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Research article

Effects of 12 weeks of combined exercise training on visfatin and metabolic syndrome factors in obese middle-aged women

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Abstract
Visfatin is a highly expressed protein with insulin-like functions located predominantly in visceral adipose tissue and has been linked to obesity and increased health risks. The purpose of this study was to examine the effects of 12 weeks of combined exercise training on visfatin and metabolic syndrome factors in obese middle-aged women. Subjects were randomly assigned to either a training (n = 10) or control (n = 10) group. The training group exercised for 1 hour, 3 days per week during the 12 week supervised training program. The training program included 3 sets of 10 repetition maximum (10RM) resistance exercise as well as aerobic exercise at an intensity of 60-70% of their heart rate reserve (HRR). The control group was asked to maintain their normal daily activities. Two-way (group X time) repeated measured analysis of variance revealed no significant main effects, but there was a significant group X time interaction for the following variables: body weight ($p < 0.01$), percent body fat (% fat) ($p < 0.01$), waist hip ratio (WHR) ($p < 0.01$), diastolic blood pressure (DBP) ($p < 0.05$), fasting glucose level ($p < 0.01$), triglyceride levels (TG) ($p < 0.01$), high density lipoprotein cholesterol levels (HDL-C) ($p < 0.05$), and visfatin ($p < 0.01$). In conclusion, the 12 week combined resistance and aerobic training program used in this study was very effective for producing significant benefits to body composition and metabolic syndrome factors, as well as lowering visfatin levels in these obese middle-aged women.

Key words: Metabolic syndrome, combined resistance and aerobic exercise, visfatin.

Introduction

Visfatin is a 52 kDa protein originally established as pre-B cell colony-enhancing factor (PBEF) (Samal et al., 1994; Rongvaux et al., 2002). Recently, visfatin was also reported as a highly expressed protein with insulin-like functions located predominantly in visceral adipose tissue, from which the name visfatin was derived (Fukuhara et al., 2005). In previous studies, a positive correlation between visceral adipose tissue visfatin gene expression and body mass index (BMI) was noted, however, the relationship between subcutaneous fat visfatin and BMI was negative suggesting that visfatin regulation may differ depending on different fat patterns (Berndt et al., 2005; Varma et al., 2007).

Visfatin responses to exercise training have examined by Choi et al. (2007), however, potential relationships between visfatin changes and the metabolic syndrome factors related to obesity, diabetes, and heart disease have not yet been established. Metabolic Syndrome (MS) is a common disorder caused by a combination of unhealthy diet, sedentary lifestyle and genetic predisposition (Eckel et al., 2005) and this syndrome is a major risk factor for several chronic diseases, mainly type 2 diabetes and cardiovascular diseases (Ford, 2005; Wilson et al., 2005). The risk factors for MS include higher triglyceride levels (≥150 mg/dL than normal), lower high density lipoprotein cholesterol levels (<50 mg/dL for women and <40 mg/dL for men than normal), higher blood pressure (≥130/80 mmHg than normal), higher fasting blood glucose levels (more than 100 mg/dL), and a large waist circumference (≥88cm for women and ≥102cm for men) (Gupta and Gupta, 2010). The management of MS consists of a two-pronged approach to sustain a healthy weight and increase physical activity. Previous research has shown that physical activity may be protective against MS, independent of weight loss and changes in body composition (Rice et al., 1999; Ross et al., 2000). Additionally, some retrospective studies have shown an improvement in the components of MS with moderate weight reduction (Case et al., 2002).

Contrary to most published results that only used aerobic exercise in their protocols, our previous findings have suggested that combined resistance and aerobic exercise training is better than aerobic exercise alone for improving metabolic indicators of MS (Seo et al., 2010). In fact, data from a recent study by Strasser and Schobersberger (2010) have suggested that resistance exercise training may be an effective alternative to aerobic training for improving body composition and reducing percent body fat in obese patients. It should also be noted that resistance training has been shown to preferentially mobilize visceral and subcutaneous adipose tissue in the abdominal region.

Therefore, the purpose of this study was to examine the effects of 12 weeks of combined (aerobic and resistance) exercise training on visfatin and metabolic syndrome factors in obese middle-aged women.

Methods

Subjects

This study included 20 obese (over 30% body fat) middle-

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aged women without any previous diagnosis of abnormal glucose metabolism and no other health problems. The subjects, average age of 40 years, were informed of the procedures and signed an informed consent document before participation. They were instructed to maintain their typical diet and activity pattern throughout the study, and compliance with this instruction was assessed via food-frequency and physical activity questionnaires administered at the beginning and end of the study. This study was approved by the Human Care and Use Committee of the Institute of Sports Science of Seoul National University.

Study design

Subjects were randomly assigned to either a training group (n = 10) or control group (n = 10). The training group participated in a 12 week supervised combined resistance and aerobic exercise training program. The training group exercised for 1 hour per day, 3 days per week for 12 weeks while the control group was asked to maintain their normal sedentary activities of daily living. All subjects completed pre- and post exercise training assessments for all variables of interest.

Exercise training program

All participants in the training group stretched before and after each training session. The training group performed 1 hour of exercise training which consisted of 30 minutes of treadmill-running at an intensity of 60-70% of their heart rate reserve (HRR) followed by 30 minutes of resistance training which included the bench press, lat-pull down, shoulder press, leg press, leg extension, and sit-ups. The resistance training portion of the exercise session involved 3 sets of 10 repetition maximum (10RM) for each of the exercises. Exercise intensity was monitored during the training sessions using a polar real time system to record heart rates (Polar, S810, Kempele, Finland).

Body composition

Body composition was assessed with an eight-polar electrode impedance meter (InBody 3.0, Biospace, Seoul, Korea). This instrument measures the resistance of the arms, trunk, and legs at frequencies of 5, 50, 250, and 500 kHz and makes use of 8 tactile electrodes: 2 in contact with palm and thumb of each hand and 2 with the anterior and posterior aspects of the sole of each foot (Jensky-Squires et al., 2008). Subjects wore light clothing and removed all metal items which could interrupt the electronic current during the measurement. The body composition results obtained by this technique are significantly related to body composition results obtained by Dual Energy X-ray Absorptiometry (DXA) (r = 0.98), with errors of 2-3% body fat. Waist-to-hip ratio (WHR) was calculated as waist circumference divided by hip circumference as measured to the nearest 0.5 cm with a standard measuring tape.

Blood pressure

Following a 5 minute rest period, arterial blood pressure was measured by an automatic blood pressure monitor (FT500R, Korea) on the right arm while the subject rested in a seated position. Two measurements were taken at each time point and the mean of both the systolic (SBP) and diastolic (DBP) pressures were recorded for later analyses.

Blood samples

Blood samples were obtained in the morning after a 12-hr fast and collected into vacutainer tubes with EDTA. Plasma samples from the participants were packed in ice and sent to the NEODIN Medical Institute in Seoul. Serum triglyceride concentrations (TG) were determined by enzymatic methods using a Technicron RA-500 analyzer (Bayer, Tarrytown, NY, USA) and HDL cholesterol (HDL-C) by the elimination of chylomicron and subsequent catalase (Burstein and Sammaille, 1960). Visfatin was measured using a commercially available ELISA kit (Phoenix Peptides, Karlsruhe, Germany) with inter-assay and intra-assay coefficients variation of less than 6%. Blood-glucose levels were measured by radioimmunoassay kits (Preauto S GLU, Japan) using the glucose oxidaze technique.

Statistical analyses

Descriptive data are presented as means±standard deviations. Independent t-tests were used to examine differences in participant characteristics between groups at baseline. If differences at baseline between the two groups were detected, then analysis of covariance (ANCOVA) was used in later analyses with the baseline values used as the covariates. The effects of the interventions on visfatin and metabolic syndrome factors were analyzed by means of a two-way repeated measures ANOVA (group X time). Statistical significance was set at $p < 0.05$ and all analyses were performed using SPSS version 18.0 software (Chicago, IL, USA).

Table 1. Baseline physical characteristics. Data are means (±SD).

	Control group (n = 10)	Training group (n = 10)
Age, years	40.1 (4.0)	39.8 (5.3)
Height, m	1.60 (.06)	1.57 (.05)
Weight, kg	62.0 (8.2)	64.9 (8.9)
Body Fat, %	35.6 (3.9)	36.5 (3.4)

Results

All parameters of interest were similar between the two groups at baseline ($p > 0.05$) (Tables 1 and 2) with the only exception being TG levels (94.4 ± 21.8 mg/dl pre control group versus 112.6 ± 38.5 mg/dl pre training group; $p < 0.05$). Table 2 also displays the metabolic syndrome indicators for both groups at baseline (pre training) and following the 12 week intervention (post training). There were no significant main effects (group or time) but there was a significant interaction of group X time for body weight ($p < 0.01$), % fat ($p < 0.01$), WHR ($p < 0.01$), DBP ($p < 0.05$), HDL-C ($p < 0.05$), fasting glucose level ($p < 0.01$), TG ($p < 0.01$), and visfatin ($p < 0.01$). The training group had significant decreases in body weight, % fat, WHR, DBP, fasting glucose levels, and visfatin levels while the control group remained unchanged and the HDL-C level for the training group

Table 2. Changes in body composition, blood pressure, and metabolic syndrome indicators. Data are means (±SD).

	Control group		Training group		*p* (T x G)
	pre	post	pre	post	
Weight, kg	62.0 (8.2)	62.8 (8.3)	64.9 (8.9)	62.2 (8.9)	**<.001**
Body fat, %	35.6±3.9)	35.9 (3.7)	36.5 (3.4)	33.4 (3.7)	**<.001**
WHR	.83 (.05)	.87 (.03)	.86 (.04)	.83 (.05)	**<.001**
SBP, mmHg	119.9 (9.8)	120.1 (9.4)	121.2 (8.0)	119.1 (7.0)	.452
DBP, mmHg	72.8 (10.7)	74.2 (11.8)	78.6 (6.0)	75.2 (6.0)	**.041**
HDL-C, mg/dl	52.9.0 (11.0)	51.2 (8.0)	46.1 (9.4)	52.5 (12.2)	**.028**
Glucose, mg/dl	85.9 (6.9)	88.2 (6.6)	84.4 (7.0)	78.9 (4.1)	**.001**
TG, mg/dl	94.4 (21.8)	108.9 (23.4)	112.6 (38.5)	98.8 (35.2)	**.002**
Visfatin, ng/ml	61.5 (11.4)	78.5 (21.1)	63.6 (19.2)	53.5 (12.6)	**.002**

T = time; G = group; SBP = systolic blood pressure; DBP = diastolic blood pressure; WHR = waist hip ratio; TG = triglyceride; HDL-C = high density lipoprotein cholesterol.

significantly increased with no change for the control group. The ANCOVA analyses which accounted for baseline differences in TG levels did not change any of the original findings. The Food Frequency and Physical Activity questionnaires confirmed that diet and activity levels remained fairly constant over the 12 week intervention period, however, the lack of any actual control over diet and activity may be considered a limitation to this study.

Discussion

Our study focused on the effectiveness of a 12 week combined resistance and aerobic exercise training program on potential changes in visfatin and metabolic syndrome factors. The significant improvements observed in visfatin levels and the different indicators of metabolic syndrome for the training group confirmed our hypotheses that combining both resistance exercises with aerobic exercise can provide an effective approach for combating the harmful factors associated with obesity.

In a previous study, Fukuhara et al. (2005) reported that plasma visfatin levels were strongly correlated with the quantity of visceral adipose tissue ($r = 0.68$, $p < 0.001$) as assessed by computed tomography (CT) with a weaker correlation between the quantity of subcutaneous adipose tissue and visfatin ($r = 0.22$, $p < 0.05$). Pagano et al. (2006) also reported that visfatin levels were lower in subcutaneous fat locations and higher in visceral adipose tissue of obese subjects compared to lean individuals. In contrast to those studies, Berndt et al. (2005) did not report any significant relationships between visfatin levels and the amounts of visceral adipose tissue as determined by CT measures. Concerning our results, the combined exercise training program resulted in a reduction of body weight, percent body fat, and the waist hip ratio (WHR), implying that our subjects lost visceral fat and/or abdominal subcutaneous fat after the intervention. As a result of the decrease in body fat, especially in the abdominal area, there was a concomitant reduction in visfatin from 63.6 ± 19.2 ng/ml pre training to 53.5 ± 12.6 ng/ml post training ($p < 0.01$), similar to the findings of Choi et al. (2007).

Metabolic syndrome (MS) and obesity have been known worldwide as clinical markers for early detection of cardiovascular disease and type 2 diabetes (Gale, 2008). The risk factors for MS include higher triglyceride levels (≥150 mg/dL than normal), lower high density lipoprotein cholesterol levels (<50 mg/dL for women and <40 mg/dL for men than normal), higher blood pressure (≥ 130/80 mmHg than normal), higher fasting blood glucose levels (more than 100 mg/dL), and a large waist circumference (≥ 88cm for women and ≥102cm for men) (Gupta and Gupta, 2010). Each of these metabolic syndrome factors, that included TG, HDL-C, WHR, fasting levels of glucose, and DBP, each parameter showed significant improvement following the exercise intervention, with only SBP remaining unchanged ($p = 0.452$).

Program's Adult Treatment Panel III reported that the increasing prevalence of obesity has been accompanied by a parallel increase in the prevalence of metabolic syndrome (NCEP, 2002). Also, a previously published report indicated that obesity was strongly associated with the development of incident MS while low physical activity levels were only weakly associated with incident MS (Cheriyath et al., 2010). These findings suggest the need to directly target obesity, rather than physical activity in an attempt to prevent the development of MS in the general population, however, the interaction of physical activity levels and obesity are obvious (Balkau et al., 2006; Pitsavos et al., 2005).

Conclusion

In conclusion, our findings demonstrated that a 12 week supervised program that combined resistance training with aerobic exercise is effective in modifying factors related to metabolic syndrome in obese middle-age women and for lowering visfatin levels.

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Key points

- Recent studies have linked visfatin to obesity and increased health risks.
- The study was done to investigate the effects of 12 weeks of combined exercise training on visfatin and metabolic syndrome factors in obese middle-aged women.
- The exercise program used in this study was found to be very effective for lowering visfatin levels in obese middle-aged women.

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