The relationship between obesity indexes with vascular endothelial function after a period of circuit combined training in older women

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ABSTRACT: Obesity and its indices including BMI, WHR, and fat% are related with cardiovascular diseases and also involved in endothelial dysfunction and endothelium-dependent dilation. However, the correlations of these indices with endothelial function, especially in older women remain very poorly defined. The aim of this study was investigation on the relationship between some of the obesity indices with vascular endothelial function after a period of combined circuit training in older women. Subjects were 24 healthy andenable to do physical activity old women from Shahrekord (Chaharmahal and Bakhtiary province, Iran) retirement home (age=74.22±4.46). Subjects were randomly divided to two groups including experimental (n=12) and control (n=12). Obesity indices (Fat%, WHR, and BMI) and endothelium-dependent dilation of brachial artery were measured in both experimental and control groups, just before the training protocol starting. Then Experimental group was participated in 12 week (three times a week) combined circuit training program. All of mentioned measurements repeated at the end of 12th week. The obtained results showed that 12 week combined circuit training program has significant effect on reduction of old women obesity Indices (P ≤0.001). Also, a diverse relationship was observed between age, BMI, WHR and Fat% with FMD (flow-mediated dilation) in experimental (BMI: P=0.45, r=−0.24, WHR: p=0.10, r=−0.49, Fat%: p=0.69, r=-0.12, age=0.87, r=−0.05) and control groups (BMI: P=0.18, r=−0.41, WHR: p=0.62, r=−0.15, Fat%: p=0.75, r=−0.1, age=0.757, r=−0.1). It seems that use of 12 week combined circuit training has positive effects on obesity indices and improvement of endothelial function in Iranian old women. Anthropometric measures of obesity indices may help refine estimations of endothelial health and atherosclerotic state. BMI and WHR were most consistently associated with endothelial dysfunction. Thus, using regular training through the reduction in obesity indices could improve endothelial function and body composition and eventually reduce atherosclerosis and CVD occurrence in older women.

KEY WORDS: combined circuit training, old women, endothelial dysfunction, obesity indices
INTRODUCTION

Obesity is related with cardiovascular diseases (CVDs) and also has an important role in endothelial dysfunction and endothelium-dependent dilation (EDD) [1]. Therefore, EDD improvement in obese and overweight adults could lead to prevention of CVDs [2]. It has been shown that lower energy intake and weight loss could decrease artery resistance and improve endothelial function in young and older overweight/obese adults [3]. Researchers found that interventions in lifestyle and enhancement in physical activity rate, led to either weight loss or improvement of EDD, especially in overweight and obese adults [4]. Endothelial dysfunction may be related to body fat distribution, and abdominal visceral fat [5]. Probable mechanisms that impair EDD are associated with proinflammatory and acute-phase proteins, oxidative stress, and certain neurohumoral factors which are linked with increased abdominal visceral fat [1].

Body mass index (BMI), waist-hip ratio (WHR) and fat percent (Fat%) are valid indicators for measurement of body composition, obesity, overweight, and CVD risk factors. It is believed that decrease in these indices cause EDD improvement and reduction in CVDs [6].

Aging is an inevitable process that is linked with the loss of muscle strength, endurance and cardiovascular fitness; therefore, CVDs risk increase through this process and it could be said that CVDs are a conventional reason of mortality in older adults [7]. Also, aging is associated with development of vascular dysfunction which is generally related with physiological changes such as artery stiffness and systemic vascular endothelial dysfunction. It leads to oxidative stress-dependent endothelial dysfunction and high proinflammatory condition of endothelial cells [8]. In addition, body fat increases by age especially in women; however their lean mass decreases, simultaneously [9]. It has been found that, increased fat mass in the elderly is mainly due to decreased physical activity [9]. Physical activity in sedentary older people could be used as a preventive factor for obesity, CVDs, and vascular endothelial dysfunction [10].

Studying the effect of physical exercises as a part of healthy lifestyle and its effect on cardiovascular function in elderly has sharpened, recently [11, 12]. Some studies have investigated the effect of resistance and aerobic training on older people. However, these trainings singly had different effects on their endothelial function. Older adults showed artery stiffness due to resistance training in compare with control; while, resistance training had beneficial effects on lean body mass [8]. On the other hand, aerobic trainings showed improvement in endothelial function of older people in compare with control [13].

Middle aged and older adults who participated in a combination of aerobic and resistance training showed lower artherosclerosis and improved EDD in compare with non-athletes and even the group which only had aerobic training [14]. It shows that combined aerobic and resistant training could be effective on inhibition of artery stiffness and compensate the resistant training effect [14]. Simultaneous combining of endurance and resistance trainings in a regular exercise session is known as combined training. According to specificity of training effects, combination of endurance and resistance trainings is advised for improvement of body function and health in older adults [15] and quality of life in adult people [16]. However, there is no evidence of studies on the relationship between obesity indices and elderly endothelial dysfunction. In the current study, relationship of obesity indices including BMI, WHR, and Fat% was investigated with vascular endothelial dysfunction in non-athlete Iranian older women (over 60 years old) which were free of clinical diseases after 12 weeks of combined training.
METHODS

The participants were twenty four, 65-85 years old women from Taravat retirement home of Shahrekord, Iran. Subjects were divided purposefully to experimental (n = 12) and control (n = 12) groups. All subjects were asked to read and complete the Physical Activity Readiness Questionnaire (PAR-Q) and medicinal information questionnaire to check their disease information. All experiments had mental health, no cardiovascular disease (hypertension, high blood lipids), and they did not smoking. They all had similar diet during the study, no regular exercise before and filled consent form to participate in a research study.

The subjects’ weight, height, waist and hip circumference, and fat percent were measured by SECA 769 digital measuring station and column scale, tape meter and skinfold caliper, respectively. Fat percent of samples were counted by Jackson/Pollock 3 Site Caliper Method as follow:

\[
\text{Fat } \% = \left( \frac{4.95}{BD} \right) - 4.5 \times 100
\]

where BD is body density and calculated using below formula:

\[
BD = 1.099421 - (0.0009929 \times S) + (0.0000023 \times S^2) - (0.0001392 \times \text{Age})
\]

where S is sum of three skinfold measurements (triceps, suprailiac and thigh) which were measured by caliper [17].

Subjects learned how to work with gym equipment for a week. According to assessment of subjects 1RM, an achievable weight was selected after the warm up; after a short rest, weight increased, gradually until they could repeat 1 to 10 full and correct lift. 1RM measured with using Brzycki (1993) formula for old women [18, 19] as follow in first and last sessions:

\[
1RM = \frac{wt}{[102.78 - 2.78(\text{reps})]}
\]

where wt is weight and reps is repetition number of correct lift.

Vascular endothelial function assessment was performed using Seals et al. (2011) FMD brachial model protocol. FMD was measured by Doppler ultrasound (Philips EPIQ) [20]. General properties of subjects are showed in Table 1.

### Table 2: General properties of subjects

<table>
<thead>
<tr>
<th>General properties</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre test</td>
<td>Post test</td>
</tr>
<tr>
<td>Age</td>
<td>71.41±4.2</td>
<td>76.5±4.66</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>153.41±5.42</td>
<td>155.12±7.52</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.38±10.22</td>
<td>63.29±10.06</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.31±3.71</td>
<td>26.85±3.70</td>
</tr>
<tr>
<td>WHR</td>
<td>0.88±0.04</td>
<td>0.85±0.05</td>
</tr>
<tr>
<td>Fat%</td>
<td>37.5±5.92</td>
<td>31.60±5.79</td>
</tr>
<tr>
<td>FMD%</td>
<td>6.49±2.27</td>
<td>12.86±5.62</td>
</tr>
</tbody>
</table>

*standard deviation

After collecting the basic data, 12 weeks circuit combined training of experimental group was started. Polar- HR monitor (S-series Tolkit) used for heart rate monitoring and maximum heart rate (Max HR= 220 age) was calculated to control the training intensity [21].

### Training Protocol

Experimental group trained 3 times per week on nonconsecutive days for 12 weeks. All training sessions started with warm up for 5 min; then, circuit resistance training was performed for approximately 20-45 minutes with 45-75% of 1RM (since the first session to the last one).

### Table 1: Circuit resistance training protocol

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Time (min)</th>
<th>%1RM</th>
<th>Rep*</th>
<th>Set</th>
<th>Repetition rate</th>
<th>Rest time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 s contraction, 3 s return to rest</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>45%</td>
<td>13-15</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-8</td>
<td>30</td>
<td>65%</td>
<td>10-12</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-12</td>
<td>45</td>
<td>75%</td>
<td>8-9</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Repetition
Training consisted of 1-3 sets (as shown in table 2) for eight exercises (chest press, leg press, shoulder press, abdominal crunch, leg curl, leg extension, bicep curls, and triceps extension) [22] on weight equipment (Mobarez Co., Iran). Immediately after the resistance training, 10-20 min rhythmic aerobic exercise was started with intensity of 45-60 % maximum HR (as shown in table 3). Training sessions were finished with 5 min of cool down.

Table 3: Aerobic protocol (low impact rhythmic aerobic exercise)

<table>
<thead>
<tr>
<th>weeks</th>
<th>Time (min)</th>
<th>%HR max</th>
<th>BPM*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>10</td>
<td>45%</td>
<td>130</td>
</tr>
<tr>
<td>5-8</td>
<td>15</td>
<td>55%</td>
<td>135</td>
</tr>
<tr>
<td>9-12</td>
<td>20</td>
<td>60%</td>
<td>140</td>
</tr>
</tbody>
</table>

*Beat per minute

STATISTICAL RESULTS

Data are presented as mean± Standard deviation. Data normality was tested using Kolmogrov-Smirnov and homogeneity of variances tested by Levene’s test. The samples with normal and homogenate distributions were compared using parametric methods. Paired t-test was used to compare pre-test and post-test in groups (table 4); while, independent t-test was used for group comparisons. Analyses were performed using SPSS 20.0 for Windows (SPSS Inc., Chicago, IL), and statistical significance was set at P ≤0.01.

Table 4: Paired Samples t-Test results

<table>
<thead>
<tr>
<th>Groups</th>
<th>Training</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ±Std. Dev.*</td>
<td>t</td>
</tr>
<tr>
<td>BMI</td>
<td>Pre test</td>
<td>27.31±3.71</td>
</tr>
<tr>
<td></td>
<td>Post test</td>
<td>26.85±3.70</td>
</tr>
<tr>
<td>WHR</td>
<td>Pre test</td>
<td>0.88±0.04</td>
</tr>
<tr>
<td></td>
<td>Post test</td>
<td>0.85±0.05</td>
</tr>
<tr>
<td>FAT%</td>
<td>Pre test</td>
<td>32.75±5.92</td>
</tr>
<tr>
<td></td>
<td>Post test</td>
<td>31.6±5.79</td>
</tr>
<tr>
<td>FMD</td>
<td>Pre test</td>
<td>6.7±2.1</td>
</tr>
<tr>
<td></td>
<td>Post test</td>
<td>12.84±5.44</td>
</tr>
</tbody>
</table>

* Standard deviation
**shows significant difference at the 0.01 level

DISCUSSION

This research is investigated the effect of 12 weeks of circuit combined training on 24 elderly non-athletes women for the first time, and showed significant reduction between BMI, WHR, fat%, and FMD in experimental group. Also, there was a diverse relationship between age, BMI, WHR, and fat% with endothelial function of participants. Previous studies found that overweight and obesity are associated with metabolic disorders and CVD [23]; while age increasing is associated with obesity [24].
In addition, central obesity is effective in coronary vascular diseases occurrence; however, body fat amount, BMI and WHR are independent indices for CVD occurrence [25]. New findings of the current study showed that BMI, WHR and fat% could be mentioned as predictive markers for endothelial function and atherosclerosis in older women without CVD and other major CVD risk factors.

It could be said that, EDD (Endothelium-dependent dilation) occur due to enhanced bioavailability of NO. Our results showed more occurrence rate of EDD in individuals with lower fat percent. Also, obtained results showed improvement of endothelial dysfunction after the reduction in obesity indices. Both control and experimental groups followed a similar pattern of the relationship between obesity indices and endothelial function.

Production and release of nitric oxide (NO) by endothelial cells is deficient in obese peoples, maybe explaining part of the pathophysiology of the development of vascular disease in obesity [26]. Some mechanisms are proposed for the decreased production of NO and activity in obesity, such as insulin resistance and higher levels of free fat acids (FFAs) [27]. FFAs elevated levels is seen in obese people, which have been related with increased levels of oxidative stress, pro-inflammatory signaling, and impaired endothelial function [28]. In addition, some evidences showed that higher levels of FFAs may inhibit NO synthase and its phosphorylation in endothelial cells [29]. It has been shown that insulin induces changes in the endothelium dependent response to vascular stimuli [30]. Also, impairment of endothelial function has been shown in coronary vasculature of obese people [31].

Impairment of endothelial function in obese subjects is found in former studies. Shankar and Steinberg (2005) showed significant endothelial dysfunction in association with obesity, and impaired endothelial function in response to endothelium-dependent vasodilators [26]. Billie et al. (2013) studied the relationship between cardiovascular disease and obesity on 1462 healthy middle-aged men and showed that this relationship is stronger when obesity is measured by WHR and BMI [32]. Also, Arcaro et al. (1999) showed a strong correlation between body fat distribution and endothelial function, without any background of hyperglycemia, dyslipidemia and hypertension [33].

Our findings showed significant differences in obesity indices and endothelial function in non-athlete older women after 12 weeks of combined circuit training; however, there was seen a relationship between obesity indices including BMI, WHR, and fat% with atherosclerosis and endothelial dysfunction in these objects. Thus, using regular training through the reduction in obesity indices, could probably improve endothelial function and body composition and eventually reduction in atherosclerosis and CVD occurrence in older women.

It is suggested that association between obesity degrees and vascular dysfunction could be studied.

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REFERENCES


