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Original Article

Electromyographic Activity Profile of Transverse Abdominis and Multifidus Muscles During Bridging Exercise Variants in Collegiate Cricketers

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Abstract

Purpose: The purpose of the study is to investigate activity of local muscles of the trunk during back bridging exercise using ball (BUB), bridging using sling (BUS) & normal bridging (NB) exercises and conduct the effectiveness of different unstable stable surface during bridging exercise. **Subject:**Twenty nine healthy male cricketers were recruited in the study. **Methods:** The EMG activity of transverse abdominis (TA) and multifidus (MF) were recorded during lifting of the pelvis with legs or feet in contact with the floor, ball or sling using surface electrodes.Normalisationwere done by taken maximal surface EMG activity during maximal voluntary isometric contraction (MVIC) maneuver. The EMG data of each bridging exercise were recorded in percentage MVIC (%MVIC) and analyse using repeated measure analysis of variance. **Results and Discussion:**%MVIC of transverse abdominis during BUB is significantly higher than NB and BUS ($p<0.05$) but no such difference is found in between NB and BUS ($p>0.05$). For multifidus no significant difference was found in any types of bridging exercise. **Conclusion:** The athletic population did not had discernible effects on activity of the local muscles of the trunk by using various unstable surfaces except back bridging using swiss ball.

Key words- bridging exercise using ball (BUB), bridging using sling (BUS)exercise , normal bridging (NB) exercises, EMG, MVIC , transverse abdominis , multifidus

Introduction

Anatomically, the core is the musculature surrounding the lumbar-pelvic region like a natural corset . The core muscles and the thoracolumbar fascia play a role in the stability of the lumbopelvic region1. The definition of spinal stability is not definitive but many researchers have defined it as coactivation of local and global muscles2. Spinal stabilization through the coactivation of trunk muscles is crucial preventing and rehabilitation of damage caused by lumbar instability3. Increase in thedynamic stabilization of this lumbopelvichip complex is gained by the of dual muscular systems1. The local system is based on the muscle consisting which have direct connection to the spine that control inter-segment movement between adjacent vertebrae or act by increasing intra-abdominal pressure. These muscles have short lever arms due to the proximity to the spine and must be activated before the global muscles with the purpose of stabilizing the lumbopelvic region4,5,6,7,8, whereas global muscles are located near the surface and produce power and torque9. Spinal stabilization can be achieved through specific training exercises designed to enhance the coactivation of both local and global muscles. Among such exercise, the back bridging is very common and most frequently used10,11. Numerous studies of stabilization exercises that strengthen spinal stability have been conducted and conflicting result have been presented concerning unstable surfaces12.

Low back pain (LBP) is one of the most common representative musculoskeletal disorder13,14. There is a large emphasis on strengthening the trunk muscles as part of rehabilitation programmes to provide support for the spine in patients with LBP. In patients with acute and chronic LBP, physical deconditioning of the musculature is evident and manifests as muscle atrophy, decreased muscle strength and endurance15. Research has shown localized and unilateral reduced cross-sectional area (CSA) of multifidus in patients with LBP at the painful level16. Active rehabilitation of trunk musculature has been shown to reduce LBP symptoms, increase muscle strength, CSA and

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endurance17,18,19. Bridging exercises are a commonly used form of training the trunk muscles and they can be applied to a large spectrum of patients with LBP10. It was demonstrated that incorporating unstable conditions in these exercises led to increased muscle activation20.

Training devices which challenge stability, such as balls, can be used to increase the difficulty of exercises employing diverse body weight and free-weight resistance21. The use of balls therefore can improve the dynamic balance ability, the flexibility and stability of the spine, and the sense of balance as ways to prevent damage22. Marshall and Murphy23,24 reported that a 12 week regimen of spinal stabilization exercises using balls by LBP patients brought about pain relief and decreases in flexion-relaxation disorders as well as improvements in the ability to control balance through the strengthening of the multifidus muscle, which has an important role in stability. However, other previous studies reported that spinal motions did not change and revealed no increase in trunk muscle activity during core stability exercises on unstable surfaces25,26,27.

In most of sports activities, the human body act as in the form of a kinetic chain and the core serves as the centre of this functional kinetic chain. The kinetic chain is the coordinated, sequenced activation of the body segments that places the distal segment in the optimum position at the optimum velocity with the optimum timing to produce the desired athletic task. On the other hand, stability is required at the proximal part of kinetic chain i.e. the core. For the kinetic chain to function at its maximal capabilities, athletes must maximize the relationship between providing sufficient stability while producing forceful motions of sports performance. Since the core is the central to almost all kinetic chains of sport performance tasks, control of core stability, core strength and motion will maximize upper and lower body extremity function28.

This article aims to determine the effects of using unstable surfaces on the transverse abdominis (TA) and multifidus (MF) activity in athletic population during the back bridging exercise. The study has following Clinical relevance

- ★ Clinically these results may have implications for the selection of the exercises indicated.
- ★ The ball bridging exercise is used as the progressive stabilization exercise after the normal bridging or sling bridging exercise when strength training of trunk is implicated to the athletic population.
- ★ Normal bridging exercise can be easily applicable during stabilization exercise rather than the sling bridging exercise because it required equipment to apply.

Methology

Subject

Twenty nine healthy collegiate male cricketers from JamiaMilliaIslamia and other universities were recruited by convenience sampling aged between 18 to 28 (21.65 ± 3.05) years, 171.41 ± 5.97 cm height, 63.91 ± 10.13 kg weight.The inclusion criteria were healthy cricketer players playing at university level for at least 2 months of training and exclusion criteria were includedlow back pain since 6 months, history of spinal, abdominal and lower limb surgery, history of neurological disorder, pulmonary and cardiovascular dysfunction, scoliosis, kyphosis, ankylosis, limb length discrepancy and postural asymmetry.All subjects gave their informed consent to participate in the study after explanation about nature and procedure of study and all the doubts from the participants were cleared before starting of procedure.

Procedure

Ethical clearance was taken from Institutional Ethical Committee of JamiaMilliaIslamia, New Delhi, by giving details of the research and consent required for the study. Subjects who met the inclusion and exclusion criteria were selected for the study. Prior to participation, all subjects were explained the purpose of the study.Height and weight of the subjects will be measure by digital weighing machine and stadiometer respectively.

Surface EMG preparation

Before the experimental procedure , each subject was prepared for EMG recording . The skin will be prepare by shaving excess hair and rubbing the skin with skin abrasive and alcohol swabs to reduce impedance (typically d" 10 kOhm). Disposable bipolar Ag/AgCl surface electrodes with a diameter of 1cmwere attached parallel to the muscle fibre orientation, unilaterally (the side was randomly selected) over the following so called local trunk muscles:

The inferior fibres of the Internal Oblique (IO) were considered to represent local muscle activity29,30 because it was shown that on the site medial and inferior to the anterior superior iliac spine, the fibres of the transverses abdominis and the IO are conjoined , so a distinction between the muscle signals cannot be made at this location31. The site of the electrode for Transverse Abdominis/Internal Oblique muscles is 2 cmanteromedial from the anterior superior iliac spine32,33 and for lumbar Multifidus is lateral to the midline of the body, above and below a line connecting both posterior superior iliac spines34.

The maximum inter-electrode spacing between the recording electrodes was 2.5 cm as recommended by Ng35. The ground electrode was placed over superior aspect of the left iliac crest of same side11.

Maximal voluntary isometric contractions (MVIC) assessment

The MVIC of the muscles were measured in three trials before the experimental tasks. These exercises were performed to develop readings for EMG signal amplitude normalization36,37,38,39,40,41,42.

Normalization of EMG corresponding maximal EMG amplitude allows inter individual comparison to the individual maximum43. Failure to normalize EMG data before quantitative analysis introduces confounding variables not related to muscle function (for example skin impedance, electrode orientation and amount of subcutaneous tissue)43. Two different isometric exercises were performed in which manual resistance is given. Verbal cues are given to ensure maximal effort.

The maximum activation of the transverse abdominis was recorded when performing a maximal expiratory maneuver with abdominal hollowing in a sitting posi-tion44 (Figure 10) whereas the maximal multifidus activation was obtained by applying manual resistance to the posterior aspect of the scapula while the subject lay in the prone position, with the legs tied to the table to prevent them from moving and the subject was asked to perform trunk extension37,39,40,45,46.

MVIC trials help to ensure a maximum effort throughout the 3 seconds, and the subjects was asked after each MVC that it is the maximum effort. If not, the MVIC will be repeated. MVIC trial will be perform with a 1-minute rest between each trial.

EMG data was collected for the 3-second period of the isometric phase. The MVIC was calculated for the 1 second period that consisted of the highest signal activity44.

Exercise procedures

The subjects executed 3 experimental exercises in a random sequence. All the exercises are performed in supine position. After a specific explanation of each exercise followed by a guided trail, the exercises were recorded. The bridging exercise on the 3 surfaces in supine position is presented. Instructors provided feedback to ensure that a consistent spine and lower limb posture was maintained during the exercise.

Normal back bridging

The subject was supine on the floor, with the feet flat on the ground, knees bent at 90oand toes facing forward. The hands were positioned directly underneath the shoulders, with the fingers facing forward. The angle of the shoulder joint and trunk was approximately 30o and the lumbar spine in neutral position as measured manually by goniometer. The subject raised the pelvis to achieve hip flexion angle to zero degree

Back bridging using swiss ball

The subject was supine on the floor, with the legs and heels in contact with the swiss ball, knees straight and toes facing upward. The hands were positioned directly underneath the shoulders, with the fingers facing forward. The angle of the shoulder joint and trunk was approximately 30o and the lumbar spine in neutral position as measured manually by goniometer. The subject raised the pelvis to achieve hip flexion angle to zero degree .

Back bridging using sling

The subject was supine on the floor, with the ankles were placed in two separate slings that was suspended from the ceiling, knees straight and toes facing upward. The hands were positioned directly underneath the shoulders, with the fingers facing forward. The angle of the shoulder joint and trunk was approximately 30o and the lumbar spine in neutral position as measured manually by goniometer. The subject raised the pelvis to achieve hip flexion angle to zero degree .

At the beginning of the each exercise, a neutral position of lumbar spine was determined by the examiner (anterior and posterior iliac spines in line) and the subject was instructed to maintain this position during all the exercises. To standardize the subject and equipment positions, markers were placed on the floor and the goniometer measured the position.

The dynamic phases, lifting and lowering of the pelvis and the extremities, lasted 2 seconds. The bridged positions in the exercises were held for 5 seconds. The pace of 60 beats/min was set by a metronome. Three trials for every exercise were performed. A pause of at least 15 seconds was allowed between the trials.

Instrumentation

The raw surface EMG signals were band pass-filtered between 10 and 500 Hz and amplified 1000 times. The sampling frequency was 1000 Hz. The signals were analogue/digitally (A/D) stored in a personal computer.

Normalization of data

EMG data were collected during both dynamic and isometric phases of exercise performance. The root-mean-square (RMS) of EMG amplitude was calculated for a second period of the isometric phase of each exercise. The mean RMS of three MVC trials for each muscle was used to provide a basis for EMG amplitudes normalization of data obtained during the experimental exercises (%MVC). The static phase of the experimental exercise were analysed, using mean of three trials of different exercise for each muscle of 4700-4800 ms after starting point of the holding position. The mean of root mean square (RMS) for the 3 repetitions of different bridging exercises after normalization (%MVC) were used for the comparison.

Data Analysis

The SPSS version 21.0 software program was used for the data analysis. The Shapiro-Wilk test was used to verify the normality of variables distribution. When the requirements did not met to normal distribution then the data was log transformed. After that one way analysis of variance (ANOVA) with repeated measures was used to compare the difference in transverse abdominis and multifidus during back bridging exercises using 3 different surfaces. And post hoc least significance difference (LSD) tests was performed using Bonferroni correction were used for the analysis significant differences between individual muscles in each exercises. We also used paired t-test for the analysis of the significant differences in between the two muscles concerning both MVIC and experimental exercises. The confidence interval used was 95% with level of significance was set at $p<0.05$.

Results

Activation of transverse abdominis in BUB was significantly higher than the NB and BUS ($p<0.05$), whereas no significant difference was found in between NB and BUS ($p>0.05$) . No significant difference were found in the activation of multifidus in variants types of back bridging exercises ($p>0.05$) . In comparison between TA and MF, there was significantly lower activity of transverse abdominis with the multifidus in all variants of bridging exercise $p<0.05$.

Discussion

The aim of this study was to evaluate the muscle activity during performance of sets of bridging stabilisation exercise. Due to this investigation, the exercises are supposed to be helpful for the stabilization at lumbar region, so that the kinetic chain to function at its maximal level for the sports activities. It is important to understand the muscle activity in healthy athletic conditions. In the current study the muscle activity is expressed as relative EMG (%MVIC). Some researcher and clinicians reported that the optimal stabilization of the lower back during basic stabilization exercise may be created by good activation of the local muscles5,47,48,49. The present study explored the effects of using different support surfaces for the back bridging exercise on the activity of transverse abdominis and multifidus muscles.

The current study shows no significant differences in between MVIC of the transverse abdominis and multifidus ($p>0.05$), whereas Stevens et al11 found MVICs of the abdominal muscle and back muscles did not differ significantly except MVIC of RA is higher in comparison with the MVIC of the IO and EO which is similar to current study.

oncerning transverse abdominis muscle, the present study found that the activity in Bridging exercise using ball is significantly higher than the Normal Bridging exercise and Bridging exercise using Sling ($p<.0.05$) which is still a question of debate that previous studies have increased20 as well as unchanged10,12 in the activity of the ball bridge exercises. However, they have reported about the activity of internal oblique. Stevens et al11researched on the various bridging exercise (normal bridging, ball bridging and unilateral bridging exercises) in healthy adults to compare %MVIC showed higher %MVIC values in the unilateral bridging than in the normal bridging and ball bridging. In addition to this, the ball bridging had increased %MVIC values of IO (local muscle), RA, and ES than normal bridging which is quite similar to this study considering transverse abdominis, one of the local muscles. Imai et al44 found that the RA, TA, EO, ES and MF were highly activated during an elbow-toe exercise on unstable support surfaces. They did not find any significant difference in the back bridging when performed on an unstable support surface which is contrast with the result of present study. However, the back bridging exercise describe in latter studies were performed with the feet flat on the ball, in contrast to them the lower calves were positioned on the ball in the present study. Due to the calf positioned on the ball there might be higher activation of transverse abdominis to prevent the limbs from rolling of the ball and making the trunk to more stable position by increased intra-abdominal pressure via tension produce in the thoracolumbar fascia50,51.

The present study reported no significant difference in the activation of TA in bridging exercise using sling and normal bridging (*p* = *1.000*) which is different in previous study reported %MVIC values of the IO, RA, MF and ES muscles during sling bridging exercise were significantly higher than those during the ball bridging and normal bridging exercise52, the study is conducted on the low back pain patients, making it difficult to apply on the healthy athletic adults. Stuge et al53 reported that the use of sling exercises increases the use of local muscles focussing on transverse abdominis, internal obliqus and multifidus, whereas Dannelly et al54 reported that application of the sling exercise is closed to kinetic chain exercise method that contributes to balance improvement because it uses both local and global muscles, present study only consider about the two common local muscles.

In this research, there is no significant difference in the activation of multifidus in all different ways of bridging exercises ($p > 0.05$), which is similar to the previous studies11,44. Lehman, Hoda& Oliver10 and Kim & Kim12 also reported no difference in the activation of erector spinae during stable and unstable back bridging exercises. In addition to this, other study also shows no difference in the activities of trunk muscles were seen in various stabilization exercises with the swiss ball23. Kang, Jung, Yu52 research showed higher %MVIC values in the MF muscle in back bridging exercise using sling than those other two positions and also ball bridging exercise is higher than the normal bridging exercise which is different in the present study. However, the study is done on the low back patients. Behmet al20 also claimed the unstable surface using ball have higher activity in erector spinae during supine bridging exercise.

This study shows that the ball bridging is probably more effective than normal bridging as well as bridging exercise using sling in terms of stabilization of the trunk due to disturbed in balance because of ball rolling whereas no difference in multifidus. The ball used in the study was 55cm in diameter and the sling length form the ceiling to the leg was around 1m 50 cm. The sling length was lesser might be the limitation of the study because the increment in the moment arm result into increased in instability52but it is clear that the mechanism of the ball exercise is better than the sling exercise.

The study also mentioned about the difference between the activation of multifidus and TA which is found as higher activation of MF as compare with the activation of the TA in all types of the bridging exercises ($p < 0.05$). The previous studies mentioned about the activation ratio of IO/RA have highest values compared to the other abdominal and back muscle activity ratios during bridging exercise11 which is similar to current study. Carvalhoet al55 was reported difference in activation ratio of TA and MF during various Pilates exercises. This suggests that there is a force creating a trunk into the extension (i.e. gravity attempts to decrease the lordosis which is resisted by the muscle activity) due to fact that the centre of mass of the trunk and head segment comes closer to the axis of the trunk. The amount of muscle activation required for stability of the trunk varies to the spinal posture and spinal stiffness. Thus, stability either as a constraint or as part of a physiological cost function which might provide more physiological coactivation patterns and better activities of safe postures during unstable loads.

An important observation from all exercises tasks was large variability in muscle activity between subjects that can greatly influence the interpretations of the results. This indicates that some subjects shows large changes in the muscle activity while some showed minimal changes when change in the to exercise was done. It could be due to subjects volitionally contracting their trunk muscles to provide stability while others may have not. It is also possible that individuals may be able to influence their trunk muscle activity through verbal encouragement and EMG feedback.

Perspective for future study

★ Biomechanical model including kinematic data with subsequent force data to determine the