



Original Article

# Effects of aerobic exercise intervention on serum cartilage oligomeric matrix protein levels and lymphocyte DNA damage in obese elderly females

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**Abstract.** [Purpose] The aim of the reported research was to investigate the effects of regular aerobic exercise on cartilage oligomeric matrix protein and oxidative DNA damage in obese, elderly females. [Subjects and Methods] Sixteen class I obese, elderly females, according to World Health Organization criteria, were randomly and equally assigned to a control group (n=8) or an exercise group (n=8). The exercise group participated in exercise sessions of 60 minutes per day, 3 days per week, for a period of 8 weeks. [Results] After aerobic exercise intervention, weight, body mass index, body fat, waist circumference, and DNA damage (Tail moment) were significantly decreased, compared with baseline values. In contrast, serum cartilage oligomeric matrix protein levels were not significantly different among any groups or time-points. [Conclusion] Regular aerobic exercise may be effective for reducing obesity-induced high DNA damage levels in obese females, without causing the deformation or degradation of lower extremity articular cartilage.

**Key words:** Aerobic exercise, Articular cartilage, DNA damage

(This article was submitted Feb. 4, 2016, and was accepted Mar. 12, 2016)

## INTRODUCTION

The rapid global increase in obesity prevalence has resulted in an obesity epidemic. Obesity is a serious health threat not only for metabolic diseases, but also for several types of cancers<sup>1, 2)</sup>. Oxidative stress has been reported as one of the chief causes of the onset of various obesity-related diseases<sup>3)</sup>. In brief, obesity is accompanied by increased levels of free fatty acids (FFA) and hyperglycemia; which, in turn, leads to increased reactive oxygen species (ROS) production and oxidative stress<sup>4)</sup>. Increased oxidative stress could initiate cancer not only by damaging DNA directly, but also by inducing error-prone DNA repair<sup>5)</sup>.

It has been reported that physical activities such as regular exercise can reduce the oxidative stress level in the body that is elevated by obesity<sup>6)</sup>. Konopka et al. suggested that exercise could reduce DNA oxidative damage in obese females by significantly decreasing exercise-induced 8-oxo-2'-deoxyguanosine (8-oxo-dG)<sup>7)</sup> formation. However, there has been limited research investigating the effects of obesity and exercise on DNA damage by using the Comet assay<sup>8)</sup>, which enables rapid and sensitive measurement of DNA damage. It has been reported that, although regular aerobic exercise could be effective for obesity prevention and alleviation<sup>6, 9)</sup>, walking and running, the representative modes of aerobic exercise, could cause temporary cartilage deformation and degradation by increasing the load on the lower extremity joints (e.g., knee joint), as reflected by elevated serum cartilage oligomeric matrix protein (COMP) levels<sup>10, 11)</sup>.

Therefore, two aspects should be considered for obese subjects who exercise regularly: while it is effective for main-

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tenance and promotion of health by reducing DNA damage, it can induce cartilage deformation by repetitively increasing the load on the lower extremity joints. However, no research has yet been reported in this regard. Accordingly, the present research aims to identify the effect of aerobic exercise on lymphocyte DNA damage in obese subjects by using the Comet assay, as well as the stress level of the lower extremity articular cartilage by analyzing serum COMP levels.

## SUBJECTS AND METHODS

Sixteen obese, elderly females volunteered as subjects for this research. All subjects had a body mass index (BMI) above 25 kg/m<sup>2</sup>, and waist circumference above 80 cm. Minimum acceptable values for BMI and waist circumference were based on the criteria for class I obesity for adult Asians, established by the World Health Organization (WHO). Subjects also had to be free from any orthopedic or cardiovascular problems that would limit exercise. The research conformed to the standards set by the latest revision of the Declaration of Helsinki. All subjects read and signed a written informed consent statement consistent with the guidelines set by the Department of Physical Education at Yonsei University.

Anthropometric measurements included height, body composition, and waist circumference, measured using a stadiometer (SECA 213; SECA, Hamburg, Germany), a bioimpedance analysis (BIA) device (Inbody 720; Biospace, Seoul, Korea), and a circumference measuring tape (SECA 200; SECA, Hamburg, Germany), respectively.

After the anthropometric measurements, subjects were randomly and equally assigned to either an 8-member control (CON) group (age: 62.3 ± 4.8 years, height: 159.0 ± 5.0 cm, weight: 71.0 ± 3.6 kg, BMI: 28.1 ± 2.2 kg/m<sup>2</sup>, percent body fat: 35.9 ± 2.7%, waist circumference: 86.7 ± 3.8 cm) or an 8-member exercise (EX) group (age: 63.8 ± 4.0 years, height: 158.3 ± 5.4 cm, weight: 69.9 ± 6.6 kg, BMI: 27.9 ± 1.9 kg/m<sup>2</sup>, percent body fat: 35.0 ± 3.0%, waist circumference: 87.6 ± 4.6 cm). The EX group participated in sessions of 60 min per day, 3 days per week, for a period of 8 weeks. Each session began with a 10-min warm-up, continued with a main set of 40-min treadmill running at their individual target heart rate zone (70% of heart rate reserve), and finished with a 10-min cool-down period. The individual target heart-rate zone was determined according to the Guidelines for Exercise Testing and Prescription of the American College of Sport Medicines<sup>12)</sup>.

Before and after the 8 weeks of intervention, 8 ml of blood was collected from the antecubital vein of each subject with a 22-gauge needle and SST tubes. The serum COMP levels were determined by an enzyme-linked immunosorbent assay (ELISA) using a commercially available Human COMP<sup>®</sup> ELISA kit (AnaMar AB, Lund, Sweden). The absorbance was measured at 450 nm with a microplate reader (Molecular Device, Sunnyvale, CA, USA). The lymphocyte DNA damage was determined by using a Comet assay as described by Singh et al., which showed single- or double-strand DNA breaks<sup>13)</sup>. DNA in tail, Tail length, and Tail moment were also determined.

Statistical analyses were performed using the Statistical Package for the Social Sciences software, version 21.0 (SPSS Inc., USA). Experimental analysis was performed with a 2 × 2 repeated-measures analysis of variance (ANOVA) model to determine differences within and between groups over time. The level of significance was set at α<0.05.

## RESULTS

The changes of anthropometric and biochemical characteristics for the two groups before and after intervention are shown in Table 1. The weight, BMI, body fat, waist circumference, and tail moment were significantly decreased after intervention, as compared with those before intervention, in the EX group (p<0.05). In addition, body fat after intervention was significantly lower in the EX group than in the CON group (p<0.05). In contrast, serum COMP, DNA in tail, and Tail length were not significantly different among any groups or time points (Table 1).

**Table 1.** Changes of anthropometric and biochemical characteristics before and after intervention

Variables	CON (n=8)		EX (n=8)	
	Before	After	Before	After
Weight (kg)	71.0 ± 3.6	70.9 ± 3.0	69.9 ± 6.6	66.7 ± 5.1*
BMI (kg/m <sup>2</sup> )	28.1 ± 2.2	28.1 ± 2.1	27.9 ± 1.9	26.6 ± 1.3*
Body fat (%)	35.9 ± 2.7	36.0 ± 2.6	35.0 ± 3.0	32.5 ± 2.2* <sup>‡</sup>
WC (cm)	86.7 ± 3.8	86.8 ± 4.8	87.6 ± 4.6	85.5 ± 3.5*
COMP (U/L)	11.5 ± 2.4	11.6 ± 2.9	10.9 ± 2.1	10.4 ± 2.2
DNA in tail (%)	8.2 ± 2.1	8.2 ± 1.9	8.8 ± 2.2	7.9 ± 1.7
Tail length (μm)	49.8 ± 14.1	48.0 ± 6.7	49.8 ± 4.5	47.1 ± 5.2
Tail moment	4.9 ± 2.3	5.1 ± 2.0	5.1 ± 1.1	4.2 ± 0.9*

Data are presented as mean ± SD. CON: control; EX: exercise; WC: waist circumference; \*Significantly lower than before within the group (p<0.05); <sup>‡</sup>Significantly lower than CON within the time point (p<0.05).

## DISCUSSION

Measuring DNA damage in cells has been suggested as a method not only for detecting the occurrence of genotoxicity caused by toxic materials that are harmful to the human body, but also for the early prediction of the presence of severe diseases such as cancer<sup>14</sup>. The research described herein used the Comet assay to investigate the effect of a regular aerobic exercise intervention on lymphocyte DNA damage in obese, elderly females. The result showed that after intervention, the EX group showed a significant decrease in Tail moment, a reflection DNA damage. This result supports preceding research that showed reduced DNA damage, based on the Comet assay, after aerobic exercise training<sup>15, 16</sup>. Another result of the present research was a significant decrease in obesity-related indexes (weight, BMI, body fat, and waist circumference) in the EX group after intervention. Taken together, the results of the present research indicate that obesity reduction, due to exercise, alleviates DNA damage. Our results are supported by Luperini et al., who reported obesity as a cause of DNA damage, based on significantly high levels of DNA strand breaks and oxidized purines and pyrimidines in morbidly obese females compared with that in eutrophic females<sup>17</sup>. Additionally, Karaman et al., suggested that comet-tail length had positive correlations with waist circumference and BMI<sup>18</sup>.

In contrast, it has been reported that COMP, a protein component of cartilage, was released into the blood when cartilage was damaged, because of repetitive training or physical stress on a joint; and that joint diseases, such as osteoarthritis, also led to elevated blood COMP levels<sup>10, 11, 19</sup>. The present research analyzed serum COMP to examine the change in the level of stress on lower extremity articular cartilage in obese, elderly females, according to regular aerobic exercise intervention. The result showed no significant difference in serum COMP levels before or after intervention. Therefore, it is considered that the aerobic exercise regimen of the present research did not exert deleterious stress on the lower extremity articular cartilages of the subjects. However, it is known that serum COMP levels, elevated by walking or running, return to baseline levels within 30 minutes after exercise<sup>10, 11</sup>. For this reason, follow-up research for investigating change in circulating COMP levels would need to employ an acute exercise protocol for stimulating articular cartilage before and after intervention.

In conclusion, it is suggested that the regular aerobic exercise involved in this research, may be effective for reducing obesity-induced high DNA damage levels in obese, elderly female subjects, without causing deformation or degradation of lower extremity articular cartilage.

## ACKNOWLEDGEMENT

This work was supported by the Dong-A University research fund.

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