THE EFFECTS OF CORE STABILITY TRAINING ON THE FUNCTIONAL MOVEMENT SCREEN AND POSTURAL STABILITY IN COLLEGIATE STUDENTS

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This study evaluated effects of core stability training (CST) on the functional movement screen (FMS) and postural stability (PS) in healthy young collegiate students. 28 healthy collegiate female students were assigned to an experimental (CST exercises twice a week for six weeks) or control group (equal time of warm-up and stretching exercises only). The CST combined Pilates and Swiss ball exercise for fifty minutes, twice per week, for six weeks. FMS scores were evaluated by a certified professional. The PS was evaluated by the 8-direction limits of stability (LOS) test using the Biodex Balance System. Repeated measures analyses of variance (ANOVAs) revealed the FMS and LOS performances in the experimenat group were significantly improved after training. It was concluded that regular CST can improve the performance of FMS and dynamic postural stability in healthy young students.

KEY WORDS: balance control, limits of stability, core training.

INTRODUCTION: Postural stability (PS) may play an important role in injury prevention and in athletic activities. Stability is preserved through the dynamic integration of internal and external forces and environmental factors. Greater core stability may benefit sports performance by providing a foundation for greater force production in the upper and lower extremities (Omkar, Vishwas, & Tech, 2009). Core stability training (CST) targets the muscles deep within the abdomen which connect to the spine, pelvis and shoulders, to assist in the maintenance of good posture and provide the foundation for all arm and leg movements (Akuthota, Ferreiro, Moore, & Fredericson, 2008). On a more significant note, muscle power is derived from the trunk region of the body and a properly conditioned core helps control that power, allowing for smoother, more efficient and better coordinated movement in the limbs (Wang, Lin, Huang, Liang & Lee, 2012).

The Functional Movement Screen (FMS) was developed by Dr. Gray Cook (Cook, Burton & Hogenboom, 2006a & 2006b) and consists of 7 different body movements to assess: trunk and core strength and stability, neuromuscular coordination, asymmetry in movement, flexibility, and dynamic flexibility. The FMS evaluates the efficiency of movement patterns rather than the quantity of repetitions performed or the amount of weight lifted. It measures the quality of the movement based on specific criteria and identifies asymmetry in one's selected test movements. In addition, the FMS also provides a visual-identification score guidance and immediate feedback, and can be easily administered in all kinds of facilities and environments. It is a simple, rapid, non-invasive, and inexpensive training program and/or evaluation method of physical condition. The aim of this study was to examine the effects of regular CST on FMS scores and PS performance in collegiate female students.

METHODS: Twenty-eight healthy collegiate female students volunteered to participate in the study, and were randomly assigned (14 athletes in each group) to the experimental group (162.5 ± 3.2 cm, 51.3± 3.7 kg, 20.1 ± 1.1 yrs) or the control group (161.79 ± 4.3 cm, 52.1 ± 3.4 kg, 20.1 ± 1.4 yrs). All participants completed a self-report health history questionnaire and signed an informed consent before testing. Any participant self-reporting the presence of any injury or impaired physical condition within the last 6 months was excluded from the study.
The CST program used in the experimental group was a synthesis of findings derived from published conditioning and injury prevention research. The CST combined Pilates mat (Teaser, Swimming, Leg Pull Front, The Hundred, The Roll Over, and Shoulder Bridge One

Leg Lift Exercise, etc.) and Swiss ball exercises together (bridge, plank, V-up, and crunch, etc.) in fifty minutes, twice per week, for six weeks, including warm-up exercise. The CST program consisted of three progressive phases with the major goal being to strengthen the abdominal and lower limb musculature.

The FMS was performed by an exercise instructor who has completed FMS level 1 Certification. The 7 different movement tests of FMS: deep squat (DS), hurdle step (HS), incline lunge (ILL), shoulder mobility (SM), active straight leg raise (ASLR), trunk stability push-up (TSPU), and rotary stability (RS), were fully described and performed before each test. Each subject was then assessed for performance and an FMS score provided.

When the FMS is performed, 5 of the 7 tests (HS, SM, ASLR, TSPU, and RS) are scored independently on the right and left sides of the body. Due to the relationship between neuromuscular asymmetry and injury risk (Kuenze et al.), the FMS scoring system highlights asymmetry and takes the lowest score of 2 as the overall score for that movement. For example, an ASLR score of 3/3 on the left leg and 2/3 on the right gives an overall score of 2/3 on the ASLR movement. No complications or adverse events occurred during testing and/or data collection.

PS was evaluated by the Biodex Balance System (BBS, Biodex Medical Systems, Shirley, NY, US), which comprised of a multi-axial foot platform connected to a computer and a screen located in front of the subject. The magnitude and direction of the displacement of the tilting platform can be monitored by cursor movement on a computer screen. In this study, the subjects performed the dynamic limit-of-stability (LOS) protocol, a task requiring them to control a cursor on a computer screen by moving the foot platform, such that the cursor moves back and forth from a central box to eight peripheral boxes appearing successively in random order.

Subjects were tested bilaterally at level 3 of the platform control difficulty. Prior to performing the experimental measures, subjects were familiarized and asked to adopt a standardized foot position on the platform. The LOS score was calculated for each direction according to the percentage between the straight line distance to target and the number of samples. The LOS score was calculated as follows: score = (shortest linear displacement between the central and target boxes/total distance between the central and target boxes)*100. The overall LOS score (calculated as the average of the LOS scores corresponding to each of the eight directions) was also calculated. A larger score represented better dynamic PS and the mean of the two trials were used for data analysis.

All statistical procedures were performed using SPSS version 12 for Windows (Chicago, IL, USA). Eighteen 2 × 2 (group × training) repeated measures analyses of variance (ANOVAs) were conducted to determine if any differences existed between groups (CST group versus control group) and time of testing (pre-training versus post-training) for overall LOS score and the eight individual directions LOS scores. The overall LOS score and the eight individual directions LOS scores at two different stability levels were the dependent variables, with training an independent variable. An alpha level = .05 was set to determine significance level for all analyses.

RESULTS: The compliance rate for training program participation was 91%. The overall LOS scores for the experimental group and the control group pre- and post-training changed from 16.2 ± 9.8 % to 23.5 ± 5.1 % ($P < .05$) and 16.9 ± 6.5 % to 16.6 ± 8.7 %, respectively. Additionally, the results of the ANOVA for each direction of the LOS score indicated a statistically significant interaction between group × training in the forward ($P < .05$), left ($P < .05$), right ($P < .05$), forward-right ($P < .05$), and forward-left ($P < .05$) directions, and a main effect for training, with post-training performance being better than pre-training in the experimental group. Further, the results of the ANOVA for each movement test of the FMS score also returned a statistically significant interaction between the variables of group × training for the; in-line lunge ($P < .05$), active straight leg raise ($P < .05$), trunk stability push-up (*P* < .05), and rotary stability (*P* < .05), and the main effect for training, with post-training performance being better than pre-training in the experimental group.

DISCUSSION: Functional movement is the ability to produce and maintain balance between mobility and stability along the kinetic chain while performing fundamental patterns with accuracy and efficiency. A previous study suggested poor PS or balance as a risk factor for lower extremity injury (Mckeon & Hertel, 2008), therefore, we assessed postural stability through tests that elicited static and dynamic balance control and neuromuscular contractions of the trunk musculature (Lee & Lin, 2008; Lin et al., 2009). The finding of this study demonstrated statistically improved performance in the FMS and LOS test in the experimental group after regular CST.

The assessment of fundamental movements is an attempt to pinpoint deficient areas of mobility and stability that may be overlooked in an asymptomatic active population. The ILL requires appropriate stability and dynamic control of the pelvis and core within an asymmetrical hip position.The ASLR tests the ability to isolate the lower extremity from the trunk while maintaining stability in the torso, and therefore assesses active hamstring and gastroc-soleus flexibility while maintaining a stable pelvis and active extension of the opposite leg. The TSPU tests the ability to stabilize the spine in an anterior and posterior plane during a closed-chain upper body movement, and assesses trunk stability in the sagittal plane while a symmetrical upper-extremity motion is performed. The RS observes multi-plane pelvis, core and shoulder girdle stability during a combined upper and lower extremity movement.

This study showed that the score of the ILL, ASLR, TSPU, and RS was improved following regular CST, demonstrating that CST might enhance the dynamic control of multi-plane stability in the pelvis and the lower extremities, improved the stability in the trunk torso and the anterior and posterior motion of the spine. This resulted in improved the postural stability during the dynamic LOS testing. Many functional activities in sport require the trunk stabilizers to transfer force symmetrically from the upper extremities to the lower extremities, such as rebounding in basketball, overhead blocking in volleyball, or pass blocking in football. If the trunk does not have adequate stability during these activities, kinetic energy will be dispersed and lead to poor functional performance (Cook, Burton, and Hogenboom, 2006b).

Previous studies investigating the measurement properties of the BBS tested the dynamic PS (Costa, Graves, Whitehurst, & Jacobs, 2008). Testing in the dynamic LOS mode seems to be more demanding than testing in the static balance mode (Perron, Hebert, McFadyen, Belzile, & Regniere, 2007), since subjects have to maintain balance while actively controlling joint movements in the functional limits of their range of motion. Further, the LOS test was designed to measure the ability of subjects to actively control the ankle and proximal joints to the limits of their functional range of motion, while keeping balance on a multi-directionally unstable surface.

Moreover, significant improvements in the LOS test were found in the overall, forward, left, right, forward-left, and forward-right directions, which supports the hypothesis that CST can improve lower extremity coronal and sagittal plane control (Myer, Ford, Brent, & Hewett, 2006). These direction-specific benefits might be related to the movement of training exercises which were utilized in this study, and might improve lower extremity coronal and frontal plane dynamic control during the LOS test in an unstable condition. Further, the findings of this study also provided support for this hypothesis, showing that core training could facilitate voluntary active postural and lower extremity corrections during the unstable LOS test. However, it is acknowledged that there is little evidence linking performance on the FMS and BBS, and definitive injury risk. Subsequently more studies are required to establish this relationship.

CONCLUSION: This study demonstrated that six weeks of core strength training can improve an individual's functional movement screen performance and the dynamic postural stability in healthy young students.

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ACKNOWLEDGEMENT: This study was supported by grants from the Ministry of Science and Technology (MOST) and the National Tsing Hua University, TAIWAN, R.O.C.