The Effects of Eight-Week Pilates Training on Limits of Stability and Abdominal Muscle Strength in Young Dancers

Yen-Ting Wang, Pao-Cheng Lin, Chen-Fu Huang, Lung-Ching Liang, and Alex J.Y. Lee*

Abstract—This study examined the effects of 8-week Pilates training program on limits of stability (LOS) and abdominal muscle strength in young dancers. Twenty-four female volunteered and randomly assigned as experimental group (EG) or control group (CG). All subjects received the same dance lessons but the EG underwent an extra Pilates mat exercises for 40 minutes, three times a week, for 8 weeks. LOS was evaluated by the Biodex Balance System and the abdominal strength was measured by 30/60 seconds sit-ups test. One factor ANCOVA was used to examine the differences between groups after training. The results showed that the overall LOS scores at levels 2/8 and the 30/60 seconds sit-ups for the EG group pre- and post-training were changed from 22/38 % to 31/51 % and 20/33 times to 24/42 times, respectively. The study demonstrated that 8-week Pilates training can improve the LOS performance and abdominal strength in young dancers.

Keywords—Balance, Core Strength Exercise Training, and Posture Stability.

I. INTRODUCTION

DANCE is not only a performing art, but a highly rigorous athletic sport that is one of the most physically and mentally demanding athletic sports in the world [1]. Dancers are a unique group of athletes in that they execute physically challenging movements while making them look beautiful and artistic. This performance ability requires a high level of fine motor control and core stability.

In general, dancers usually spend 17 to 29 hours per week in organized rehearsals for a typical company [2]. In addition, the core muscles generate power and transfer it to the limbs, then also responsible for protecting the spine, muscles in this process are the spinal flexors and extensors, which offer adequate support of the spine edge, spine borne dispersion burden and allows the limbs to potential increase in power. If Without proper muscle power and explosive strength, it is hardly to perform well but easily get injury.

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The Pilates Method was originally developed by Joseph Pilates during the First World War and brought to the United States in 19 century. The initial concept mixed elements of gymnastics, martial arts, yoga and dance, focusing on the relationship between body and mental discipline [3]. More recently, the traditional elements of the Pilates have been updated and incorporated into physical training and fitness, which focus on efficient movement, core stability and enhanced performance [4]. In this respect, Modern Pilates mat exercises resembles the theory of weight training to gain optimum strength and endurance [5].

Despite the increased popularity of Pilates mat exercises within the last two decades, however, little research has been conducted on the method and its benefits in dancer population. Furthermore, further original research is necessary to ascertain the benefits potential of Pilates mat exercises on dynamic postural control and abdominal strength in dancers. Therefore, the purpose of this study was to investigate the effects of eight-week Pilates mat exercise training on limits of stability (LOS) and abdominal muscle strength in young dancers.

II. METHODS

The subjects in EG were underwent a series of Pilates exercise program which trained 3 times a week, for 40 minutes, and a total of 8 weeks. Guidelines from the United States aerobic fitness association was followed, including warm-up exercise, the main movement along with three phases, (beginning, intermediate and advanced) in order promote a progressive manner, and impose different intensity at different stages of the training protocol as well as strengthen the abdominal muscle strength and lower limb muscle strength. A physical education and sports instructor who had 2 years of experience in Pilates mat exercises initiated the exercises.

The Limits of stability (LOS) was evaluated by the Biodex Balance System which offers four testing and five training modes (BBS, BIODEX Medical System, New York, USA). The BBS allows testing and training in both static and dynamic formats. Using this device, clinicians can assess neuromuscular control by quantifying the ability to maintain dynamic bilateral and unilateral postural stability on a static or unstable surface. The two-leg stance balance test was performed with the BBS, which comprises a multi-axial foot platform connected to a computer and a screen located in front of the subject. The magnitude and direction of the displacements of the tilting platform can be monitored with the help of a cursor moving on the screen.

In this study, the subjects carried out the dynamic limit-of-stability protocol, consisting of moving the cursor (platform) back and forth from a central box to eight peripheral boxes appearing successively in a random order on the screen. The BBS offers several levels of difficulty from L1 (most unstable) to L12 (most stable), which determines the rate of deflection of the platform. Prior to performing the experiment measurements, subjects were familiarized with proper practice. During the test session, subjects warmed up for 5 to 10 minutes on running and performed dynamic stretching lasting approximately 12 seconds for each lower muscle group. The LOS was evaluated with the Biodex Balance System protocol under level 2 and level 8. The performance is based on their ability to accurately move the display cursor to a target 10 degrees from a level platform position and back to level again. The subject was instructed to start moving the cursor toward the flashing target. The cursor had to stay within the center point for a minimum of 0.5 seconds before it disappeared and showed the next target on the screen. Each trial ended when the eight target points had been reached and cursor was return to the center point.

The dynamic LOS score was calculated for each direction according to the percentage between the straight line distance to target and the number of samples. The individual dynamic LOS was calculated as follows:

$$\text{Direction LOS score (\%)} = \frac{\text{Straight line distance target}}{\text{Actual distance traveled}} \times 100$$

$$\text{Overall direction LOS score} = \sum_{i=1}^{i=8} (DLOSScore)$$ or the average of the eight targets.

Therefore, more direct the path to the target and back to center; the higher score will be achieved. The variables chosen for the balance tests were the overall and the eight individual dynamic LOS score for each trial which calculated by the System. Abdominal strength was evaluated by 30 seconds and 60 seconds sit-ups test. Subjects were prepared by lying supine on the mat, arms across the chest, hands placed gently on the shoulders, knees at 90 degrees and feet flat on the ground. The subject laid down on a mat with their knees bent at right angles and their hands were folded over their chest. The subject's ankles were firmly held by a partner for support. The partner maintained count of how many sit-ups were performed. For a complete repetition, sit-up was performed to approximately a 30 degree angle, to touch the knee, and then the subject returned to the starting position. The subjects were instructed to not arch their back during the exercise and to keep their arms flat against their chest. The duration of this test lasted one minute. The subjects were instructed to do as many repetitions as possible. Repetitions were recorded in the middle (30 seconds) and at the end (60 seconds) of the test.

All statistical procedures were performed by using SPSS version for Windows 12 (Chicago, IL, USA). A mixed design, one-way ANCOVA was used to evaluate the difference between groups after training for each parameter.

The statistic significance was set at $p < .05$.

III. RESULTS

The overall LOS scores for the EG group at levels 2 and 8 pre- and post-training changed from 22.6±8.3% to 31.3±9.0% and from 38.2±9.1% to 50.6±8.8%, respectively. The overall LOS score for the CG at levels 2 and 8 in pre- and post-training changed from 26.3±10.5% to 27.3±11.2% and 38.2±13.8% to 50.3±14.4%, respectively. The results of the ANOVA for the overall、right and left direction LOS scores at level 2 (Figure 1) indicated a significant interaction between the trained/untrained groups × pre/post repeated measures with post-training scores higher than pre-training scores in the EG (F=11.06、8.93 & 4.98, $p < .05$).
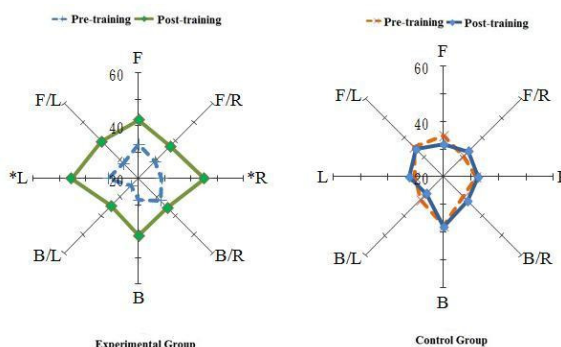

Fig. 1 LOS scores in each direction between groups at level 2 before and after training.

After eight weeks of Pilates exercise training, the average 30 seconds sit-ups in the EG and CG were 20.1 ± 5.1 times and 18.8 ± 2.8 times in pre-training, and changed to 24.4 ± 4.5 times and 21.6 ± 2.4 times after the eight weeks period. The average 60 seconds sit-ups in the EG and CG were 33.0 ± 11.4 times and 33.1 ± 7.6 times in pre-training, and changed to 42.4 ± 8.5 times and 34.8 ± 9.5 times after the eight weeks period. The results of the ANCOVA for the 30/60 seconds sit-ups tests (Figure 2) indicated a significant interaction between the trained/ untrained groups × pre/post repeated measures with post-training scores higher than pre-training scores in the EG (F = 6.04 & 6.11, $p < .05$).
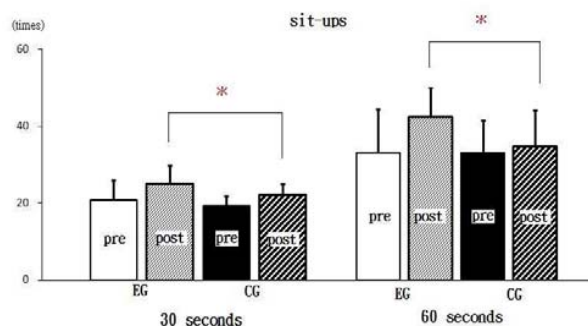

Fig. 2 30/60 seconds sit-ups performance between groups before and after training

IV. DISCUSSION

With regard to the results of this study, Pilates mat exercises training were found to be an efficient training method with significant changes in LOS performance and the abdominal strength in young female dancers. In dancers, intact muscular coordination and well-balanced antagonists could be decisive factors for excellent performance and in protection against injury. Insufficient muscle strength and poor postural stability could lead to an injury and destroyed its peak performance.

Previous studies investigating the measurement properties of the BBS tested the dynamic postural stability [6, 7]. To our knowledge, our study was the first to investigate the effects of Pilates training on dynamic postural stability in the LOS mode. Testing in the dynamic LOS mode seems to be more demanding than testing in the static balance mode [8, 9], since subjects have to maintain balance while actively controlling joint movements in the functional limits of their range of motion. Furthermore, 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.

The finding of this study showed significant improvement in the overall performance on the unstable, level 2 LOS test indicates that a 8-week period of Pilates training can improve dynamic postural stability. This study provided support for this hypothesis, since it showed that Pilates training could facilitate voluntary active postural and lower extremity corrections during the unstable LOS test. In addition, One recent study have indicated that Pilates training can enhances the control of trunk movement, and improves the jump neuromuscular coordination of movements, thus enhancing the overall jump performance [10].

This study also demonstrated that regular Pilates training can improve the abdominal strength that consisted with previous study [11] which carried out in middle aged female subjects trained three times a week for 5 weeks significantly increased their 1-minute sit-up performance (14.0 times vs. 29.2 times) confirming and support that Pilates mat exercise increase muscular endurance. Furthermore, another study [12] also verified this and also indicated that the transversus abdominis is mainly, which helps maintain better lumbo-pelvic control.

Core muscles are located in the vertebral column and around the abdominal cavity. Depending on the role and properties of the core muscles it can be divided into deep and shallow core muscles, the former covering the transversus abdominis (TrA) and the multifidus muscle, while the latter contains the rectus abdominis, abdominal oblique muscle, external oblique, and lumbar paraspinal muscles. This study also indicated that Pilates training not only improve the core muscles strength, but also can improve the stability of the body movement during the LOS test which requires the well coordination of the upper and lower extremity limb, because a recent studies also indicated that Pilates training can enhances the control of trunk movement, and improves the jump neuromuscular coordination of movements [10].

One recent study also demonstrated that both TrA and obiliduus internus muscles were significantly thicker during performed Pilates exercises investigated compared with resting supine. It is suggesting that this thickness increase indicates muscle activity, possibly in order to help stabilize or protect the spine [13], therefore, Pilates exercises investigated activate the deeper abdominal muscles. An abdominal hollowing action has been shown to give muscle activity suitable for lumbo-pelvic stability, and has the ability to dissociate activity in the TrA and internal oblique muscles from that of the rectus abdominis. Furthermore, when either an abdominal hollowing or gym exercise including abdominal curl activities was performed over a 10-week programme, rectus abdominis EMG activity increased in the abdominal curl group [14]. Therefore significant improved abdominal strength and LOS performance may be due to a motor learning recruitment of the rectus abdominis. This should be considered in further research.

This study demonstrated that eight weeks Pilates exercise can significantly improve the LOS and abdominal strength in young dancers. Therefore, Pilates exercise is beneficial and should be implemented into elementary dance curriculum. To verify this hypothesis, more research is still needed to determine the effectiveness of Pilates and its ability to reduce lower extremity impact injuries.

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