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# Six weeks of combined aerobic and resistance exercise using outdoor exercise machines improves fitness, insulin resistance, and chemerin in the Korean elderly: A pilot randomized controlled trial

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## ABSTRACT

*Background:* The aim of this study was to investigate the effect of a six-week-long exercise program using outdoor exercise equipment on fitness, insulin resistance and adipocytokines among Korean elderly.
*Methods:* A total of 47 participants were randomized into one of the following three groups; control, resistance exercise or combined exercise (aerobic and resistance exercise). The resistance exercise group completed three resistance types of exercise. The combined exercise group completed five exercises, including three resistance types of exercise and two aerobic types of exercise. Participants' body composition, fitness level, homeostasis model assessment of insulin resistance (HOMA-IR), and adipocytokines were measured at baseline and at the end of six weeks.
*Results:* After six weeks of exercise training, participants in the combined exercise group exhibited significant reduction in insulin, HOMA-IR and chemerin levels, while significant reduction was observed in HOMA-IR only in the resistance exercise group compared with the control group. Meanwhile, six weeks of exercise training, whether resistance exercise alone or combined, significantly improved upper body muscular strength/endurance and physical function compared to the control group.
*Conclusions:* Six weeks of combined exercise using outdoor exercise equipment was effective in improving fitness, HOMA-IR, circulating chemerin levels, and other known risk factors of chronic diseases.

## 1. Introduction

Aging is associated with increased risk of chronic disease such as type 2 diabetes, cerebrovascular, and cardiovascular diseases (Collaboration, 2002; Horiuchi & Wilmoth, 1997). Age-associated increase in insulin resistance is one of the primary causes of these chronic diseases (Fagot-Campagna, Bourdel-Marchasson, & Simon, 2005; Jeon et al., 2006; Pyörälä, Miettinen, Halonen, Laakso, & Pyörälä, 2000; Rewers et al., 2004; Rowe, Minaker, Pallotta, & Flier, 1983; Weyer, Tataranni, Bogardus, & Pratley, 2001). Increased fat mass and reduced muscle mass (sarcopenia), observed among most elderly population, result in the age-associated insulin resistance (Weisberg et al., 2003; Xu et al., 2003). Aging-associated change in inflammatory markers such as interleukin-6 and chemerin could also contribute to the development of insulin resistance in the elderly (Arai, Takayama, Abe, & Hirose, 2011). Among inflammatory markers, chemerin is a newly discovered adipocytokine that is associated with adiposity, insulin sensitivity, components of metabolic syndrome (Chu et al., 2012) and inflammation (Bozaoglu et al., 2007; Bozaoglu et al., 2009; Hah et al., 2011; Lehrke et al., 2009; Weigert et al., 2010; Zanetti et al., 2009).

Knowing that fat mass is increased and muscle mass is reduced in the elderly, the importance of exercise for the elderly is evident (Koopman & van Loon, 2009). Indeed, both aerobic and resistance exercises are recommended to the elderly and reflected in the recent

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public health guidelines from the American college of sports medicine and the American heart association (Nelson et al., 2007). A randomized controlled trial of 136 obese elderly demonstrated that both aerobic and resistance exercises improved glycemic control, but combined exercise, including both aerobic and resistance, improved glycemic control more than either aerobic or resistance exercise alone in elderly people (Davidson et al., 2009). Furthermore, previous studies have primarily reported that combined exercise significantly improved cardiopulmonary and muscular strength in elderly people (Cao, Maeda, Shima, Kurata, & Nishizono, 2007; McKelvie et al., 2002).

Although it is evident that exercise has much health benefit for the elderly, especially combined exercise, the mechanisms of exercise-associated improvement in factors contributing to the development of chronic diseases still need to be elucidated in the elderly (Cao et al., 2007; Chodzko-Zajko et al., 2009). Interestingly, several studies recently demonstrated that exercise and lifestyle modification can significantly reduce circulating chemerin levels, and the degree of reduction in chemerin level to be associated with the degree of reduction in insulin resistance in obese (Lee et al., 2013) and type 2 diabetic patients (Kim et al., 2014). However, the effects of exercise on circulating chemerin levels in the elderly have not been studied to date. Knowing that circulating chemerin is associated with increased risk of colorectal cancer (Erdogan et al., 2016), cardiovascular disease (Gu et al., 2015) and renal diseases (Leiherer et al., 2016), which increase with aging, understanding whether exercise can reduce chemerin level in the elderly is of interest.

South Korea is aging faster than any other countries (Phang, 2011). Since exercise is an effective strategy to improve health in elderly population, outdoor exercise facilities have gained popularity due to their accessibility (Chow, 2013). In South Korea, central and local governments have invested extensively in installing outdoor exercise facilities to increase the physical activity level of the general public. However, the effectiveness and efficacy of this mode of exercise on fitness level and insulin resistance have not been studied in the elderly. Therefore, the purpose of this study is to test whether resistance exercise alone or combined aerobic and resistance exercise using outdoor exercise facilities improves fitness, insulin resistance, and adipocytokine levels in the Korean elderly.

## 2. Methods

### 2.1. Study design and participants

We conducted a pilot randomized controlled trial with 47 healthy elderly participants from the Eunpyung Municipal Welfare Center in Seoul, Republic of Korea who met our inclusion criteria. The inclusion criteria were as follows: (1) those with no significant illness within the last 6 months, (2) those aged over 65 years, and (3) those who had not exercised regularly in 3 months before the participation in this study. A simple randomization method was used by drawing lots. The individual who coordinated the randomization process was not involved in any of the screening and outcome assessments. Participants were assigned to one of the three study groups: control group (n = 15), resistance exercise group (n = 16) and combined aerobic and resistance exercise group (n = 16). The trial was conducted for six weeks (Fig. 1). This study was approved by the Ministry of Health and Welfare, Republic of Korea, and written informed consent was obtained from all participants.

### 2.2. Exercise program

This study encompassed six pieces of outdoor exercise equipment, including pull weight, chair pull, leg extension, sky-walk and cross-country, all of which are widely installed around cities in Korea (Fig. 2). Frequency, intensity and duration of exercise were set according to the American College of Sport Medicine (ACSM)'s guidelines for elderly population (American College of Sports Medicine, 2013). In addition, exercise intensity was revised weekly using Borg's rating of perceived exertion (RPE) (Borg, 1970) to ensure participants' safety. Participants in the exercise groups participated in six weeks of either supervised resistance exercise or combined exercise. The details of each six-week-long exercise program are shown in Table 2.

### 2.3. Measurements

All measurements were conducted at baseline and after completion of the six-week-long program. Anthropometric measurements and body composition were determined using the JENIX (DS-102, Seoul, Republic of Korea) and In-Body (IHU070R Biospace, Seoul, Republic of Korea) which was previously tested for validity and reliability in estimating body composition (Jensky-Squires et al., 2008). Fitness was evaluated based on the five fitness tests designed for the elderly (30 s chair stand, 30 s arm curl, 244 cm up and go, one-leg stand, and 2 min step), as well as push-ups and six-min walk tests, which were performed using standard protocols (American Thoracic Society, 2002). A blood sample was collected after a 12-h fast and analyzed for glucose metabolism-related substances, including fasting glucose (ADVIA 1650, Siemens, Tarrytown, NY, USA) and fasting insulin (Roche, Indianapolis, IN, USA). Insulin resistance was estimated using the homeostasis model assessment of insulin resistance (HOMA-IR) index (Insulin [μIU/mL] × Fasting glucose [pmol/L]/22.5). High-sensitive interleukin-6 (IL-6) levels were measured using a commercially available enzyme-linked immunosorbent assay (R&D, Minneapolis, USA). The intra- and inter-assay coefficients of variation for hs-IL-6 were 7.4 ± 0.5% and 7.8 ± 1.6%, respectively. Chemerin was measured using enzyme-linked immunosorbent assay (Mesdia, Seoul, Republic of Korea). The intra- and inter-assay coefficients of variation for chemerin were 8.4 ± 3.7% and 11.3 ± 6.0%, respectively.

### 2.4. Statistical analysis

Statistical analyses were performed with SPSS, Windows version 18.0 (SPSS Inc, Chicago, IL, USA). Descriptive analyses and independent *t*-tests were used to assess baseline characteristics and gender differences. Paired *t*-tests were used to compare baseline data with data collected after six weeks for each of the study groups.

Additionally, analysis of variance (ANOVA) was performed for between-group comparisons in the changes of study parameters at baseline and at six-week follow-up. To test for any sex-related variations in physiological responses, we further conducted analyses after excluding three male participants. Statistical significance was set at $p < 0.05$.

## 3. Results

### 3.1. Baseline characteristics of the participants (Fig. 1, Table 1)

Forty-seven healthy elderly participants initially agreed to participate in this study, and 35 participants successfully completed the entire study protocol [control (10/15, 67%), resistance (12/16, 75%) and combined exercise group (13/16, 81%)]. Six subjects were unable to complete the study due to personal matters, four cited lack of time, and two left the study for personal medical reasons; in addition, one subject was excluded from the analysis because blood sample was not collected. There was no drop-out due to side effects of exercise program during the study period. Participant characteristics are presented in Table 1. Mean age of the participants was 73.20 ± 4.90 years and mean BMI was 25.41 ± 2.42 kg/m$^2$.

### 3.2. Effects of exercise on body composition and fitness (Table 3)

There were no significant differences in the changes in body composition among participants in both exercise groups compared with the