study. The group had a mean age of 22.18 yrs and a mean weight of 55 kgs, and a mean height of 162.01 cms. The subjects were excluded if there was any history of low back pain in last 3 months[17], any balance impairment, history of abdominal surgery, spinal surgery and hernia, orthopedic disorder of back, hip or knee, back and lower extremity malignancies, were pregnant, had hypertension, any neurological disorders affecting back and lower extremities, were

under medication (muscle relaxants), had unhealed scar or wound on the trunk, metal implants in back and lower leg.

Potential subjects were apprised of the procedure and its potential risks and benefits and the evaluation was done. Subjects who fulfilled the inclusion and exclusion criteria and gave their informed consent were included in the study. Subjects were asked to perform abdominal crunches on four different surfaces (plinth, swiss ball, 2-dimensional wobble board and 3-dimensional wobble board) and electromyographic activity of the upper and lower rectus abdominis was noted. A rest period of two minutes was allowed in between each task. Two practice trials on each surface were given prior to data collection.

Testing procedure

Self adhesive electromyographic electrodes were placed approx 3 cm lateral and 5 cm superior to the umbilicus for upper rectus abdominis and approx. 3 cm lateral and 5 cm inferior to umbilicus for lower rectus abdominis.[17] The subject was made to lie supine with both feet flat on the plinth and hips and knees flexed. The resting muscle activity of the upper and lower rectus abdominis was noted.

Fig 1: Abdominal crunch on plinth

Fig 2: Abdominal crunch on swiss ball

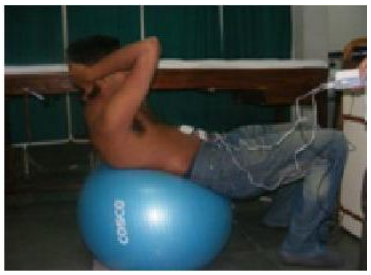


Fig 3: Abdominal crunch on 2-dimensional wobble board

Fig 4: Abdominal crunch on 3-dimensional wobble board

The subjects then performed the abdominal crunch on 4 different surfaces. Subjects were instructed to lift their upper body till the inferior angle of scapula was off the supporting surface but not to flex the neck. Subjects were then asked to maintain this position for 6 seconds and electromyographic activity of the upper and lower rectus abdominis was noted. On the plinth subject was positioned with both feet flat on the plinth and hips and knees flexed. On gym ball the subjects were positioned with lower lumbar region supported on a gym ball & feet placed flat on the floor. The inflation of the Swiss ball was checked between subjects to ensure that the diameter remained at 60 cms prior to each test. On a 2 and 3-dimensional wobble board the subject were made to lie with board under his lower lumbar region and both hips and knees flexed and feet flat on the ground.

Results

Activity of upper and lower rectus abdominis muscle on different surfaces is shown in table 2 and table 3.

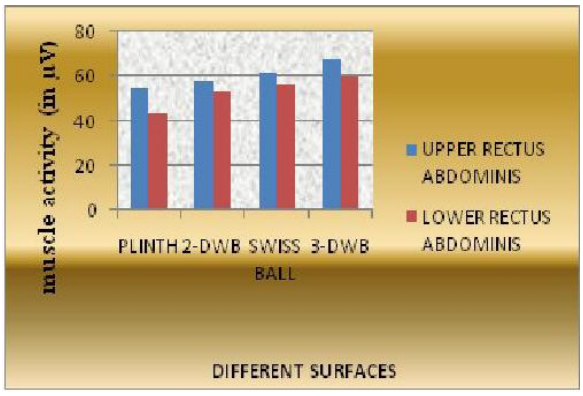
Table 1: Comparison of average activity of upper and lower rectus abdominis muscle on various surfaces

MUSCLE	PLINTH	2-DWB	SWISS BALL	3-DWB
UPPER RECTUS ABDOMINIS Mean (SD)	54.81 (26.41)	57.8 (33.5)	61.65 (35.05)	67.87 (49.74)
LOWER RECTUS ABDOMINIS MEAN (SD)	43.69 (26.41)	53.83 (54.37)	56.86 (52.87:)	60.33 (54.81)

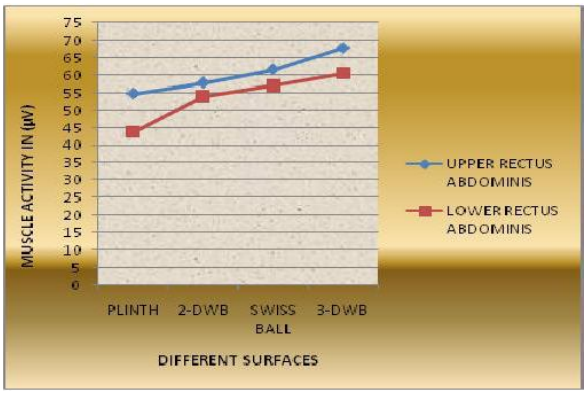
Table 2: Comparison of peak activity of upper and lower rectus abdominis muscle on various surfaces

MUSCLE	PLINTH	2-DWB	SWISS BALL	3-DWB
UPPER RECTUS ABDOMINIS Mean (SD)	123.81 (114.86)	126.59 (92.70)	116.78 (19.14)	139.95 (103.4)
LOWER RECTUS ABDOMINIS Mean (SD)	91.75 (54.25)	110.74 (101.63)	114.83 (111.59)	136 .93) (114.0)

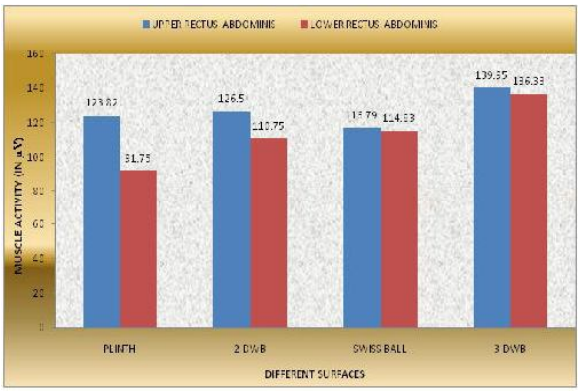
Graph 1: Comparison of average upper and lower rectus abdominis muscle activity on different surfaces.



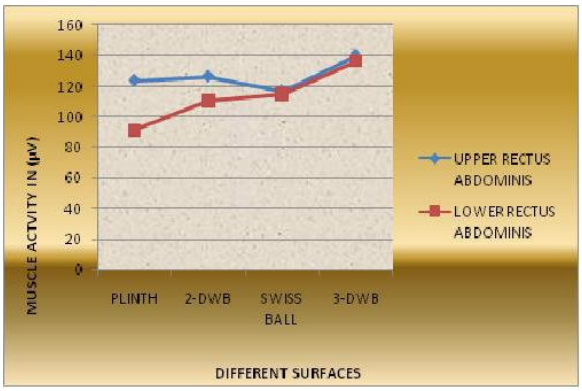
Graph 2: Comparison of average upper and lower rectus abdominis muscle activity on different surfaces



Graph 3: Comparison of peak upper and lower rectus abdominis activity on different surfaces



Graph 4: Comparison of peak upper and lower rectus abdominis muscle activity on different surfaces



Average activity of upper and lower rectus abdominis muscle

Average activity of upper and lower rectus abdominis muscle was found to increase as subject performed on progressively more unstable surface. The amount of rise in lower rectus abdominis muscle was more as compared to upper rectus abdominis muscle, though the level of activity of upper rectus abdominis muscles was greater on all the surfaces.

Peak activity of upper and lower rectus abdominis muscle

Peak activity of upper and lower rectus abdominis were found to increase as subject performed on progressively more unstable surface. But the amount of rise in lower rectus activity was more as compared to upper rectus abdominis on Swiss ball due to extended hip position. The upper rectus abdominis activity is more on other surfaces.

Discussion

The hypothesis proposed in the current study was supported by the positive result of increased rectus abdominis muscle activity as the unstability of the surface is increased. The result indicated that the muscle activity was highest on 3-dimensional wobble board.

The activity of the upper rectus andominis muscle is more than that of the lower rectus abdominis muscle while performing crunch on all the surfaces. Performing crunch exercises on labile surfaces appears to increase abdominal muscle activity. This increase in muscle activity is probably due to increased requirement to enhance spine stability and whole body stability to reduce the threat of falling off the labile surface. The use of labile surfaces appears to increase muscle activity levels and co activation, further challenging endurance capabilities. Axler and McGill noted that generally curl-ups (at least on stable surfaces) were the safest of those chosen from a wide variety of abdominal muscle exercises.

It's also claimed that Swiss ball training improves nervous-system function that results in functional strength gains. The neural component of strength is well established, and maximum strength development requires the development of this component along with that in contractile tissue.[19] A study has proposed taxonomy of tasks based on task function and the environmental context in which the task is carried out. The simplest tasks are closed tasks in which the regulatory stimuli (the pertinent sensory information) are stable and no variability exists between trials to trial. Practicing closed tasks results in fixation, a type of learning that narrows the range of performance. The most complex tasks are open tasks in which the regulatory stimuli are unstable and there is variability between trials to trial. Practicing open tasks results in diversification, the acquisition of a more flexible motor strategy, adaptable to changing environmental conditions.[20] Swiss ball training has been used by physical therapists to challenge their patients toward diversification [13]. If Swiss ball training with weights results in a similar motor strategy diversification in athletes, the strength gains may be more functional to performance.[21]

The result of this study differed from the study done which proposed that the unstable surface does not cause an increase in muscle activity. Different individuals respond differently to unstability.[22] But there are many studies that support the result of the current study which states that[23] there is a significant increase in rectus abdominis muscle activity while performing single leg holds on Swiss ball. Also a study[24] done concluded that the rectus abdominis muscle activity becomes double on a Swiss ball.

Studies have already shown that introduction of an unstable surface increases the muscle activity while performing crunches on an unstable surface. The inflatable disc, perhaps due to a combination of higher instability and a smaller base of support, elicited greater activation of the rectus abdominis than when compared to levels of activation during the stable curl up. A similar

study[25] done concluded that the rectus abdominis muscle activity was maximum on a 3-dimensional wobble board while performing abdominal crunches as compared to crunches performed on Swiss ball and 2-dimensional wobble board.

In this study the hold time for a crunch is of 6 seconds[17] and a rest of 2 minutes is provided in between each task.[17] The 6 seconds time is taken because McGill suggested that there is some seconds needed by all the nuscle fibfres to be recruited. And hence to get the peak activity of the muscle.[17]

Although it appeared that the unstability of the surface increases the rectus abdominis muscle activity while performing the crunches, many questions remain unanswered regarding the muscle contraction that whether the subjects were able to recruit the upper rectus abdominis properly while performing crunch.

The limitations of this study were that only young normal adults were included, number of subjects is less due to limited sample of subjects and time constrains, the abdominal muscle strength is not tested for inclusion as it can vary from person to person. Surface electrodes were used instead of needle electrodes.

Future investigations may include persons with different age groups, spinal conditions, measuring muscle activity of other abdominal muscles along with rectus abdominis.

Conclusion

The result of this study showed that the upper rectus abdominis muscle activity is more as compared to lower rectus abdominis muscle while performing crunch on stable and unstable surfaces. The maximum increase in muscle is on 3-dimensional wobble board and least increase on plinth as compared to Swiss ball and 2- dimensional wobble board. Among Swiss ball and 2-dimensional wobble board the upper rectus abdominis muscle activity is more on Swiss ball.

Hence this study concluded by accepting the suggested hypothesis that the rectus abdominis muscle activity increases on unstable surfaces. Therefore, it is suggested that the 3-dimensional wobble board is most challenging in training the upper rectus abdominis muscle followed by Swiss ball, 2-dimensional wobble board and plinth.

References

1. Hodges PW, Richardson CA. Contraction of the abdominal muscles associated with movement of the lower limb. *Phy Ther.* 1997; 77(2): 132-42.
2. Fredricson M, T Moore. Core stabilization training for middle and long distance runners. *New Stud Atheletics.* 2005; 20: 25-37.
3. Akuthota V. Core strengthening. *Arch Phy Med Rehab.* 2004; 85: S86-S92.
4. Bergmark A. Stability of the lumbar spine in mechanical engineering. *Acta Orthop.* 1989; 230: 20-24.
5. Whiting and Rugg S. Electromyographic comparison of a stability ball crunch with a traditional crunch. 2007; 21.6. Gray's Anatomy. 40th British Addition.
6. Fredricson M, T Moore. Core stabilization training for middle and long distance runners. *New Stud Atheletics.* 2005; 20: 25-37.
7. Elizabeth Quinn. Guide to sports medicine. 2009.
8. McBride JM, P Cormite, R Dean E. Isometric squat force output and muscle activity in stable and unstable conditions. *J Strnghth Cond Res.* 2006; 20(4): 915-918.
9. Bell JT. Building six- pack abs, developing the abdominal muscles. 2006
10. Carter JM, WC Beam, SG Mcmahan, ML Barr, L Brown. The effects of stability ball training on spinal stability in sedentary individuals. *Strength Cond Res.* 2006; 20(92): 429-435.
11. Gregory J Lehman, Hodaw *et al.* Replacing a Swiss ball for an exercise bench causes variable changes in trunk muscle activity during upper limb strength exercises. 2005; 10: 1186/1476-5918-4-6.

12. Casio-Lima LM, Reynolds KL, Winter C, Paolone V. Effects of physioball and conventional floor exercises on early phases adaptations in back and abdominal core stability and balance in women. 2003; 17(4): 721-725.
13. Grenier SG *et al.* An unstable surface is not a sufficient condition for increase in muscle activity during rehabilitation exercise. 2007; 51(3): 139-143.
14. Flett, Maureen *et al.* Swiss Ball: For Strength, Tone and Posture. Sterling Publishing Company; 2003.
15. Goodman P *et al.* NCSA'S Performance. *Training Journal.* 2003; 2(6): 9-25.
16. Michael Duncan. Muscle activity of upper and lower rectus abdominis during exercises performed on and off a Swiss ball. *Journal of Body Work and Movt Therapies.* 2009,13(4): 364-367.
17. Stuart M McGill, Sylvain G Grenier.Abdominal muscle response during curl- upon both stable and labile surfaces. *Phy Ther.*2000; 80(6): 564-569
18. Souza GM, Baker LL, Powers CM. Electromyographic activity of selected trunk muscles during dynamic spine stabilization exercises. *Arch Phys Med Rehab.* 2001; 82(11): 1551-7.
19. Meshram Swati C. A differential electromyographical analysis of rectus abdominis muscle segments during performance of different test movements. *Indian Journal of Physiotherapy and Occupational Therapy.* 3: 0979-6674.
20. Hall SJ, Lee J & Wood TM. Evaluation of selected Sit-Up variations for the individual with low back pain. *Journal of Applied Sport Science Research.* 1990; 4(Suppl. 1): 42-46.
21. Taylor MJ, JS Gunther, A motor control rationale for the therapeutic use of a Swiss ball. In Swiss ball applications for orthopedic and sports medicine. *Ball Dynamics International.* 1995; 5-21.
22. Tirish Gordan, JO Langley. Replacing a Swiss ball for an exercise bench causes variable changes in trunk muscle activity during upper limb strength exercises. *Dynamic Medicine.* 2005; 1476-5918-4-6.
23. Marshall PW, Murphy BA. Core stability exercises on and off a Swiss ball. *Arch Phys Med Rehab.* 2005; 86(2): 242-9.
24. Jerrold S, Batt Jeniffer, Davis. Core muscle activity during exercise on a mini stability ball compared with abdominal crunches on the floor and on a Swiss ball. *Journal of Applied Research.* 2007; 7(3).
25. Robinson, Mark, Lees, Adrian, Barton, Gabor. An electromyographic investigation of abdominal exercises and the effects of fatigue. 2005; 48(11-14): 1604-1612.