

The Effect of the Nine-Square Step Dance on the Postural Stability of Overweight Female Undergraduate Students: A Randomized Trial

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Received: 9 December 2020, Revised: 17 August 2021, Accepted: 24 August 2021

Abstract

Obesity impacts balance by increasing mechanical constraints and reducing plantar mechanoreceptors. The nine-square step dance is an exercise adapted from the Wii balance board exercise. It is low in cost and has the same effectiveness as the aforementioned board exercise. The purpose of this study was to determine the effect of the nine-square step dance on the postural control of overweight undergraduate women. Twenty-four female undergraduate students with overweight, aged 18 - 25 years, were randomly allocated into the intervention and control groups. The Star Excursion Balance Test (SEBT), Dot Drill Test (DDT), and 4 Step Square Test (FSST) were measured in both groups at the beginning of each week of a 4-week research period. The intervention group was trained in nine-square step dance exercises for 30 min/day for 3 days/week over 4 weeks. Repeated measure ANOVA was used for the comparison within and between the groups. After exercising with the nine-square step dance for 4 weeks, there were significant differences between the intervention and control groups in their SEBT score both stance leg and the 3 directions, anterior, posteromedial, and posterolateral direction. Agility and coordination were not significantly different between the 2 groups. In conclusion, the nine-square step dance had an impact on the postural control in overweight undergraduate women.

Keywords: Overweight, Postural stability, Nine-square step dance, Co-ordination

Introduction

The prevalence of overweight and obesity in children and adolescents is a serious worldwide problem. Obesity in early life is associated with the risk of excess weight in adulthood. This could lead to the burden of obesity-related diseases and non-communicable diseases [1-3]. Obesity is also associated with Type 2 diabetes, coronary heart disease, pulmonary dysfunction, musculoskeletal disorders, liver dysfunction, and cancer [4].

Obesity has a secondary outcome effect on postural stability and neuromuscular control [5-8], and it directly contributes to neurological problems, musculoskeletal problems, and abnormal biomechanics of the body. These defects result in a decreased ability in postural control. A previous study found that being overweight reduced the relative strength of the lower extremities and gait speed performance [9]. The impairment of gait and arthritis of the knee were associated with the sway of the body and the risk of falling [10]. To control posture without falling, the body needs to maintain vertical control by controlling the center of mass at the base of the support, which keeps the body in balance. Another balance response of the body is the need for autonomic postural strategies [13,14]. Consequently, increased weight has the effect of decreasing postural control and balance. The weight passes through the ankle joint vertically, which impacts the joint sense caused by the changing of the joint's feeling and deterioration [11]. A high body weight in obese persons could also lead to an increase in mechanical strength and a decrease in the response to mechanical stimulation on the lower leg. Moreover, obesity alters the sensory information of the plantar mechanoreceptors, which affect balance vertically [12]. Obese adolescents thus have a reduction in postural stability, which has an impact on the gait speed and postural stability [15,16]. Additionally, the obese adolescent has a longer stance phase and shorter swing phase than a non-obese adolescent. This might cause obese adolescents to need a longer period of support than non-obese adolescents. Therefore, obesity may have an impact on postural stability [15].

There are many interventions for increasing balance and postural stability. Dietary control and 30 min of aerobic exercise, e.g., bicycle and treadmill, have been used to improve postural balance in obese adolescents [5]. Task-oriented dynamic balance in association with coordination exercise and trunk strengthening exercise, hippotherapy, and ballistic strength training are some of the interventions that have been used to improve balance in adolescents with cerebral palsy [17-19]. The traditional exercises of Tai Chi and Qigong have also been effective interventions for improving balance [20].

An interesting effective intervention for balance improvement is the home-based Nintendo Wii-fit or Wii-balance board exercise [21,22]. There is evidence that supports the application of the Wii-balance board exercise as a suitable option for clinical use [23]. The board has been used for balance training in stroke patients [24] and improving the balance and reducing the risk of falling in obese women [25]. The Nintendo Wii-fit program has also been utilized for developing balance in multiple sclerosis patients [26], effectively bettering the dynamic balance and mobility in older adults [27], as well as enhancing the balance in overweight young adults by increasing the strength of their lower extremity muscles and improving their physical activity and balance performance [9]. Therefore, this step exercise has been found to be very effective.

Similarly, the square step exercise, e.g., the nine-square step dance or the nine-square table balance, is widespread around Asia, including Thailand [28-38]. This form of exercise has been utilized to improve agility in people with autism [39]. Additionally, the nine-square table balance exercise has been applied to improve physical fitness in community-based residences. As a consequence, the exercise program with the nine-square table balance can improve people's quality of life [42] by increasing autonomic reaction, stimulating thinking, and improving meditation and decision-making [40]. Psychiatric patients who had exercised with the nine-square table balance also improved in balance, memory, meditation, agility, muscle strength, and joint movement [41]. This dance has also improved balance in the elderly who are at risk of falling [30].

The nine-square step dance consists of step patterns that range from simple to complex. In contrast, the square step dance consists of more complex steps than the nine-square step dance [33]. From a previous study, the nine-square step dance program has shown many benefits among several groups, especially for improving balance [38,42]. Therefore, this study was undertaken to determine the effect of the nine-square step dance on the postural control of overweight undergraduate women.

Materials and methods

Twenty-Four overweight female undergraduate students, studying at Walailak University, aged 18-25 years were selected and randomly divided into 2 groups: The control and intervention groups (**Table 1**). In this study, overweight was defined with a body mass index (BMI) of 25.0 - 29.9 kg/m². The inclusion criteria consisted of the following: 1) BMI between 25.0 and 29.9 kg/m², 2) aged between 18 - 25 years, 3) normal visual field and acuity (the subjects were able to wear eyeglasses), and 4) normal hearing. The exclusion criteria comprised the following: 1) a history of musculoskeletal disorders, 2) a history of neurological disorders 3) a history of back or lower limb surgery, and/or 4) the presence of any joint diseases; such as, osteoarthritis, gout, and/or rheumatoid arthritis. All of the study procedures were approved by the Ethics Review Committee for Research Involving Human Research Subjects, Walailak University (Project WU-EC-AH-2-121-60).

The control group was given suggestions on how to use the nine-square step dance and received an exercise program to undertake by themselves for a period of 4 weeks. The intervention group was given an exercise program with the nine-square step dance for 3 days per week for a period of 4 weeks. The Star Excursion Balance Test (SEBT), Dot Drill Test (DDT), and Four Step Square Test (FSST) were used to detect postural control, agility, and neuromuscular coordination. The nine-square step dance had 9 basic steps as follows: 1) step up and down, 2) lateral step, 3) V step, 4) diamond step, 5) double triangular step, 6) large triangular step, 7) cross X step, 8) star step, and 9) cross diagonal step. The nine-square step dance exercise was utilized to be the intervention for improving the postural stability of overweight undergraduate women. The control group received leaflets on the nine-square step dance program and was asked to do it by themselves 3 times a week for a period of 4 weeks. The intervention group was trained in this exercise following the steps as instructed by Associate Professor Charoen Krabuanpatana (<https://www.youtube.com/watch?v=hl4wPoUEaVA>), and they exercised for 30 min per day, 3 days a week for a period of 4 weeks. Both groups were not allowed to exercise for more than 30 min per day during the 4 weeks. Both the control and intervention groups were re-examined for the parameters related to postural stability at the beginning of each week until the termination of the exercise program (**Figure 1**). The Star Excursion Balance Test (SEBT) was used to assess the postural control during the dynamic

balance, which measured eight directions of both leg stances for 3 s, which was repeated 3 times. In this experiment, 3 direction parameters, i.e., anterior, posteromedial, posterolateral, were selected for this test. The test parameter for the SEBT was to maintain a single leg stance on 1 leg while reaching as far as possible with the contralateral leg (**Figure 2**). The Dot Drill Test (DDT) was used to assess agility. This test was a 5-circle test (**Figure 3**). The test had 4 directions, i.e., up and back, right foot, left foot, and both feet. Up and back had 4 steps as follows: 1) start with the feet on A and B, 2) jump rapidly with both feet on C, 3) jump putting 1 foot on D and another on E, and 4) jump back to the starting point; repeating 2 times. Right foot and left foot started as follows: 1) feet on A and B, 2) jump on C with the right foot, and 3) jump with the right foot on D, E, C, A, and B; repeating 5 times. After placing the right foot on B, participants jumped with the left foot as follows: 1) jump with the left foot on C, and 2) jump with the left foot on D, E, C, A, and B; repeating 2 times. The Four Step Square Test (FSST) was used to assess neuromuscular coordination. This test also assessed the dynamic balance and coordination through stepping forward, sideways, and backward (**Figure 4**). The participants were instructed as follows: 1) stand in Square 1 facing Square 2, 2) step as fast as possible into each square in the following sequence: 2, 3, 4, 1, 4, 3, 2, and 1, and 3) step forward, backward, and sideways to the right and left.

A total of 24 participants were used in this study, which the number was determined by purposive sampling utilizing the Bonferroni calculation.

The results were expressed and presented as mean values. These data were analyzed using repeated measure ANOVA. In all statistical comparisons, a p -value of ≤ 0.05 was used to indicate a significant difference.

Results and discussion

The Effect of the nine-square step dance on the Star Excursion Balance Test score

To assess the postural control with the dynamic balance test, the Star Excursion Balance Test (SEBT) was performed. **Table 2** shows the results of the SEBT for pre- and post-exercise between the control and intervention groups. After exercising with the nine-square step dance, 3 days per week for 4 weeks, there were significant difference in the SEBT score of the both leg at 3 directions, the anterior, posteromedial, and posterolateral directions with p -value, 0.024, 0.000, 0.000, 0.017, 0.000, and 0.001, respectively (**Table 2**).

The Effect of the nine-square step dance on the Dot Drill Test

To assess agility, the Dot Drill Test (DDT) was performed. **Table 3** shows the results of the DDT for the pre- and post-intervention between the control and intervention groups. At the end of the exercise program, there was no statistically significant difference between the control and intervention groups that had a p -value = 0.544. However, in the intervention group, there was a statistically significant difference between the pre- and post-intervention (**Table 3**).

The effect of the nine-square step dance on the Four Step Square Test

To assess the neuromuscular coordination and dynamic balance, the Four Step Square Test (FSST) was performed. **Table 3** presents the results of the FSST for the pre- and post-intervention between the control and intervention groups. At the end of the exercise program, there was no statistically significant difference between the control and intervention groups that had a p -value = 0.218. The FSST score in the intervention group decreased not statistically and significantly different between the pre- and post-intervention (**Table 3**).

In the intervention group, the Star Excursion Balance Test (SEBT) score was increased in all 3 directions, i.e., anterior, posteromedial, and posterolateral, in both legs. Therefore, the nine-square step dance exercise affected the dynamic postural control [32]. The SEBT score was associated with the posteromedial and posterolateral directions for the single leg stance test. The single leg stance induced the changing of the center of gravity in each movement direction. The control forward or anterior mobility was involved with the ankle strategies [43]. In contrast, the control backward or posterior mobility was involved with the hip strategies. The pattern of the nine-square step dance involved multidirectional steps, i.e., anterior, lateral, posterior, posterolateral, anterolateral, posteromedial, and anteromedial. Obesity also affected the plantar mechanoreceptors. This led to balance perturbation and affected the gait speed [12]. Therefore, the multidirectional steps were also involved with the ankle proprioceptive sensation [44]. The exercise program was formed to progress from easy to difficult, slow to fast, and simple to complex. The limit of support (LOS) was changed as a result of the postural stability adjustment, associated with a change in the base of support (BOS), followed by the direction of each step [31,32]. These led to increased balance

in multi directions, e.g., anterior, posteromedial, and posterolateral, which was shown from the results of the SEBT. In contrast, another intervention from the square step exercise determined static balance from the single leg stance with the eyes closed [37,38]. The nine-square step dance had the effect with the postural control and postural stability. The direction of movement in this training encouraged the weight shifting training. These led to improved postural adjustment [45].

Neuromuscular coordination and dynamic balance were assessed by the Four Step Square Test (FSST). Neuromuscular coordination involved the complex mechanism of body control through muscle strength, endurance, speed, and elasticity of the connective tissues [31,32,37,38,46]. Obesity impaired these functions when compared to a person of normal weight. After intervention at 3 days per week for 4 weeks, the FSST score in the intervention group was reduced and was statistically and significantly different between the pre- and post-intervention. However, at the end of the intervention period, there was no significant difference between the control and intervention groups. This might have been caused by the postural adjustment from the FSST. The movement pattern of the FSST was related to the shifting of the weight, changing of the BOS, and feedforward postural adjustment. This phenomenon involved the increasing of motor planning, which was a requirement for postural adjustment [47].

Agility was assessed by the Dot Drill Test (DDT). The DTT in the intervention group decreased and was statistically and significantly different when compared to the control group. The nine-square step dance enhanced and increased physical activity and agility [39,46]. The nine-square step dance not only had benefits for balance improvement, but it was also a cheap, low-cost, and easy DIY exercise that could be implemented at home [35-38].

From the findings of this intervention, the authors' study presented 4 limitations. First, the intervention program in this study was for a short period of time. Therefore, further study should consider designing a program for a longer period. Second, the study did not include information of the postural muscles, i.e., back, abdominal, quadriceps, gluteus, hamstrings, ankle dorsiflexor, and ankle plantar flexor muscle, strength and endurance, which would be related to the increasing of the postural control and postural adjustment. Third, this study did not include information of muscle, i.e., back, abdominal, and lower extremities, flexibility, which would be involved with the postural adjustment and feedforward mechanism. Finally, the participants in this study included only overweight undergraduate women, so further study should be transferable to other population groups.

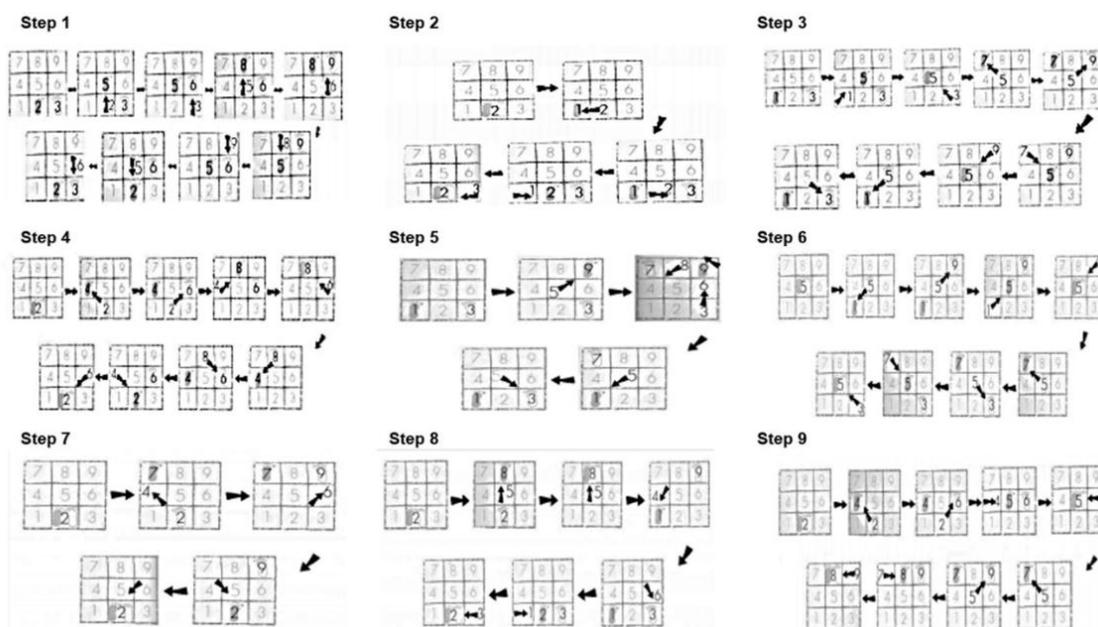


Figure 1 Schematic model of the nine-square step dance exercise. The progress from simple to complex steps is shown from steps 1 - 9; 1) step up and down, 2) lateral step, 3) V step, 4) diamond step, 5) double triangular step, 6) large triangular step, 7) cross X step, 8) star step, and 9) cross diagonal step.



Figure 2 Star Excursion Balance Test (SEBT).

Participants were instructed to step in the anterior, posterolateral, and posteromedial directions. The 3 direction parameters, i.e., anterior, posteromedial, posterolateral, were selected for this test. The test parameter for the SEBT was to maintain a single leg stance on 1 leg while reaching as far as possible with the contralateral leg.

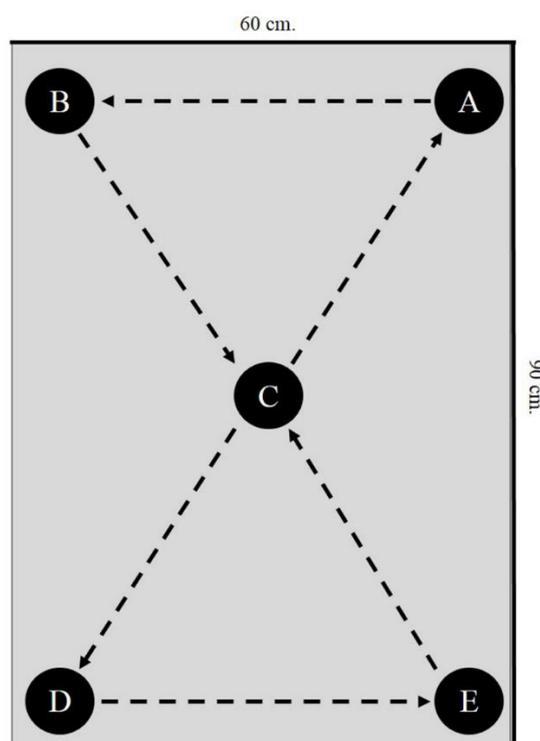


Figure 3 Dot Drill Test (DDT).

The schematic design of the direction of the DDT, which was a 5-circle test with 4 directions, i.e., up and back, right foot, left foot, and both feet. Up and back had 4 steps as follows: Participants were instructed to jump from A to B, B to C, C to D, D to E, E to C, and return from C to A.

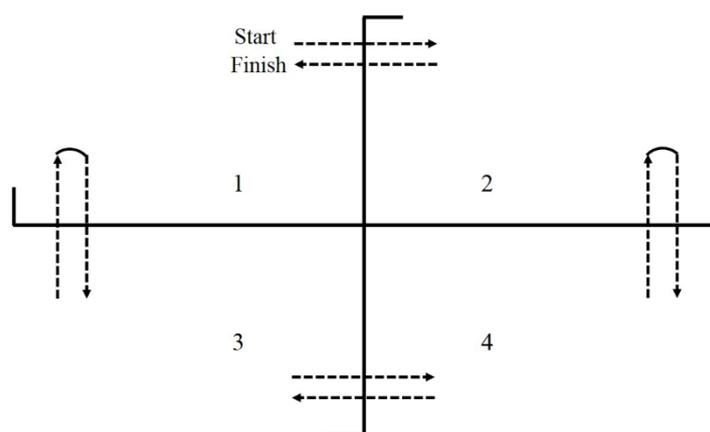


Figure 4 Four Step Square Test (FSST).

The assessment of the dynamic balance and coordination through stepping forward, sideways, and backward. Participants were instructed to step from 1 to 2, 2 to 4, 4 to 3, 3 to 1, and return from 1 to 3, 3 to 4, 4 to 2, and 2 to 1.

Table 1 Characteristics of the participants (n = 24).

	Control (n = 12)	Intervention (n = 12)
Age (years)	21.25 ± 0.97	20.83 ± 1.75
Body weight (kg)	66.48 ± 7.35	70.05 ± 6.67
Height (cm)	158.50 ± 6.48	158.33 ± 3.96
BMI (kg/m ²)	26.72 ± 1.48	27.89 ± 2.10
Waist circumference (cm)	84.29 ± 5.47	88.25 ± 9.19
Hip circumference (cm)	102.00 ± 6.88	109.67 ± 4.00
Waist and hip ratio	0.80 ± 0.06	0.81 ± 0.07
Right leg length (cm)	82.50 ± 5.02	83.25 ± 3.14
Left leg length (cm)	82.33 ± 5.00	83.13 ± 3.11

The characteristic of the participants before intervention. There was not a different mean of each parameter between the control and intervention groups.

Table 2 The Star Excursion Balance Test score on both legs in 3 directions (anterior (A), posteromedial (PM), and posterolateral (PL)).

SEBT Score (cm)		Right stance			Left stance		
		Anterior (A)	Postero-medial (PM)	Postero-lateral (PL)	Anterior (A)	Postero-medial (PM)	Postero-lateral (PL)
Day 0	Control	63.45 ± 3.76	88.20 ± 5.59	87.96 ± 5.58	59.44 ± 3.52	85.89 ± 5.73	85.64 ± 5.79
	intervention	63.32 ± 4.02	89.16 ± 3.74	89.59 ± 3.32	61.56 ± 4.15	87.06 ± 3.85	87.57 ± 2.56
	<i>p</i> -value	0.590	0.628	0.394	0.190	0.563	0.302
Week 4	Control	72.08 ± 3.48	94.15 ± 3.98	93.74 ± 3.71	68.93 ± 4.21	91.27 ± 3.71	90.94 ± 3.51
	intervention	75.99 ± 4.08	102.63 ± 4.33	101.96 ± 3.98	73.52 ± 4.45	100.71 ± 7.00	99.31 ± 6.47
	<i>p</i> -value	0.0024*	0.000*	0.000*	0.017*	0.000*	0.001*

* *p*-value ≤ 0.05 compared with the control

* *p*-value ≤ 0.05 compared with pre-intervention

After 4 weeks of intervention, the posterolateral direction of the right stance and the posteromedial direction of the left stance increased with a significant statistically difference.

Table 3 The Four-Square Step Test and Dot Drill Test before and after intervention.

Parameters	Pre-intervention			Post-intervention		
	Control (n = 12)	Intervention (n = 12)	<i>p</i> -value	Control (n = 12)	Intervention (n = 12)	<i>p</i> -value
FSST	6.84 ± 1.35	6.88 ± 1.52	0.935	5.56 ± 0.55	5.09 ± 1.13	0.241
DDT	26.62 ± 3.47	29.32 ± 8.45	0.319	21.32 ± 3.65	19.81 ± 4.40	0.611

FSST: Four steps square test, DDT: Dot drill test

**p*-value ≤ 0.05 compared with the control

***p*-value ≤ 0.05 compared with pre-intervention

After intervention for 4 weeks, the scores of both the FSST and DDT were reduced significantly compared to the pre-intervention.

Conclusions

The nine-square step dance could increase postural adjustment, neuromuscular coordination and dynamic balance, and agility. This step exercise program resulted in the weight shifting training in each direction, which involved the improvement of postural adjustment, neuromuscular coordination, and dynamic balance. Therefore, the nine-square step dance exercise improved balance in overweight undergraduate women. Furthermore, this tool would be easy, low-cost and helpful for balance, coordination, and agility training in balance deficit groups.

Acknowledgements

The authors would like to express gratitude to Assistant Professor Pornpimol Charntaraviroj (Walailak University), Associate Professor Manas Kotepui (Walailak University), and Associate Professor Chuchard Punsawad (Walailak University), for their comments and suggestions.

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