ABSTRACT

Metabolic syndrome (MS) is emerging as a serious public health problem in Iran. The purpose of this study was to examine the effects of 8 weeks of aerobic exercise training on body composition and MS factors in obese Iran male college students. Subjects were randomly assigned to exercise (n = 19) and control (n = 19) groups. The exercise group trained for 50 min/day, for 3 day/week for 8 weeks. Each exercise session comprised 3 phases: warm-up for 10 min, aerobic exercise for 30 min (The exercise intensity for aerobic exercise was 60–80% of the heart rate reserve (HRR) for 30 min) and cool down for 10 min. The paired and unpaired t-test in <0.05 significantly level were used in the statistical analysis. Compared to pre-training, after 8 weeks progressive aerobic exercise on the MS-related factors of blood lipid composition such as triglycerides (TGs), total cholesterol (TC), low-density lipoprotein (LDL) significantly decreased (P<0.05) and high-density lipoprotein (HDL) significantly increased (P<0.05); Also the result shows that percent body fat, waist circumference (WC), systolic blood pressure (SBP), and diastolic blood pressure (DBP) significantly decreased; while it remained unchanged in control subjects (P>0.05). A 8-week aerobic exercise program could effectively reduce TGs, TC, LDL, percent body fat, WC, SBP, DBP and increase HDL in a sample population of obese Iran male college students.

Key Words: Body Composition, College Student, Obesity, Iran
INTRODUCTION

The prevalence of Metabolic Syndrome (MetS) has been increasing worldwide, in parallel with the increasing prevalence of obesity. MetS is characterized by the grouping of several cardiovascular risk factors such as: abdominal obesity, hypertension, insulin resistance, glucose intolerance/type 2 diabetes, and dyslipidemia (5). Furthermore, various epidemiologic studies have shown strong associations between these risk factors and the development of other chronic diseases problems such as gastrointestinal cancer (22), diabetes (33), cardiovascular disease (CVD) (14), or even premature mortality (15, 18). Thus, the development of strategies to prevent and treat MetS, overweight and obesity are of great importance.

The prevalence of metabolic syndrome has increased. Existing data suggest that it has reached an alarming rate (1, 34). It presents a major challenge to physicians and public health agencies (24). Obesity plays a central role in metabolic syndrome and leads to the development of chronic diseases (2). A recent study in Tehran showed an estimated prevalence of more than 30% in adults. It is more common in women than in men, and the prevalence is higher than in most developed countries (8). The therapeutic goals reported for MS management are reduced levels of abdominal obesity, sedentary lifestyle, atherogenic diet, smoking, pharmacotherapy (anti-obesity agents), and control of elevated blood pressure (8). Furthermore, interestingly, increasing physical activity and fitness are considered to reduce the risk of MS and constitute important components of MS prevention (8, 22).

The results of many studies have confirmed that exercise is a good method for preventing MS as it increases muscle mass, decreases percent body fat and body weight, controls diabetes, reduces blood pressure, and reduces overall CV risk factors; however, only a few studies have examined the effects of aerobic exercise (26). Moreover, to our knowledge, none of the studies have focused on obese male college students in Iran for the purpose of MS prevention. Therefore, the purpose of this study was to examine the effect of 8 weeks of aerobic exercise, on body composition and MS-related factors in a sample population of obese Iran male college students.

MATERIALS AND METHODS

Subjects

We used a sample size consisting of 40 subjects to factor in the subjects who would be dropped from the analysis. The subjects were randomly classified into 2 groups: exercise (n = 20) and control (n = 20) groups. The subjects were obese
female college students aged 21–27 years, who had >30% body fat, and exercised at the Guilan University fitness center in Iran. They did not exercise regularly, and had not been previously diagnosed with abnormal glucose metabolism, or other health problems. The subjects were instructed to maintain a typical diet and a particular activity pattern throughout the study, and compliance with this instruction was assessed via physical activity and food frequency questionnaires administered at the beginning, and end of the study (6.31). However, 1 subject from the exercise group was excluded because they attended only part of the exercise program, and 1 from the control group was excluded because she did not participate in the test conducted at the end of the study. Thus, 19 subjects from the exercise group and 19 from the control group completed the pre- and post-study assessments. All the subjects submitted a written consent form, and all the study procedures were approved by the Human Care and Use Committee of the Society of Sport Research Institute at Guilan University. The characteristics of the subjects are shown in Table 1.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Control group</th>
<th>Exercise group</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>22.18 ± 3.91</td>
<td>23.11 ± 2.72</td>
<td>-0.491</td>
<td>0.598</td>
</tr>
<tr>
<td>Height, cm</td>
<td>172.13 ± 4.41</td>
<td>173.31 ± 5.45</td>
<td>-0.373</td>
<td>0.673</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>74.31 ± 6.60</td>
<td>75.29 ± 7.60</td>
<td>-0.789</td>
<td>0.389</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>25.6 ± 5.48</td>
<td>25.1 ± 6.34</td>
<td>-0.573</td>
<td>0.499</td>
</tr>
<tr>
<td>WC, cm</td>
<td>78.64 ± 5.55</td>
<td>79.21 ± 6.13</td>
<td>-0.771</td>
<td>0.401</td>
</tr>
<tr>
<td>Body Fat, %</td>
<td>27.70 ± 3.11</td>
<td>28.69 ± 3.18</td>
<td>-0.633</td>
<td>0.473</td>
</tr>
</tbody>
</table>

BMI; Body Mass Index, WC; Waist Circumference
Tested by independent t-test

**Experimental procedures**

The exercise group participated in an 8 week supervised aerobic exercise program. The exercise group trained for 50 min/day, and the program was composed of 3 steps: warm-up for 10 min, aerobic exercises for 30 min, and cool down for 10 min. The exercise group trained for 3 day/week for 8 weeks, while the control group was asked to maintain their normal sedentary activities. All the variables pertaining to the parameters were measured 2 days before, and 2 days after the
study: body composition (weight, body mass index [BMI], fat free mass [FFM], and percent body fat), MS-related factors (waist circumference [WC], triglyceride [TG] levels, high-density lipoprotein [HDL] levels, systolic blood pressure [SBP], diastolic blood pressure [DBP], and glucose levels), and other blood lipid components (total cholesterol [TC] and low-density lipoprotein [LDL] levels).

Body composition

The BMI (kg/m²) of each subject was calculated on the basis of their weight and height, and body composition (weight, FFM, and percent body fat) was assessed using an 8 polar bioelectrical impedance instrument (In Body 3.0, Biospace, Seoul, Korea). Subjects were prohibited from consuming food/liquids for 4 h, performing exercises for 12 h, and urinating just before the impedance measurement. They were recommended to wear light clothing and to remove all metallic items, which could interrupt the electric current during the measurement. All the methods used for assessing body composition followed the recommendations from the book, Applied Body Composition Assessment (19).

MS-related factors and other blood lipid components

The WC was measured in the region of the trunk that is midway between the lower costal margin (bottom of the lower rib) and the iliac crest (top of the pelvic bone), while the subject stood with her feet placed ~25–30 cm apart. The person recording the measurements carefully wrapped the tape around the subject’s trunk without compressing any underlying soft tissues. The circumference was measured at the end of a normal expiration and rounded off to the nearest 0.5 cm (11). The TG, HDL, LDL, TC, and glucose concentrations were measured using the ADVIA 1650 automated analyzer (Bayer HealthCare Ltd. Tarrytown, NY, USA), with the Pureauto S TG-N (Daiichi, Japan), Cholestest N-HDL (Daiichi, Japan), Cholestest N-LDL kits, respectively. The subjects rested for over 10 min in a sitting position. A specialist nurse then measured SBP and DBP at the right brachial artery by using a mercury sphygmomanometer (Alpk, Japan). Blood pressure was measured thrice separately over a 2-min interval. The specialist nurse determined the average blood pressure value (35).

Exercise program

All the subjects in the exercise group were asked to stretch their entire body before (warm up, 10 min) and after (cool down, 10 min) each training session. They performed a 30 min main exercise program, which consisted of treadmill running for 30 min at intensity of 60–80% of their heart rate reserve (HRR). Exercise inten-
sity was monitored during the training sessions by using a Polar real time system (Polar S610, Finland).

**Statistical analysis**

All the descriptive data were expressed in terms of mean ± standard deviation. Independent t-tests were used to examine the differences in subject characteristics between the groups at baseline. All the analyses were performed using SPSS version 19.0. The statistical significance level was set at $P < 0.05$.

**RESULTS**

The subjects’ characteristics did not significantly differ between the groups at the baseline ($P > 0.05$) (Table 1). Compared to pre-training, after 8 weeks progressive aerobic exercise on the MS-related factors of blood lipid composition such as triglycerides (TGs), total cholesterol (TC), low-density lipoprotein (LDL) significantly decreased ($P<0.05$) and high-density lipoprotein (HDL) significantly increased ($P<0.05$); Also the result shows that percent body fat, waist circumference (WC), systolic blood pressure (SBP), and diastolic blood pressure (DBP) significantly decreased; while it remained unchanged in control subjects ($P>0.05$) (Table 2, 3).

**Table 2: Changes in body composition after aerobic exercise for 8 weeks**

<table>
<thead>
<tr>
<th>Items</th>
<th>Exercise</th>
<th>Pre-exercise</th>
<th>Post-exercise</th>
<th>Paired t-test</th>
<th>P Value</th>
<th>Independent t-tests</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight, kg</td>
<td>Control</td>
<td>74.31 ± 6.60</td>
<td>74.60 ± 7.10</td>
<td>-1.25</td>
<td>0.75</td>
<td>4.63</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>75.29 ± 7.60</td>
<td>72.32 ± 5.43</td>
<td>4.40</td>
<td>0.002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>Control</td>
<td>25.6 ± 5.48</td>
<td>25.8 ± 6.29</td>
<td>-2.10</td>
<td>0.81</td>
<td>2.21</td>
<td>0.044*</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>25.1 ± 6.34</td>
<td>24.1 ± 3.15</td>
<td>1.28</td>
<td>0.043</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle mass, kg</td>
<td>Control</td>
<td>40.11 ± 5.35</td>
<td>39.09 ± 6.10</td>
<td>-2.53</td>
<td>0.64</td>
<td>3.13</td>
<td>0.003*</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>41.23 ± 3.59</td>
<td>42.22 ± 4.18</td>
<td>3.38</td>
<td>0.004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body Fat, %</td>
<td>Control</td>
<td>27.70 ± 3.11</td>
<td>29.45 ± 3.80</td>
<td>-3.30</td>
<td>0.83</td>
<td>4.23</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>28.69 ± 3.18</td>
<td>26.32 ± 2.90</td>
<td>4.10</td>
<td>0.001*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BMI; Body mass index/* P<0.05; Tested by Paired t-test and Independent t-tests
Table 3: Changes in metabolic syndrome related factors and blood lipid composition after aerobic exercise for 8 weeks

<table>
<thead>
<tr>
<th>Items</th>
<th>Exercise</th>
<th>Pre-exercise</th>
<th>Post-exercise</th>
<th>Paired t-test</th>
<th>P Value</th>
<th>Independent t-tests</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WC, cm</td>
<td>Control</td>
<td>79.61 ± 4.78</td>
<td>78.32 ± 6.10</td>
<td>-2.29</td>
<td>0.236</td>
<td>2.63</td>
<td>0.003*</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>82.29 ± 5.21</td>
<td>76.28 ± 6.38</td>
<td>2.52</td>
<td>0.003*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBP, mmHg</td>
<td>Control</td>
<td>116.39 ± 12.18</td>
<td>118.56 ± 8.84</td>
<td>1.53</td>
<td>0.061</td>
<td>3.18</td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>115.53 ± 10.22</td>
<td>110.39 ± 9.11</td>
<td>2.98</td>
<td>0.041*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DBP, mmHg</td>
<td>Control</td>
<td>71.10 ± 5.40</td>
<td>71.56 ± 4.97</td>
<td>-3.15</td>
<td>0.443</td>
<td>5.13</td>
<td>0.002*</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>74.82 ± 6.13</td>
<td>68.74 ± 4.94</td>
<td>4.67</td>
<td>0.032*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TG, mg/dl</td>
<td>Control</td>
<td>103.21 ± 23.43</td>
<td>97.18 ± 18.94</td>
<td>-1.56</td>
<td>0.274</td>
<td>3.30</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>99.13±26.54</td>
<td>52.42±8.53</td>
<td>4.11</td>
<td>0.021*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDL, mg/dl</td>
<td>Control</td>
<td>55.65±5.53</td>
<td>52.76±3.44</td>
<td>-2.56</td>
<td>0.232</td>
<td>2.65</td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>49.72±8.65</td>
<td>59.43±4.47</td>
<td>2.39</td>
<td>0.043*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose, mg/dl</td>
<td>Control</td>
<td>87.66±5.53</td>
<td>88.46±4.70</td>
<td>-1.87</td>
<td>0.39</td>
<td></td>
<td>-1.72</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>86.71±7.73</td>
<td>88.33±3.98</td>
<td>-1.38</td>
<td>0.302</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC, mg/dl</td>
<td>Control</td>
<td>181.02±16.21</td>
<td>179.12±23.11</td>
<td>-2.28</td>
<td>0.481</td>
<td>4.43</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>180.21±31.19</td>
<td>162.11±20.43</td>
<td>3.34</td>
<td>0.042*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDL, mg/dl</td>
<td>Control</td>
<td>100.49±42.13</td>
<td>103.24±38.27</td>
<td>-3.10</td>
<td>0.671</td>
<td>3.21</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>exercise</td>
<td>105.13±21.26</td>
<td>89.24±20.18</td>
<td>2.98</td>
<td>0.032*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WC; Waist circumference, SBP; Systolic blood pressure, DBP; Diastolic blood pressure, TG; Triglycerides, HDL; High density lipoprotein, TC; Total cholesterol, LDL; Low density lipoprotein $P<0.05$ * Tested by Paired t-test and Independent t-tests

DISCUSSION

This study focused on the effectiveness of an 8 week aerobic exercise program on potential changes in MS-related factors and body composition. Significant improvements were observed in percent body fat, WC, blood pressure, and blood lipid components. Traditionally, since aerobic exercise is associated with greater
energy expenditure, it is considered to be more effective in reducing body weight and fat mass (4). Moreira et al. (2008) reported that total body mass (TBM), body mass index (BMI), waist circumference (WC), plasma concentrations of glucose (GLU) and body composition variables showed significant changes in the aerobic exercise groups (23).

Malina (2007) reported that young college students show a high correlation between BMI and FFM. Although the obese subjects in this study had high BMI, they also had higher FFM than that reported for adults. We felt that this was responsible for the observation that combined exercise did not affect their FFM. However, since combined exercise also represented increased energy expenditure, the percent body fat and WC decreased (20).

In a meta-analysis study by the American College of Sports Medicine (ACSM), the results showed that regular physical activity and exercise decreased SBP by 6 mm Hg and DBP by 5 mm Hg (21). Interestingly, our study also shows significant decrease in blood pressure; this result is supported by that from the ACSM report despite the subjects in our study being younger. Hagberg et al. (1989) also demonstrated a decrease in SBP (20 mm Hg) in hypertensive men following 9 months of low- to moderate-intensity aerobic training, with a concomitant decrease in DBP (11–12 mm Hg) (13). Based on previous studies, it was hypothesized that the association between exercise and BP was not linear (17, 31). The literature demonstrates the benefits of physical exercise (aerobic activity) (32) or strength-training activity (16), on the BP, physical activity is being considered as one important component in the non-pharmacological treatment of hypertension (13, 32).

Exercise is considered as a natural, inexpensive, feasible, and effective means of control for hypertensions and is a primary lifestyle measure required to lower BP in NPE male students. Insulin is a hormone with many functions, and the fasting serum level of insulin is increased in subjects with a low fitness level as well as in subject with a high BMI. Besides its effect on glucose transportation, insulin has an anabolic effect on fat storage in the fat cells (3, 9). Insulin affects appetite regulation through the change in substrates in the blood, and effect on BP regulation (3). It is known that insulin sensitivity increases with aerobic training and the effect is local in the trained muscle. In a one-leg training model, Dela et al., (1996) showed an increase in insulin sensitivity in the trained leg, but no change in the untrained leg (9). Insulin sensitivity may therefore is one of the key mechanisms behind the association found between BP, BMI, and fitness.

In our study, the MS-related factors of blood lipid composition were not affected. Obesity and MS have been known to be common and important clinical markers for early detection of CV disease and type 2 diabetes (12); Risk factors for MS include higher TG levels (R150 mg/dl), lower HDL levels (<50 mg/dl for women), high blood pressure (R130/80 mm Hg), high fasting blood glucose levels (R100 mg/dl), and a large WC (R88cm for women) (24). Several previous studies
have reported that aerobic exercise significantly improves MS-related factors of blood lipid composition \((25, 26)\).

The researchers found that aerobic exercise may be a gradual reduction of TG, TC, LDL, BMI, body mass, body fat and increase HDL, body mass, and BMR is the net \((30)\). Some researchers reported that people who adhere to diet and aerobic exercise for 60 to 90 minutes in 5 to 7 days a week due to the increase in VO2 max and HDL levels are achieved and their waist circumference decreased. Since physical activity significantly reduces body fat content for the treatment of heart disease, it is very important in cardiovascular exercise (aerobics) compared to other training is more effective in reducing body fat percentage, so most studies, exercises offer aerobics \((7, 27)\). Perhaps the increased skeletal muscle lipoprotein lipase activity and increased lipoprotein lipase mass index, blood lipids during exercise is one of the factors. Increase in capillary density, the greater the potential for harvest and use of fatty acids that may increase the density function of HDL in people who provide training \((29)\).

These findings are in agreement with a previous study on endurance exercise training that reported positive changes in lipid and lipoprotein metabolism \((10)\). Furthermore, it is generally considered that aerobic exercising has several beneficial effects on health. For example, regular exercise may promote chronic positive effects such as an improvement in lipid profiles, insulin resistance, BMI, and % body fat, as well as basal metabolic state \((27)\). As the metabolism of lipoproteins occurs mainly during the aerobic exercise \((16, 28)\), the positive changes in anthropometric variables observed in the present study indicate that periodical aerobic exercising has the potential to improve the lipid profile. The pathological changes in the lipid and glucose metabolism in metabolic syndrome are closely related to the state of insulin resistance, unfortunately we have no data of fasting insulin concentration (IRI); further studies are needed to rectify the relation between IRI and exercise.

This study has a few limitations. Since the subjects were recruited from only 1 university at Guilan, Iran, and included only male students, the study population does not represent the entire Iran population. Furthermore, it comprised of a small number of students \((N = 38)\). Our results show that aerobic exercise significantly decreases the percent body fat and WC, but does not increase FFM. This could be a result of our small study sample.

Moreover, this study has an advantage in that it focuses on a young adult population, in contrast to previous studies that focused on middle-aged or older adults. Further studies are required to determine the effects of aerobic exercise on FFM. We conclude that a 8-week aerobic exercise program could effectively reduce TGs, TC, LDL, percent body fat, WC, SBP, DBP and increase HDL in a sample population of obese Iran male college students.
CONCLUSION

Based on these finding, we wish to recommend that part of the preventive measures, secondary college NPE the male students in Iran should be provided with the opportunity to engage in regular and appropriate exercise programmed in order to keep their weights and high BP within desirable levels.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGEMENT

The authors would like to thank the male students for their willing participation in this study.

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