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Original Article

Effect of yoga training on one leg standing and functional reach tests in obese individuals with poor postural control

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Abstract. [Purpose] The aim of the present study was to investigate the effect of yoga training on static and dynamic standing balance in obese individuals with poor standing balance. [Subjects and Methods] Sixteen obese volunteers were randomly assigned into yoga and control groups. The yoga training program was performed for 45 minutes per day, 3 times per week, for 4 weeks. Static and dynamic balance were assessed in volunteers with one leg standing and functional reach tests. Outcome measures were tested before training and after a single week of training. Two-way repeated measure analysis of variance with Tukey's honestly significant difference post hoc statistics was used to analyze the data. [Results] Obese individuals showed significantly increased static standing balance in the yoga training group, but there was no significant improvement of static or dynamic standing balance in the control group after 4 weeks. In the yoga group, significant increases in static standing balance was found after the 2nd, 3rd, and 4th weeks. Compared with the control group, static standing balance in the yoga group was significantly different after the 2nd week, and dynamic standing balance was significantly different after the 4th week. [Conclusion] Yoga training would be beneficial for improving standing balance in obese individuals with poor standing balance.

Key words: Standing balance, Obesity, Yoga training

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INTRODUCTION

According to the definition of "obesity" of the WHO[1)], obesity is classified as a body mass index (BMI) equal or greater than 30 kg/m^2. However, the WHO criteria for obesity classification might not be appropriate for classifying obesity in the Asian population considering the differences in body composition between individuals of different ethnicities. Therefore, the Regional Office for the Western Pacific (WPRO) standard was used as an alternative obesity classification for Asian people[2)]. According to the WPRO standard, obesity is defined as a BMI equal or greater than 25 kg/m^2. In Thailand, the number of individuals with obesity is increasing for all ages and genders as well as the incidence in other countries of the world[2)]. Obese individuals are at risk of several noncommunicable diseases such as cardiovascular disease, diabetes mellitus, and hypertension[3)], and there is an increased risk of falling associated with obesity[4)]. It has been demonstrated that obese individuals have poor postural control and balance when compared with nonobese individuals[5)]. In 2009, Singh et al.[6)] revealed that obese individuals showed increased postural sway while standing compared with individuals with normal weights. Hence, obese individuals would be at risk of falling, and it would be interesting to determine if there are any effective treatments to prevent falling in obese individuals.

Yoga training has been known as an exercise protocol that combines the practice of physical, mental, and spiritual components[7)]. The advantages of yoga training have been studied widely, and one of the advantages is improvement of balance[8–10)]. In 2010, Schmid et al.[10)] investigated the effects of 12 weeks of yoga training on balance in the elderly and found a significant increase in balance after training. Also in 2010, Telles et al.[11)] studied the effect of a short course of yoga training with diet control on health status in obesity. They reported a significant improvment in static postural stability while standing in obese individuals after 6 days of training. However, a longer duration of yoga training may be more beneficial in improving standing balance in obese individuals, and the effects of yoga training on balance should be investigated under both static and dynamic conditions. Therefore, the purpose of this study was to investigate the effect of 4 weeks of yoga training on static and dynamic standing balance in obese individuals with poor postural control. The subjects were obese volunteers aged 18–35 years from Phitsanulok Province, Thailand.

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SUBJECTS AND METHODS

Obese volunteers who met the inclusion criteria were recruited into this study. All subjects were obese with a BMI of 25 kg/m^2 or more and had poor standing balance as demonstrated by only being able to stand on a single leg with the eyes open for less than 30 seconds[12]. The volunteers had no medical history of serious injury or operative treatment and had no musculoskeletal, neurological, visual or vestibular problems leading to balance disturbance. After completing an informed consent form, blood pressure, weight, height, and body mass index of the volunteers were measured. A summary of the subjects' characteristics is shown in Table 1.

Static and dynamic balance were tested in the obese volunteers with one leg standing and functional reach tests. Static standing balance was tested with one leg standing under the eyes open and eyes closed conditions[13]. Standing still for longer periods of time represents better static standing balance. The functional reach test[14] was used to investigate dynamic standing balance by determining the farthest distance subjects could possibly reach forward.

Volunteers were randomly assigned into yoga training and control groups. In the yoga training group, obese volunteers performed yoga exercise for 4 weeks. The yoga training used in this study consisted of Hatha yoga, in which asana (posture) and pranayama (breathing) are essential components of training[15]. Both physical and mental awareness were emphasized during the practice of yoga postures. The yoga postures in the current study consisted of consecutive 8 yoga postures. The yoga postures were purposefully selected to improve standing balance. The yoga training initially started with breathing control training for a few minutes. The subjects were then instructed to perform the 8 consecutive yoga postures, including the Tree, Eagle, Warrior, Triangle, One leg T-standing, Sailboat, Applied Dancing, and Knee to Chest postures (Fig. 1). Each posture was slowly performed and maintained for approximately 15–30 seconds, and each was performed twice. Lastly, a relaxation technique in the supine lying position was applied for at least 5 minutes before finishing the training program. The total duration of the yoga training was approximately 45 minutes. The yoga training in this study was supervised by a skilled yoga trainer.

In the control group, obese volunteers were asked to maintain their usual physical activity level for 4 weeks and to not participate in any exercise programs. The studied parameters, including standing times during one leg standing (OLS) with the eyes open and eyes closed and the forward reach distance from the functional reach test (FRT) were measured every single week at the end of the training session in both the yoga training and control groups. The studied parameters for both one leg standing and the functional reach test were measured by the same testers, who had been verified to have high intrarater reliabilities (tester 1 for one leg standing, ICC 3, 1 = 0.97; tester 2 for the functional reach test, ICC 3, 1 = 0.98). To identify the representative data of each subject, 3 trials of OLS and FRT were averaged and used as representative data for each subject. The procedures used in this study were approved by the Naresuan University Institutional Review Board. All subjects were asked to read a participant information sheet and to then sign an informed consent form. All testing procedures were performed at the Faculty of Allied Health Sciences, Naresuan University.

Table 1. Subject characteristics

Subject characteristics	Yoga training group (n=8)	Control group (n=8)
Age (year)	21.9 (1.2)	22.5 (1.5)
Weight (kg)	75.1 (12.9)	80.8 (12.4)
Height (cm)	162.4 (6.7)	164.3 (9.3)
BMI (kg/m^2)	28.6 (3.5)	29.6 (2.8)
Systolic blood pressure (mmHg)	123.3 (7.0)	123.9 (15.3)
Dyastolic blood pressure (mmHg)	77.6 (8.0)	74.4 (8.6)
Resting heart rate (beats per minute)	86.3 (6.5)	85.0 (8.4)

There were no significant differences between the yoga and control groups ($p > 0.05$). mean (SD)

Fig. 1. Examples of the 8 yoga postures

The Shapiro-Wilk test was used to test the data distribution. The differences in subjects' characteristics between the yoga training and control groups were determined with the unpaired Student's t-test. Two-way (group × time) repeated measure analysis of variance (ANOVA) with Tukey's honestly significant difference (HSD) post hoc analysis was used to determine the differences in static and dynamic standing balance between the yoga training and control groups. Statistical analyses were performed using the SPSS statistical software (SPSS Inc., Chicago, IL, USA). Values of $p < 0.05$ were considered significant.

RESULTS

There were 8 subjects (2 males, 6 females) in the yoga training group and 8 subjects (6 males, 2 females) in the control group. The results showed no significant differences ($p > 0.05$) in subjects' characteristics between the yoga training and control groups. The results of outcome

Table 2. Outcome measures of one leg standing (OLS) with the eyes open and eyes closed and functional reach test (FRT) in the yoga training and control groups

Test	OLS with eyes open (seconds)		OLS with eyes closed (seconds)		FRT (cm)	
	Yoga	Control	Yoga	Control	Yoga	Control
Before training	10.9 (5.0)	13.0 (8.3)	5.6 (2.9)	5.1 (1.7)	34.4 (5.1)	33.8 (6.5)
After 1st week	18.5 (6.3)	12.7 (8.7)	7.4 (3.2)	4.7 (1.2)	36.9 (5.0)	33.6 (5.8)
After 2nd week	21.6 (6.0)[a]	12.6 (8.2)	10.5 (3.7)[a,b]	4.6 (1.3)	38.5 (6.1)	31.9 (5.3)
After 3rd week	27.7 (8.3)[a,b]	12.5 (7.8)	11.8 (4.6)[a,b]	4.7 (1.2)	40.2 (7.0)	31.6 (5.7)
After 4th week	37.8 (12.8)[a,b]	11.8 (8.3)	14.3 (5.7)[a,b]	4.3 (1.1)	41.3 (6.9)[b]	31.4 (6.1)

[a]Significant difference when compared with before training ($p < 0.05$)
[b]Significant difference when compared with the control group ($p < 0.05$)
mean (SD)

measures in the yoga training and control groups are shown in Table 2. Two-way repeated measure ANOVA revealed significant effects for groups (yoga group versus control group), time (before and after a single week of the 4 weeks training), and interaction (group × time) in the OLS with the eyes open (interaction effect, $F = 8.04$, $p < 0.05$; within group, $F = 19.28$, $p < 0.05$: between groups, $F = 18.43$, $p < 0.05$), OLS with the eyes closed (interaction effect, $F = 10.79$, $p < 0.05$; within group, $F = 13.98$, $p < 0.05$: between groups, $F = 21.15$, $p < 0.05$), and FRT (interaction effect, $F = 6.41$, $p < 0.05$; within group, $F = 2.35$, $p > 0.05$: between groups, $F = 9.72$, $p < 0.05$).

As a result of the Tukey's HSD post hoc analysis, no significant differences ($p > 0.05$) were found in standing times during OLS under the eyes open and eyes closed conditions or in the distances obtained in the FRT between the yoga training and control groups before starting the training program. After the second week, there were significant differences in standing times during OLS under the eyes open and eyes closed conditions in every single week in the yoga training group ($p < 0.05$) compared with before the training session. However, there was no significant difference in distances in the FRT in the yoga training and control groups, as shown in Table 2.

The results of the comparisons between the yoga training and control groups showed that the training group demonstrated significant differences in standing time during OLS with the eyes open in the 3rd and 4th weeks ($p < 0.05$). Likewise, the results showed significant differences in standing time during OLS with the eyes closed in the 2nd, 3rd, and 4th weeks ($p < 0.05$). Moreover, the results of the functional reach test revealed a significant difference in the yoga training group in the 4th week ($p < 0.05$) compared with the control group.

DISCUSSION

It has been shown that obese individuals have a greater risk of serious noncommunicable diseases[3], a greater risk of falling[4] and poor postural control and balance[5]. Much of the research cited in the review article of Del Porto et al. in 2012[4] revealed that obese individuals have limited postural stability control due to improper biomechanics of stability control including body segment orientation, muscle work, and posture. Moreover, obese individuals need to exert more effort in recovering balance when their posture is perturbed.

The aim of this study was to evaluate the effect of yoga training on static and dynamic standing balance in obese individuals. Obese individuals who have poor one leg standing balance were recruited into the current study. All of the obese individuals were asked to maintain their physical activity level during the study. The results demonstrated no significant differences in subjects' characteristics between groups. Therefore, it could be stated from the results that the changes in static and dynamic standing balance in the yoga training group resulted from the yoga training. Regarding the results showing increased static and dynamic standing times during OLS under the eyes open and eyes closed conditions in the yoga training group beginning in the 2nd week of yoga training, they may indicate that yoga training improves static standing balance in obese individuals with poor postural control. These outcomes may be the result of improved muscular strength of the trunk and legs induced by yoga training[16]. The postures used in yoga training were similar to those used in balance testing protocols. Therefore, this would help to promote specific muscular adaptations of the trunk and lower extremities, enabling better performance in the static and dynamic standing balance tests after 4 weeks of training.

The yoga training program was only 4 weeks long; however, this is possibly long enough to induce neuromuscular adaptation to improve standing balance[17] as shown in the OLS tests. To control single leg standing within the base of support with no extraneous force disturbing the balance, trunk, hip, knee, and ankle muscles were co-contracted to maintain single leg standing balance through a neuromuscular control strategy[5]. On the other hand, dynamic standing balance requires a more complex strategy than static postural control. During the functional reach test, the body maintains dynamic standing balance using hip, knee, and ankle strategies to control the center of gravity within the base of support. This requires more recruitment of trunk and leg muscles. The dynamic standing balance ability was observed at the end of the 4 weeks in the yoga training group and compared with that of the control group. The results might indicate that the duration of yoga training should be

longer than 4 weeks in order to apparently improve the dynamic standing balance in obese individuals.

The limitations of this study were that the age range of the recruited obese volunteers was narrow, only between 21–25 years, and that the body mass indexes of almost all the obese volunteers classified them as class 1 obese individuals only[2]. The duration of the yoga training program was only 4 weeks in the current study, so improvement of dynamic standing balance might not have been clearly seen in the current study. Therefore, future studies should use a longer duration for the yoga training program and recruit subjects classified as having various degrees of obesity.

In conclusion, static standing balance was increased in obese volunteers with poor postural control after participating in the yoga training program for 4 weeks, and yoga training may be helpful for preventing falls in obese individuals with poor postural control.

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