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Effects of Hula Hooping Exercise on Lumbar Stability Level and Transversus Abdominis Function in Asymptomatic Individuals with Poor Lumbar Stability

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ABSTRACT

Kiatkulanusorn S, Luangpon N, Suato BP, Sobhon P. Effects of Hula Hooping Exercise on Lumbar Stability Level and Transversus Abdominis Function in Asymptomatic Individuals with Poor Lumbar Stability. **JEPonline** 2020;23(1):1-14. The purpose of this study was to compare the effects of hula hoop exercise (HE) and core stabilization exercise (SE) on lumbar stability level and transversus abdominis (TrA) function in subjects with poor lumbar stability. Forty-five healthy participants exhibiting poor lumbar stability were randomly allocated into HE, SE, and control groups. The HE and SE groups attended the exercise sessions 3 times·wk^{-1} over a 4-wk period. Lumbar stability level was assessed via a modified isometric stability test (MIST). TrA function was measured via a prone test and reported in terms of absolute and classified TrA. The results revealed that the effects of time on MIST and absolute TrA in the SE and HE groups (P<0.001) with statistically significant differences in MIST from baseline to post 3- and 4-wks of training [2(2,2) to 3(3,5)], and absolute TrA from baseline to post 4 wks of training (2.31 ± 0.61 to 3.11 ± 0.81 and 2.36 ± 0.71 to 3.20 ± 1.30). MIST and absolute TrA demonstrated significant differences between the Control, SE, and HE Groups post 3 to 4 wks of training (P<0.05). Classified TrA was statistically significantly different from baseline to post-training amid SE training only (0% vs. 53.33%). The SE and HE programs enhanced TrA function and lumbar stability resultant of restoring neuromuscular control in those with poor lumbar stability.

Key Words: Core Stabilization Exercise, Hula Hooping Exercise, Lumbar Stability, Poor Core Stability, Transversus Abdominis Function

INTRODUCTION

Core stability refers to a person’s capacity to control the lumbopelvic-hip complex in an optimal position in addition to movement during the entirety of human movement. Accordingly, good core stability provides improved balance, good posture, and a greater efficiency and effectiveness in regards to all other movement. Therefore, core stability training has become widely focused on for injury prevention and enhanced performance in both the general population and athletes (1,4,23,27). Moreover, poor spinal stability has been identified as a pathological marker for lower back pain (LBP) (14), consequently, exercise in order to specifically contribute to spinal stability has become widely implemented in both prevention and rehabilitation programs concerned with LBP management (1,3,4,21,23,27,34).

The core muscles should to be made the primary focus of training for injury prevention, rehabilitation, and performance enhancement. These muscles have been categorized as global and local muscles. Global muscles refer to superficial muscles that function during movement; whereas, local muscles refer to deep muscles that primarily function to control movement and maintain static stabilization. The transversus abdominis (TrA) muscle is a deep abdominal muscle considered as a local spinal stabilizer (23,27). Lower back pain (LBP) patients have been shown to be significantly affected during TrA recruitment in terms of delayed activation, poor EMG activity, and lower muscle thickness which, consequently, affect spinal stability (6,11,12). These dysfunctions of the TrA have been defined as an impaired neuromuscular system to control postural stability and undesirable loads on the spine (22,24). Therefore, exercise training to improve TrA function has been widely concentrated on in relation to core stabilization exercise (17,29,30).

Globally, hula-hooping has long been a popular exercise partly due to the fitness benefits it offers in all age groups. Moreover, it is an easy, fun, low-impact, high-energy workout. It also offers wide variability in that it can be incorporated into a fitness class, individual practice at home, or as a group exercise in a community setting. Hula hoop exercise needs inexpensive equipment and does not require reinstruction from professionals during the training program. In Thailand, it has been recommended as regular exercise for the general population by the Division of Physical Activity and Health, Department of Health, Ministry of Public Health (7). What’s more, it makes up part of physical education for elementary school children in some countries (15).

Hula hooping is a complex function that requires proper organization and movement of the body in order to maintain an unstable object amid stable oscillatory motion. During hula hooping, the hula hoop moves around the waist parallel to the ground. The angular momentum of the hoop is presented as vertical and horizontal components of which the performer must manipulate the hoop’s oscillation amplitude and frequency with synchronicity throughout the hips, knees, and ankles during oscillatory movement. Simultaneously, the torso is organized in an almost straight or neutral position with minimal movement in addition to co-contraction of the torso muscles to maintain a consistent swing of the hula hoop around the waist. Various muscles are activated during hula hooping that include the torso muscles, lower abdominals, erector spinae, and muscles of the hips, knees, and ankles (2,5). Therefore, hula hooping is widely believed to be an excellent form of aerobic core training. Several previous studies (13,16,18,26,28) have demonstrated the positive effects of hula hoop exercise on weight loss, waist and hip circumference, lipid profile, body composition, muscle strength and flexibility, core muscle mass, and core strength. Interestingly, one previous quasi-experimental study showed that hula hooping was able to enhance TrA function, strengthen superficial back and abdominal muscles, and improve lumbar stability level (13). Nevertheless, no previous studies have incorporated Randomized Controlled Trials (RCT).

The purpose of this study was to examine the effects of hula hoop exercise (HE) on lumbar stability level and transversus abdominis (TrA) function in asymptomatic individuals with poor lumbar stability via a RCT design.

METHODS

Subjects

Healthy males and females aged roughly 18 to 26 yrs with poor lumbar stability who achieved a level of 1 to 2 in the Modified Isometric Stability Test (MIST) were recruited (32). The MIST of all the subjects was examined by the physical therapist with 10 yrs experience in the musculoskeletal field. The exclusion criteria were as follows: (a) a history of lower back pain in the previous 3 months; (b) a history of spinal trauma or spinal or abdominal surgery; (c) performed other exercise prior to protocol-outset; (d) a history of hula hoop exercise or core stabilization exercise in the 6 months prior; (e) could not maintain the hula hoop at waist level for at least 20 min with the correct technique; or (f) could not understand the core stabilization exercise.

Procedures

Design and Randomization

This study took the form of a single-blinded randomized controlled trial (RCT) with the protocol approved by the Human Ethics Committee of Burapha University (protocol no. sci 086/2560, approval no. 212/2560) and registered to the Thai Clinical Trials Registry (TCTR20191025001). This study was conducted from March to August, 2018 at the Physical Therapy Laboratory in Burapha University, Chonburi, Thailand. All participants received written and verbal information about the study, and they provided written inform consent prior to study allocation.

Fifty-six Burapha University students were recruited as volunteers. Eleven volunteers were excluded based on the inclusion and exclusion criteria prior to allocation as shown in Figure 1. Therefore, 45 participants with low lumbar stability were randomly assigned to 3 groups: (a) Control Group; (b) Core Stabilization Exercise (SE) Group, and (c) Hula Hoop Exercise (HE) Group. The subjects' demographic characteristics and baseline data are shown in Table 1.

The subjects were randomly assigned to each group by Researcher #1. Random allocation was performed via a simple random method. Each of the three Group names was written and concealed in similar looking packets. Each subject was asked to randomly select a packet that assigned him or her to a specific group. The SE and HE Groups were assigned training by Researcher #1 who had experience as a physical therapist for over 5 yrs. The subjects' variables at baseline and throughout the study were determined by the same physical therapist (Researcher #2) and recorded by another physical therapist (Researcher #3).

Researchers #2 and #3 were unaware of the specifics of group allocation. The subjects were requested not to discuss their randomization assignment with Researchers #2 and #3.

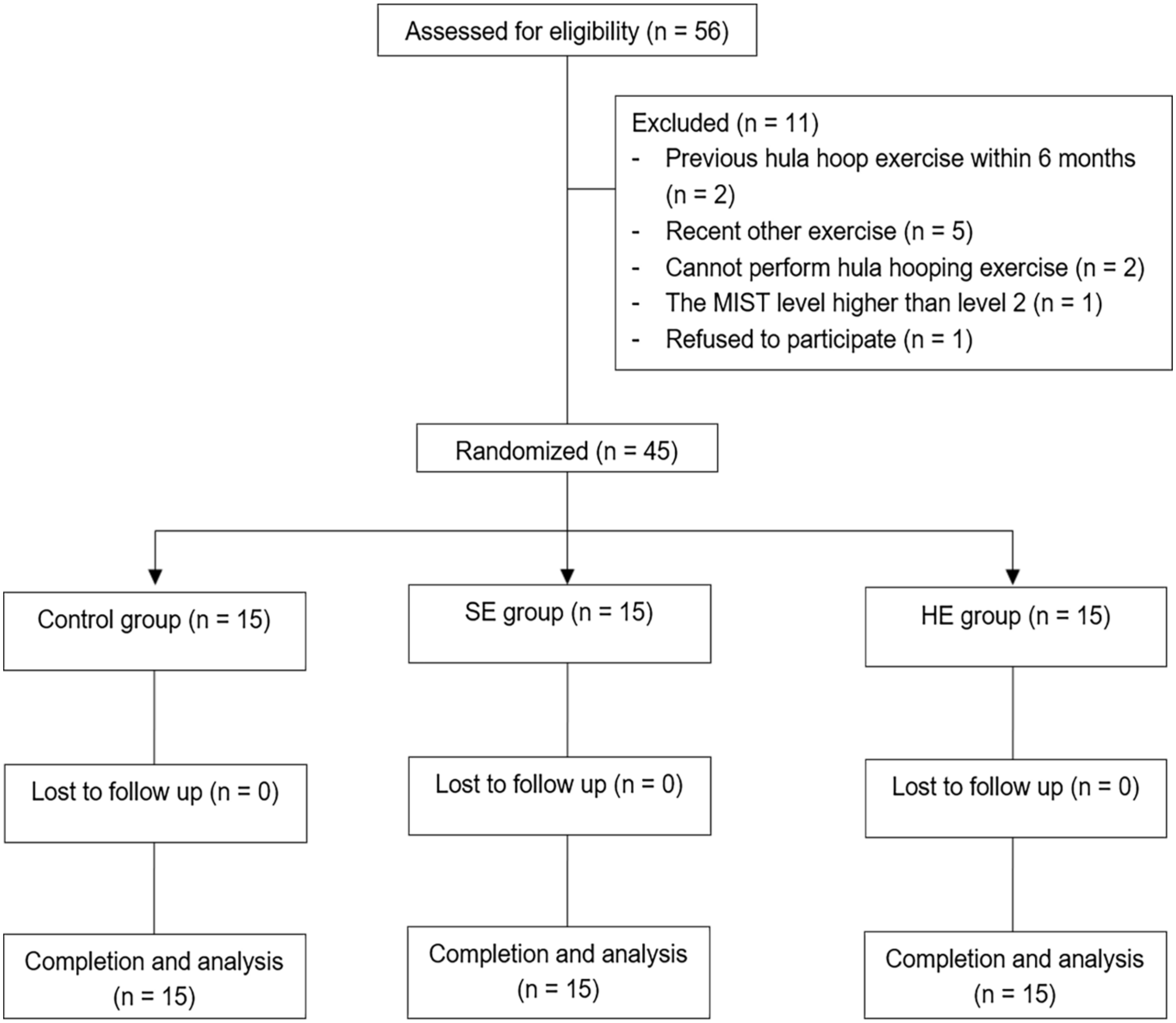

Figure 1. CONSORT Flow Diagram. HE = Hula Hooping Exercise; **SE** = Stabilization Exercise**; MIST** = Modified Isometric Stability Test

Interventions

The intervention groups, SE and HE trained 3 times a week for 4 consecutive weeks. The training period for each session was 40 min, which included a 5-min warm up, 30 min of training, and 5 min of cool down. Prior to beginning the training protocols, the subjects in the HE Group had the correct hula hoop exercise demonstrated to them. For the SE Group, each step of the core stabilization exercise was demonstrated by a physical therapist (Researcher #1). The SE and HE training protocols were performed at a physical therapy laboratory with no supervision from a physical therapist. The subjects in the Control Group had all variables measured every week for 4 wks without any training.

The SE training protocol was modified from the lower abdominal exercise progression and Sahrman Core Stability Test (9). There were 6 progression steps of training that included basic breathing (level 0), level 1, 2, 3, 4, and 5. The specific movement of each step was simultaneously executed over 20 repetitions amid each leg with continuous abdominal draw-in maneuver (ADIM) and normal breathing. Training progressed to the next step of exercise progression once the subjects were able to complete the previous step. Each training session was started with basic breathing (level 0) that was followed by the previous step of exercise progression.

The starting position of all steps was supine, bilateral hip and knee flexed, with the feet placed on a bed. The specific movements of steps 0 to 5 were as follows: continuous abdominal draw-in maneuver (ADIM) with normal breathing for 3 to 5 min, sliding the heel on the floor, unilateral flex and extension of the knee, lower unilateral heel-touch to the floor incorporating 90° hip flexion, unilateral hip and knee extension from 90° hip flexion with the feet lowered bilaterally to the floor from a full straight-leg pointing towards the ceiling, respectively. The subjects exercised and progressed following the instruction manual that was illustrated with video clips.

For the HE training protocol, all the subjects used a hula hoop with a diameter of 80 cm weighing roughly 1 kg (13). During the hula hoop exercise performance, the subjects stood with their feet apart at pelvis width and maintained movement of the hula hoop around the waist by resisting the trunk against the centrifugal force of the hoop. The hula hoop was controlled in order to be moved parallel to the ground with a consistent velocity by organizing the body with minimal movement of the trunk while transferring the weight on the feet and squeezing the abdominals as performed ADIM.

Outcome Measurements

All subjects' variables were measured at the beginning of the first week (baseline data) and the day after the 3rd day of training each week by a physical therapist (Researcher #2) who remained blinded to subjects' group allocation. The outcome of the training protocol in this study was MIST level and TrA function as measured by the pressure stabilizer biofeedback unit (PBU) (Stabilizer®, Chattanooga Group Inc., CA, USA).

Lumbar stability level in this study referred to the ability to perform the progressive lumbar stabilization exercise. This outcome was measured via MIST as modified from the modified Isometric Stability Test (IST), of which a good intratester agreement (weighted k coefficient of 0.61) was reported (8). Prior to test outset, the measurement details were conveyed to the trainees. MIST was tested in the supine position on a firm bed with approximately 90° knee flexion with the feet flat on the floor. A PBU pressure transducer was inserted under each subject's lower back and positioned at approximately the L1-S2 level. Starting pressure was set at 40 mmHg for each testing level. The success of each testing level was confirmed when the pressure was controlled at 40 ± 4 mmHg, without compensation, while the subjects completed the specific movement of each level (8,31).

The specific movement of levels 1 to 6 were as follows: abdominal hollowing, unilateral abduction, unilateral knee extensions, unilateral knee raises, bilateral knee raises, and bilateral tandem knee raises, respectively. During testing, the pressure scale was visible to both the tester and the subject. Each testing session began with level 1 and progressed to the next level on passing the previous level. The uppermost level the subjects were able to attain was recorded as the MIST level (31).

The TrA function was tested via the prone test with the PBU (27), which test-retest reliability was reported with Intraclass Correlation Coefficient (ICC) of 0.81 (33). The starting position was the prone position with arms by the side, the head at the midline, with the PBU's pressure transducer placed under the navel and its distal border lined at the level of the ASIS. The pressure was subsequently inflated to 70 mmHg while the subjects fully relaxed their abdomen. To attempt the test, the subjects were requested to take a relaxed breath in, and out, and then draw the abdomen in towards the spine without moving the spine or pelvis, and hold for 5 sec. Again, during testing the pressure scale was visible to both the tester and the subject. The examiner monitored the correct maneuver by observation of the spinal and pelvic movement, and by palpation for TrA contraction medially on the abdominal wall and inferiorly to the ASIS. Pressure that dropped from 70 mmHg was recorded. The average value of 3 consecutive repeated test pressures was defined as the absolute TrA, with the maximum value used to classify TrA function as pass or fail. Maximum scores was presented as 4 to 10 that referred to a pass, and 0 to 4 that referred to a fail (17,27).

Statistical Analyses

Differences between groups at baseline were tested via a One-Way ANOVA for absolute TrA, and Kruskal Wallis Test for MIST and classified TrA. The effects of training and times were tested through the Two-Way Repeated ANOVA for absolute TrA and the Kruskal Wallis Test and the Friedman Test for MIST and classified TrA, respectively.

Post hoc analysis was conducted with Bonferroni for absolute TrA, with Bonferroni correction applied for Wilcoxon Signed Ranks Test (within group comparison) and Mann-Whitney U Test (between group comparisons) for MIST and classified TrA. Statistical significance was set at an alpha level of $P<0.05$ for all tests.

The sample size was calculated based on absolute TrA from a pilot study conducted in 9 participants. The 3 pairs of comparison, SD of 1.1, mean difference of 1.44, α error of 0.05, and power of 80% were employed in the sample size calculation which resulted in 12.33 participants in each group. Twenty percent drop-out was added, thus 15 participants in each group were set.

RESULTS

Forty-five participants with a low lumbar stability level were recruited. There was no drop-out occurred in any group, therefore, adherence to exercise training amid the intervention group, and both SE and HE groups was excellent. The data from all 45 participants: 15 participants in each group were analyzed. The female participant in control group, SE and HE group were 14 (93.33%), 14 (93.33%), 11 (73.33%), respectively.

There was no statistically significant difference in baseline data between the 3 groups (as Table 1). The results showed statistically significant effects of time on both MIST level and absolute TrA in the SE and HE groups, yet no statistically significant difference in the control group (Tables 2 and 3). On the other hand, there were statistically significant effects brought about by the training program on MIST amid weeks 3 and 4 post training (Table 2). Lastly, no significant effect of training program, and statistically significant effects of the time and interaction on absolute TrA occurred (as seen in Table 3).

For classified TrA, there were no statistically significant effects of time in the control group (χ^2=7.304, P=0.121) and HE group (χ^2=4.320, P=0.364), though there were statistically significant effects in the SE group (χ^2=18.00, P=0.001). Subsequent to 4 wks of training, the classified TrA of the SE and HE groups presented as greater than the control group (Z=2.742, P=0.006; Z=2.436, P=0.015). Conversely, no statistically significant differences between the SE and HE groups were presented (Z=0.359, P=0.720) (Figure 2).

Table 1. Participant Demographics and Baseline Data.

Variable	**Control** (n = 15)	**SE** (n = 15)	**HE** (n = 15)	**F, χ2**	**P**
Mean ± SD					
Age (yrs)	21.00 ± 0.85	20.93 ± 1.16	20.93 ± 1.01	0.630	0.939
Weight (kg)	58.93 ± 13.49	61.73 ± 17.33	58.42 ± 14.01	0.987	0.381
Height (cm)	160.13 ± 6.52	162.93 ± 6.34	160.17 ± 6.77	1.324	0.277
BMI (kg·cm^{-2})	23.00 ± 5.22	23.17 ± 5.98	21.52 ± 3.61	0.487	0.618
Pre-Test Prone Test; Absolute TrA (mmHg)	2.27 ± 0.49	2.31 ± 0.61	2.36 ± 0.71	0.081	0.923
Frequency (Percentage)					
Pre-Test Prone Test; Classified TrA (pass)	4(26.67)	0(0.00)	4(26.67)	4.757	0.093
Median (Q1,Q3)					
Pre-Test MIST	2(2,2)	2(2,2)	2(2,2)	2.095	0.351

Values are presented as Mean ± SD, Percentage or Median (Q1, Q3); **SE** = Stabilization Exercise; **HE** = Hula Hooping Exercise; **Absolute TrA** = The Transversus Abdominis Function Recorded with Absolute Value of Prone Test; **Classified TrA** = The Transversus Abdominis Function Classified as a Pass or Fail by Prone Test

Table 2. Modified Isometric Stability Test (MIST) Variables at Baseline and After 1, 2, 3, and 4 wks Training in Each Group, and Comparison Within and Between Groups.

MIST	Control (n = 15)		SE (n = 15)		HE (n = 5)		Between Group Comparison	
	Min-Max	Median (Q1,Q3)	Min-Max	Median (Q1,Q3)	Min-Max	Median (Q1,Q3)	χ2	P
Pretest	2-2	2(2,2)	1-2	2(2,2)	1-2	2(2,2)	2.095	0.351
1 Week	1-3	2(2,2)	1-4	2(2,3)	1-6	2(2,3)	0.216	0.898
2 Weeks	1-4	2(1,2)	1-6	2(2,3)	1-5	2(2,3)	5.592	0.061
3 Weeks	1-4	2(2,2)	1-6	2(3,4)^{a,b}	2-6	4(2,4)^{a,b}	9.973	0.007*
4 Weeks	1-4	2(2,3)	1-6	3(3,5)^{a,b}	2-6	3(3,5)^{a,b}	16.031	<0.001*
Within Group Comparison								
Chi-Square	2.559		34.137		38.046			
P	0.634		<0.001*		<0.001*			

Values are presented as Min, Max, and Median (Q1,Q3); **SE** = Stabilization Exercise; **HE** = Hula Hooping Exercise; *P<0.05; ^{a}Significantly different from the pre-test (P<0.05); ^{b}Significantly different from the control group (P<0.05)

Table 3. The Transversus Abdominis Function Recorded with Absolute Value of Prone Test (Absolute TrA) at Baseline and Post 1, 2, 3, and 4 wks Training in Each Group, and Comparison Within and Between Groups.

Prone Test (mmHg)	Mean ± SD			P		
	Control (n=15)	SE (n=15)	HE (n=15)	Time Effect	Group Effect	Time x Group Effect
Pre-Test	2.27 ± 0.49	2.31 ± 0.61	2.36 ± 0.71	<0.001*	0.598	0.023*
1 Week	2.13 ± 0.52	2.18 ± 0.53	2.31 ± 0.61			
2 Weeks	2.58 ± 0.90	2.31 ± 0.66	2.27 ± 0.55			
3 Weeks	2.80 ± 1.07	2.64 ± 1.11	2.78 ± 1.21			
4 Weeks	2.16 ± 0.52	3.11 ± 0.81^{a,b}	3.20 ± 1.30^{a,b}			

SE = Stabilization Exercise; **HE** = Hula Hooping Exercise; *P<0.05; ^{a}Significantly Different from the Pre-Test (P<0.05); ^{b}Significantly Different from the Control Group (P<0.05)

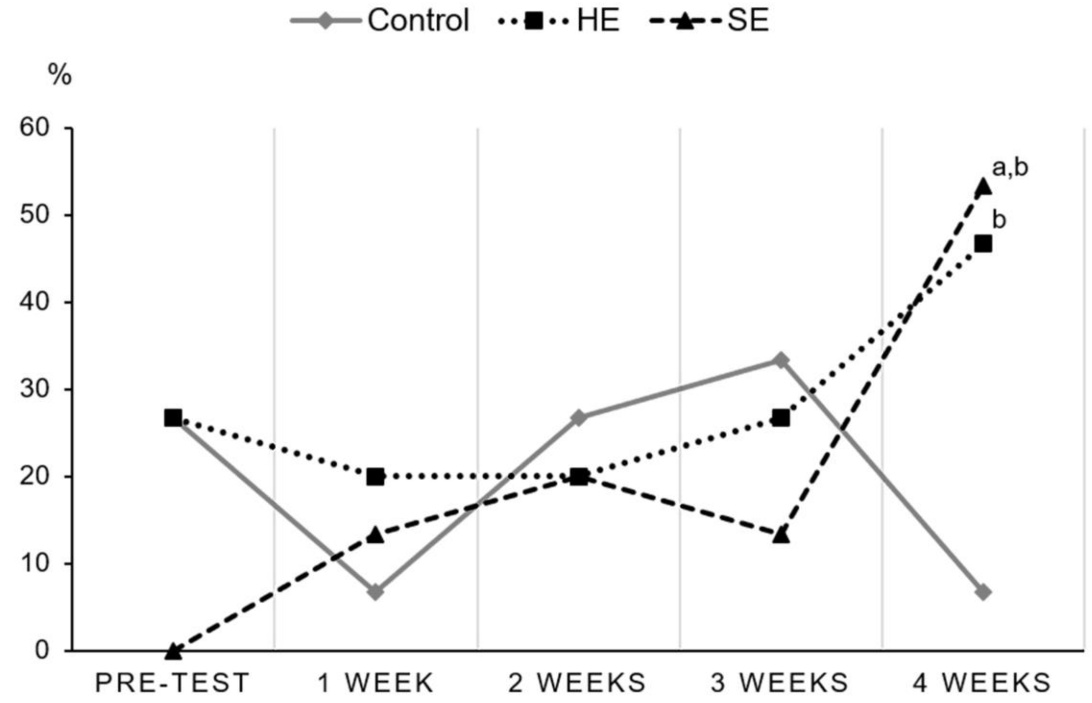

Figure 2. The Transversus Abdominis Function was Classified as a Pass via Prone Test (Classified TrA) at Baseline and Following 1, 2, 3, and 4 wks Training in Each Group, and Comparison Within and Between Groups. Values are presented as percentage. **SE** =Stabilization Exercise; **HE** = Hula Hooping Exercise. [a]Significantly Different from the Pre-Test (P<0.05); [b]Significantly Different from the Control Group (P<0.05)

DISCUSSION

This study is the first RCT to highlight the positive effects of hula hoop exercise on lumbar stability and TrA function in individuals who exhibited poor lumbar stability. The purpose of the study was to examine the effects of hula hoop exercise on lumbar stability level and TrA function in asymptomatic healthy individuals who presented with poor lumbar stability by comparison of non-training (Control Group), and core stabilization exercise (SE) Groups.

Lumbar stability level as measured by MIST demonstrated a significant increase from baseline to post 3- and 4-wks of training in the SE and HE Groups. Additionally, TrA function, as measured via the Prone Test reported as absolute TrA, showed a significant increase from baseline to post 4 wks training resultant of SE and HE training. All variables in the Control Group presented no change. Therefore, the SE and HE results were directly related to the training. These findings are in line with the clinical measurements in previous studies presenting the positive effects of an exercise program focused on core stabilization or TrA training on core stability and TrA function in asymptomatic persons (8,10,17,25,31).

At baseline, the percentage of subjects to successfully maintain a decrease in pressure at 4 to 10 mmHg (classified as a TrA pass) was just 0 to 26.67%. Moreover, these results are congruent with a previous study (10) whereby the asymptomatic individuals (abdominal exercise and no training group) demonstrated 100% poor lumbopelvic control with 71% failing the TrA isolation test. Thongjunjuea et al. (32) reported that young healthy, asymptomatic individuals presented MIST at level 3 and higher, thus those who exhibited a MIST level lower than 3 indicated local stabilizer muscle weakness. Hence, the finding in the present study can identify asymptomatic individuals with poor lumbar stability level with dysfunction of deep stabilizing muscle especially TrA, and should be recommended to undertake exercise for improving core stability by initially focusing on TrA training.

This study found that after 3 wks of training, both training groups saw an improvement in stability level without altering the ability of TrA contraction amid both absolute and classified TrA. To explain these findings, the concept of “neural control” has been used (19,23). LBP patients present irregular recruitment of core muscles which ineffectively manage the incoming and outgoing signals of the neural subsystem, and ultimately contribute to spinal instability (6,11,12). Although previous evidence concerning muscular training has demonstrated neural changes arising at around 4 to 6 wks, hypertrophy presented itself after 6 to 8 wks (20). Nevertheless, previous studies exist which demonstrate that core stabilization over a 2- to 3-wk training period could improve core stability and TrA function (17,31). Therefore, these positive revelations can be explained as improvements in neuromuscular control which deliver a precise proprioceptive input and provide optimal working of the core muscles, thus contributing to spine neutralization during limb movement without substantial improvement of muscular strength (1,4,23,27).

This study revealed that after 4 wks of training, absolute TrA was presented as significantly greater than baseline amid SE and HE training, though classified passes of TrA presented significantly greater than baseline in SE training alone. The absolute TrA referred to pure pressure that the subjects contracted their TrA muscle in order to lift their abdominals off the pressure cuff to drop the pressure from 70 mmHg. A TrA classified as a pass (dropped pressure was 4-10 mmHg) represented that the subjects were able to contract the TrA into its inner range (27). The participants were asked to squeeze abdominal as performed ADIM for organizing the body to maintain hula hoop. For this reason, the HE was able to improve the ability for contraction of the TrA muscle after 4 wks of training; however, the greater ability was not enough to classify as pass. Therefore, it is possible that the SE training was more effective in enhancing TrA strength than HE training. The SE training focused on activating the TrA via performance of ADIM with progressive limb movement during supine and hook-lying, which are more specific to promoting local stabilizer muscles (1,4,23,27). Otherwise, during the HE exercise, the subjects were attentive to maintaining minimal movement of the lumbar spine in close to the neutral position by organizing body parts during standing that provided core muscle learning to cooperate together in stabilizing the spine (while not focusing specifically on local stabilizer strengthening).

The positive effects of hula hooping exercise on core muscle activation in this study are congruent with previous reports (13,16,26) in that weighted hula hoop training was able to improve the strength of the abdominal and back extensor, increased the trunk muscle mass, promote core stability and the ability to contract the TrA. Conversely, McGill et al. (18) reported that torso muscle endurance was not improved subsequent to 6 wks of hula hooping using a weighted hoop. These positive effects can be explained whereby during the subjects’ control of the hoop circle around the waist while parallel to the ground with optimal velocity, the torso muscles and lower limbs muscles must be activated to co-contract with optimal proportion and strategy (2,5,26).

During hula hooping the spine exhibits minimal motion within the neutral zone whereby effective proprioceptive information is delivered to the motor control systems. As a consequence, the lumbopelvic muscles learn to work to maintain a neutral pelvic and spine position during the movement of other body parts. These mechanisms are congruent with the concept of core stability training that concentrates on maintaining the spine in a neutral zone during training and transfer to functional activity (1,4,23,27).

Limitations in this Study

Although the 4-wk training period in this experiment was long enough to see the positive effects of hula hooping exercise on lumbar stability and TrA function, further study should be conducted to incorporate a longer training period to bring forth maximum effectiveness. Additionally, this study was completed in asymptomatic subjects with poor lumbar stability. Hula hoop exercise should also be recommended to improve lumbar stability in asymptomatic individuals for primary prevention.

CONCLUSIONS

The present study demonstrated that HE and SE training were effective in improving lumbar stability and TrA function (absolute TrA) within 4 wks resultant of restoring neuromuscular control in subjects with poor lumbar stability. However, the passing of classified TrA improved post SE training while no change was observed in the HE and control groups. It is possible the SE training was more effective in enhancing TrA strength than the HE training. Thus, we recommend both SE and HE exercise to promote lumbar stability and TrA function for injury prevention in healthy or asymptomatic individuals exhibiting poor lumbar stability.

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