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Yoga Training Improves Metabolic Parameters in Obese Boys

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Yoga has been known to have stimulatory or inhibitory effects on the metabolic parameters and to be uncomplicated therapy for obesity. The purpose of the present study was to test the effect of an 8-week of yoga-asana training on body composition, lipid profile, and insulin resistance (IR) in obese adolescent boys. Twenty volunteers with body mass index (BMI) greater than the 95th percentile were randomly assigned to yoga (age 14.7±0.5 years, n=10) and control groups (age 14.6±1.0 years, n=10). The yoga group performed exercises three times per week at 40~60% of heart-rate reserve (HRR) for 8 weeks. IR was determined with the homeostasis model assessment of insulin resistance (HOMA-IR). After yoga training, body weight, BMI, fat mass (FM), and body fat % (BF %) were significantly decreased, and fat-free mass and basal metabolic rate were significantly increased than baseline values. FM and BF % were significantly improved in the yoga group compared with the control group ($p<0.05$). Total cholesterol (TC) was significantly decreased in the yoga group ($p<0.01$). HDL-cholesterol was decreased in both groups ($p<0.05$). No significant changes were observed between or within groups for triglycerides, LDL-cholesterol, glucose, insulin, and HOMA-IR. Our findings show that an 8-week of yoga training improves body composition and TC levels in obese adolescent boys, suggesting that yoga training may be effective in controlling some metabolic syndrome factors in obese adolescent boys.

Key Words: Yoga (asana), Obesity, Body composition, Lipid profile, HOMA-IR

INTRODUCTION

The primary cause of obesity is a chronic storage of excess energy [1], and physical inactivity is pivotal in its development [2]. The epidemic of obesity in adolescents has been expanded in the past several years [3]. Increases in body fat mass during adolescence may be related to the development and acceleration of cardiovascular risk factors [4], including hyperlipidemia [5], and insulin resistance [6]. Long-term insulin resistance may cause type 2 diabetes and a subsequent increase in morbidity and impaired glucose tolerance [7]. Thus, controlling obesity is critical for the reduction of future health problems and morbidity [8,9].

Potential therapeutic regimes for severe obesity are hospitalization, dietary modification, medication therapy, and bariatric surgery [3]; however, pharmacological agents for managing obesity are not approved in adolescents [3]. Although controlling adolescent obesity is important for quality of life and adult health, few non-invasive and non-pharmaceutical treatment options are available. Existing options that may be used alone or in combination are improving nutritional habits, increasing physical activity, and modifying behavior, and psychological outlook [10].

Yoga was developed in India to facilitate a vibrant lifestyle and meditation [11]. Currently, yoga is widely used to improve health and to attenuate or cure diseases. Dhyyana, pranayama and asana yoga practice emphasize in controlled breathing, meditation, and physical posture, respec-

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ABBREVIATIONS: IR, insulin resistance; BMI, body mass index; HRR, heart rate reserve; HOMA-IR, homeostasis model assessment of insulin resistance; FM, fat mass; FFM, fat free mass; BF %, body fat %; TC, total cholesterol; TG, triglyceride; ACSM, American college of sports medicine; CDC, centers for disease control; RPE, rate of perceived exertion; THR, targeted heart rate; BMR, basal metabolic rate.

tively [12,13]. Asana yoga uses various postures to develop physical strength, flexibility, and endurance [13], and can be used as a moderate-intensity exercise for patients with limited aerobic capacity or restricted ability to exercise [14]. Furthermore, yoga has been shown to decrease hypertension and cardiac inflammation, stabilize the sympathetic nervous system, and improve psychological health and cardiac function [15-17].

Although the American College of Sports Medicine (ACSM) and Centers for Disease Control (CDC) suggest moderately intense physical activity for obese subjects [18,19] because exercise training has been shown to improve metabolic factors in subjects with obesity [20-23], obese adolescents engage in less physical activity during school days and on weekends than their non-obese peers [24]. In that context, yoga training may help obese adolescents to achieve the recommended levels of physical activity, and it may be an attractive alternative exercise training programs because it increases heart rate and muscle strength, has limited harmful side effects, and requires virtually no equipment [13,25].

Limited information is accessible regarding the impact of yoga-asana training, on cardiovascular-metabolic risk factors in obese adolescents. Accordingly, we hypothesized that yoga-asana training may have beneficial effect on metabolic parameters in obese adolescent boys. Therefore, we evaluated the effect of an 8-week of yoga-asana training on body composition, lipid profile, and the homeostasis model assessment of insulin resistance (HOMA-IR) in obese adolescent boys.

METHODS

Subjects and study design

Obese adolescent boys between the ages of 13 and 15 years with body mass index (BMI) was greater than the 95th percentile, as defined by French population standards [26], were recruited in Busan, Korea, through flyers posted in middle schools and outpatient waiting rooms and through advertisements in the school newspaper. We have fully explained the potential risks and benefits in the study before written informed consent was provided by parents and participants, according to the guidelines of the Ju Rae middle school research ethics committee. Participants who had hypertension (blood pressure >140/90 mmHg), were using medication, or had an injury in the 6 months previous the study were eliminated. We enrolled 19 subjects in the yoga (asana) group and 15 in the control group, who did not participate in physical activity program before 6 months. However, 14 subjects overall were excluded from the analysis because of low compliance to the yoga training (n=9), defined as missing more than three sessions, or use of medication during the study in the control group (n=5). Girls were excluded from our study because of confounding hormonal effects and possible difficulty in performing yoga asana during menstruation. The yoga and control groups received general health-education regarding risk factors associated with type 2 diabetes, consuming a balanced diet and engaging in physical activity. Subjects in the control group did not participate in any after school and were encouraged not to perform >30 min of exercise weekly, which is below the minimum exercise required to improve health and fitness [27]. Subjects were advised not to change their diet and physical activity lifestyles during the study. The 8-week study was successfully completed by 20 participants (Table 1).

Yoga (asana) training protocol

Yoga training was conducted by a certified yoga in-

Table 1. Baseline clinical characteristics of the study population

	Participants (n=20)[1]
Age (years)	14.65±0.74[2]
Height (cm)	164.28±8.39
Weight (kg)	77.91±9.09
BMI (kg/m^2)	28.80±1.70
Fat-free mass (kg)	26.31±5.28
Fat mass (kg)	30.01±4.58
Body fat (%)	38.81±6.24
BMR	1403.50±191.23

[1]All participants were Korean adolescent males recruited in Busan. [2]Values are presented as means±SEM. BMI, body mass index; BMR, basal metabolic rate.

Table 2. Design of the yoga-asana training protocol

Time	Contents (Intensity)	Type
10 min	Warm up	
40 min	Sitting	Seated forward bend
		Bound angle pose
		Head to knee pose
		Wide angle seated forward bend
		Stretches the lower back and the shoulders
	Standing	Weight over to the right foot, lifting the left foot off the floe
		Extended triangle pose
		Stretches legs and arms
	Lying	Bend from the hip joints to slowly lower toes to the floor above and beyond head
		Lie on back on the floor with knees bent, feet on the floor
		Lie on your belly with hands alongside torso, palms up
		Sit on the floor with knees bent, feet on the floor, and lean back onto forearms
10 min	Relaxation	Deep relaxation pose

HRR, heart-rate reserve; RPE, rating of perceived exertion (RPE); THR, the targeted heart rate (intensity% ×(HRR+$HR_{resting}$).

structor (Dae Han Institute of Social Education, Korea) three times per week for 8 weeks using a slightly modified previously published protocol (Table 2) [28]. Each yoga session consisted of 10 min of warm-up, 40 min of asana (yoga postures), and 10 min of relaxation. The program was divided into three stages, including an adaptation stage (first 2 weeks), an improvement stage (weeks 3 and 4), and a maintenance stage (weeks 5～8). Dividing the program into stages helped to gradually increase exercise intensity. ACSM guidelines for the obese population were followed during the adaptation and improvement stages and 40～50% of heart-rate reserve (HRR) and a 12～13 level rate of perceived exertion (RPE) were enforced. During the maintenance stage, the guidelines suggested a 50～60% HRR and a 14～15 RPE [28]. HRR was calculated using the targeted heart rate (THR)=Intensity%×(HRR+HR_{rest}), following a previous method [29]. To maintain THR during exercise, we measured heart rate using the carotid artery pulse 1 min after the exercise started.

Measures and biochemical analyses

Body composition and blood sample were obtained before and after 8 weeks. Body weight and height were measured with subjects wearing light clothes and without shoes. Body composition including fat mass (FM), body fat percentage (BF %), fat-free mass (FFM), and basal metabolic rate (BMR) were measured using a multi-frequency electrical impedance analyzer. BMR was calculated using a Harris Benedict formula (X-scan Plus II, Jawon Medical, Seoul, Korea) [30-32]. BMI was calculated using the equation of weight (kg)/height $(m)^2$.

Participants were asked to abstain from alcohol and caffeine consumption for at least 24 h and from physical exercise for 48 hr prior to blood withdrawal and testing. Overnight fasting blood was collected in Vacutainer (BD Bioscience, San Jose, CA, USA) from the antecubital region of the arm. After centrifugation at 1,500×g for 15 min, separated serum and plasma were stored frozen in multiple aliquots at $-80^{\circ}C$ until assayed. Plasma glucose, total cholesterol (TC), high density lipoprotein-cholesterol (HDLc), low density lipoprotein-cholesterol (LDLc), and triglyceride (TG) concentrations were measured in an automatic blood analyzer (Hitachi 7600-210 and Hitachi 7180, Tokyo, Japan) using enzymatic techniques based on a colorimetric assay. Plasma insulin was measured using an enzyme-linked immunosorbent assay kit (Mercodia, Winston Salem, NC, USA). Insulin resistance was determined using the HOMA-IR index as [fasting insulin level (mU/ml)×fasting plasma glucose (mmol/l)/22.5] [33].

Statistical analysis

The results are expressed as the mean±standard deviation. Within-group comparisons were made using paired sample t-tests. The unpaired *t*-test was used for baseline group comparisons and changes in differences before and after in the control and yoga groups. All statistical analyses were performed using the Statistical Package for the Social Sciences version 19.0 for Windows (SPSS, Inc., Chicago, IL, USA). Statistical significance was set at p-value$<$0.05.

RESULTS

The study included 20 Korean boys 14.7±0.7 years of age who were classified as obese (BMI 28.80±1.70 kg/m^2). No significant differences in all parameters were found between groups at baseline (Table 1). Changes in body composition before and after 8 weeks the control and yoga groups are summarized in Table 3. Body weight and BMI significantly ($p<0.05$) decreased after yoga training but not after the control period. FM was significantly ($p<0.05$) decreased with yoga training and control period, but the change was significantly ($p<0.05$) greater in the yoga group. BF % decreased with yoga training by 4.3% compared with no significant decrease in the control group. BMR was increased in the yoga training group by 44 Kcal/day but there was no significant change in the control group.

The changes in blood lipids, glucose, and insulin in both groups are shown in Table 4. The lipid profile, glucose, and insulin were normal range in all participants before and after the study. TC was significantly ($p<0.01$) decreased in the yoga group. TG was not significantly decreased in the yoga group. LDLc was slightly increased and HDLc was decreased in the control and yoga groups ($p<0.05$). No significant changes were found in glucose, insulin, and HOMA-IR in both groups. The change in glucose, insulin, and HOMA-IR was less in the yoga group than the control group.

Table 3. Changes in body composition following an 8-week yoga-asana training

	Control (n=10)			Yoga (n=10)			p-value[2]
	Pre	Post	Diff (mean)	Pre	Post	Diff (mean)	
Age (years)	14.60±0.96[1]			14.70±0.48			
Height (cm)	165.19±10.33			163.85±6.34			
Weight (kg)	79.43±10.83	78.13±10.44	−1.30	76.39±7.20	74.49±7.06*	−1.90	0.566
BMI (kg/m^2)	29.04±2.11	29.57±2.97	0.53	28.57±1.23	27.56±1.50***	−1.01	0.174
Fat-free mass (kg)	27.51±5.92	28.06±5.79	0.55	25.12±4.53	26.51±4.47**	1.39	0.181
Fat mass (kg)	29.65±4.86	27.58±5.29**	−2.07	30.38±4.52	26.45±4.44***	−3.93	0.015
Body fat (%)	37.65±6.49	36.15±6.55	−1.50	39.97±6.10	35.66±6.05***	−4.31	0.031
BMR (kcal/day)	1443.20±216.52	1459.10±205.51	15.90	1363.80±163.76	1408.10±160.48**	44.30	0.195

[1]Values are presented as means±SEM. [2]Control versus Yoga group. Diff, post value − pre value; BMI, body mass index; BMR, basal metabolic rate. *$p<0.05$, pre value vs post value; **$p<0.01$, pre value vs post value; ***$p<0.001$, pre value vs post value.

Table 4. Changes in metabolic risk factors following an 8-week yoga-asana training

	Control (n=10)			Yoga (n=10)			p-value[2]
	Pre	Post	Diff (mean)	Pre	Post	Diff (mean)	
TC (mg/dl)	168.60±26.14[1]	156.70±21.90	−11.90	183.90±29.58	169.60±31.01*	−14.30	0.773
TG (mg/dl)	123.10±63.35	111.40±49.17	−11.70	146.70±64.43	98.60±30.78	−48.10	0.202
HDLc (mg/dl)	58.70±18.54	36.80±14.09**	−21.90	55.60±15.19	27.90±14.09**	−27.70	0.304
LDLc (mg/dl)	85.20±26.92	90.50±15.10	5.30	98.70±31.54	104.40±24.49	5.70	0.965
HDLc/LDLc	0.79±0.46	0.40±0.15	−0.38	0.67±0.50	0.25±0.16	−0.39	0.658
Glucose (mg/dl)	86.60±4.83	85.60±3.89	−1.00	84.10±5.04	83.90±4.38	−0.20	0.731
Insulin (mU/l)	5.62±1.88	9.93±7.94	4.30	6.15±2.65	6.63±2.74	0.47	0.137
HOMA-IR	7.19±2.38	12.74±10.51	5.54	7.92±0.78	8.08±0.93	0.16	0.105

[1]Values are presented as means±SEM. [2]Control versus Yoga group. Diff, post value−pre value; TC, total cholesterol; TG, triglyceride; LDLc, LDL-cholesterol; HDLc, HDL-cholesterol; HOMA-IR, Homeostasis Model of Assessment-Insulin Resistance. *$p<0.01$, pre value vs post value; **$p<0.001$, pre value vs post value.

DISCUSSION

The present study was designed to determine the impact of an 8-week of yoga-asana training on body composition, lipid profile, and insulin resistance in obese adolescent males. We studied adolescent boys because males are typically unfamiliar with yoga and most have not explored the benefits of yoga training. The major finding of the present study was that an 8-week of yoga-asana training improved body weight, BMI, FM, BF %, FFM, BMR, and TC compared with baseline values in obese adolescent boys.

The physiological effects of yoga training that have been previously reported include the inhibition of body weight gain, reductions in cholesterol levels, and blood pressure, and improvement in immune function as well as beneficial psychological effects [34-39]. In the study, our subjects participated in less physical activities than their non-obese peers during school days and at weekends, and their physical activity during the evenings and weekends was much lower than that during school days. Home- and family-based physical activity that can be performed alone may be the best way to increase energy consumption in obese adolescents because they are less likely to participate in group physical activities [24]. Although the obese person do not participate in dynamic exercise programs, they can participate in static exercise program, such as pilates exercise [40].

Body weight is a main metabolic syndrome factor [41]. Weight loss is related to the reduction in the risk for diabetes and cardiovascular disease through improvements in blood pressure, TG, and HDLc in obese subjects [42,43]. In the present study, the small body weight loss observed after yoga training is explained by the combined decrease in FM and the increase in FFM. Consistent with our findings, similar increase in FFM have been reported after 8 weeks of resistance exercise training in obese and lean adolescent [44,45] and Benavidses and Caballero [46] reported that yoga training was a significantly decreased body weight in children. In contrast to our findings, 8 weeks of endurance exercise training did not show changes in body composition in obese adults [47]. The increase in FFM was a significant predictor for the decreases in body weight and FM [44]. Our findings of weight loss accompanied by reduced FM and increased FFM, major determinants of resting energy expenditure, indicate that yoga training is a potential adjunct treatment for obesity in adolescents. The decrease in body weight, BMI, FM, and BF % in the yoga group may have been related to an increase in FFM, and BMR following yoga training. In this context, yoga-asana training provides an alternative option for increasing the physical activity levels required to improve body composition and BMR in obese adolescents, as shown with conventional exercise training programs [48,49].

We did not observe a clear positive effect of yoga on blood lipids, with the exception of a decrease in TC. Cholesterol is a key contributor to the development of heart disease, stroke, and other vascular diseases [50]; thus, a reduction in TC following the yoga-asana training is a promising finding. Several studies have confirmed that the yoga training significantly increases HDLc and decreases TG, and LDLc [51-53]. It is well known that yoga training, which is alternative exercise training, provides health benefits. In the present study, however, a significant decrease in HDLc was observed in both the yoga and control groups. Although significant reductions in HDLc following a high-fiber, low-fat diet, and exercise intervention have been reported [54,55], the effect of lifestyle interventions on HDLc are controversial [56]. Our finding is similar to those of Sun et al. [56] who observed that a decrease in HDLc following exercise with dietary intervention in overweight adolescents. Moreover, decreases in TC and HDLc have been reported in the control group and after 12 weeks of resistance and aerobic exercise training in overweight and obese adults with type 2 diabetes [57]. Of note, improvement in HDLc is not observed after resistance exercise training in adolescents [44]. However, the mechanism for the decreased in HDLc is not clear, and the clinical relevance of this small reduction warrants further investigation. Because the adolescent period is highly metabolically active, it is possible that an unknown factor may have interfered with or masked the positive effects of yoga training on HDLc levels that has been demonstrated in previous studies.

Damodaran et al. [58] reported that 3 months of yoga training significantly decreased plasma glucose concentrations, whereas a study by Elder et al. [59] showed no significant impact of yoga training on glucose levels. Obese adolescents who participated in regular exercise had lower insulin levels and HOMA-IR than those who did not exercise regularly [60]. Our results showed no significant between or within the group differences in glucose, insulin, and HOMA-IR. This may be related to the fact that participants in both groups had normal glucose and insulin levels, and practicing yoga-asana training did not have an impact on relatively normal glucose homeostasis. Matthews et al. [33] also found no changes in these markers of glucose control with 8 weeks of resistance exercise training in adolescents, suggesting the need of long-term interventions. Long-term yoga training has been shown to have a beneficial effect on insulin resistance in patients with diabetes [61].

Some limitations of the current study are the relatively small sample size, and 10 participants in each group may not have been sufficient to obtain statistically significant results. A future study with a larger number of participants is necessary. Furthermore, obesity is a chronic condition and thus long-term treatment and follow-up will is required. Finally, we did not monitor the diet during the study, which explains the small decrease in FM in the control group. However, the decrease in FM was smaller compared with the yoga group and did not affect other body composition and BMR.

The finding of the study demonstrate that yoga-asana training is a suitable exercise for attenuating obesity in adolescent boys, as indicated by improvements in BMI, FM, BF %, FFM, BMR, and TC, compared with baseline values. Consequently, yoga training may be effective in controlling some metabolic syndrome factors in obese adolescent boys. Future investigations are demanded to establish and expand the results of the present study and to compare the metabolic effects of yoga training with those of conventional exercise.

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