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Effects of home-based bench step exercise on inflammatory cytokines and lipid profiles in elderly Japanese females: A randomized controlled trial

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ABSTRACT

Purpose: The purpose of the current study was to investigate the effects of a 12-week home-based bench step exercise program on inflammatory cytokines and lipid profiles in elderly females.
Methods: Sixty-two postmenopausal females (65–85 years of age) were randomized to either the bench step exercise group ($n = 31$) or the control group ($n = 31$). The subjects in the bench step exercise group were instructed to perform bench step exercises at the exercise intensity corresponding to lactate threshold (LT), three times per day 10–20 min each session, for a goal of $\geq$140 min/week at home for 12 weeks. At baseline and 12 weeks, circulating levels of nine inflammatory cytokines (high-molecular-weight adiponectin, interleukin-4 [IL-4], IL-5, IL-6, IL-8, IL-15, tumor necrosis factor-α [TNF-α], TNF-β and interferon-γ [IFN-γ]) and serum lipids including high-density lipoprotein cholesterol (HDL-C) were measured.
Results: The bench step training at the LT significantly increased HDL-C levels and decreased IFN-γ concentrations in the subjects with lower (< 63 mg/dL) baseline HDL-C levels ($p < 0.05$). The change in IFN-γ inversely correlated with the change in HDL-C in the exercise group ($\rho = -0.56$, $p < 0.01$), whereas this association was not observed in the control group. Additionally, principal component analysis-derived index of what we called "inflammatory status factor" was inversely associated with the changes in HDL-C in the exercise group.
Conclusion: The bench step exercise-induced reduction in the IFN-γ levels may partially explain the degree of improvement in the HDL-C levels with the exercise program.

1. Introduction

Inflammation plays an essential role in the development of atherosclerosis (Libby, Ridker, & Maseri, 2002; Ross, 1999). Epidemiological studies have demonstrated that higher levels of typical inflammatory markers, including interleukin-6 (IL-6) and tumor necrosis factor-α (TNF-α), are linked to an increased risk of future cardiovascular disease (Pai et al., 2004; Ridker, Rifai, Pfeffer et al., 2000; Ridker et al., 2000). Other inflammatory cytokines, such as interferon-γ (IFN-γ), IL-8 and IL-15, are also closely involved in the development of atherosclerosis and cardiovascular disease (Gerszten et al., 1999; Harvey & Ramji, 2005; Houtkamp et al., 2001). Preventing chronic inflammation is especially important in older adults, who are more vulnerable to common diseases, including cardiovascular disease, as aging has been reported to be associated with chronic inflammation (Ferrucci et al., 2005; Roubenoff, 2003) and an enhanced inflammatory state predicts both mobility limitations and mortality in the elderly (Harris et al., 1999; Penninx et al., 2004).

Physical exercise is a potential strategy for improving the chronic inflammation that accompanies aging. Greater engagement in daily physical activity is associated with reduced levels of representative inflammatory markers, including C-reactive

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protein, IL-6 and TNF-α (Beavers, Brinkley, & Nicklas, 2010). In a recent systematic review by Palmefors, DuttaRoy, Rundqvist, and Borjesson (2014), the overall quality of evidence regarding the beneficial effects of exercise training on two cytokines (i.e., TNF-α and IL-6) was assessed as high and moderate, respectively, whereas that for other cytokines (e.g., IFN-γ) was assessed as low or insufficient (Palmefors et al., 2014). Therefore, the further accumulation of scientific evidence with respect to the influence of exercise intervention on less frequently investigated cytokines such as IFN-γ is needed.

Moderate exercise at the lactate threshold (LT) has been well documented to be an optimal exercise regimen that can safely increase aerobic fitness and improve HDL-C levels in elderly or patients (Kumagai, Shono, Kondo, & Nishizumi, 1994; Motoyama et al., 1995; Riedl et al., 2010; Sasaki et al., 1989; Sunami et al., 1999; Urata et al., 1987). Older subjects have a high level of compliance with good adherence to our home-based bench step exercise program (Mori et al., 2011; Ohta et al., 2012), since these exercises performed at the individually determined LT are not hard for the elderly, and are easily performed on a daily basis at home whenever they want, using a bench step (bench height 15–20 cm) and a compact disc that provides a regular rhythm set at the individual's LT (Ayabe et al., 2003). In most previous studies investigating the effects of exercise training on inflammatory markers, the study participants were under supervision during the exercise session, there are currently no reports concerning highly practical home-based exercise program for elderly people.

As aforementioned, moderate exercises at the LT augments the circulating levels of HDL-C in elderly people; however, the mechanisms underlying the beneficial adaptation are poorly understood. There are no previous studies reporting association between exercise-induced changes in inflammatory cytokines and alterations in the levels of HDL-C, after exercise. The induction of inflammation has been associated with decrease HDL-C levels in rodents (Hardardottir, Grunfeld, & Feingold, 1994). We therefore hypothesized that reduction of inflammation induced by the exercise program would be associated with improvement in the HDL-C levels with exercise. To examine abovementioned hypothesis, the current study investigated the effects of 12-week home-based bench step exercises at the LT on the circulating levels of several inflammatory cytokines and examined potential relationships with the changes in lipid profiles in elderly females.

2. Material and methods

2.1. Study design

The current study was an ancillary study to a previously published randomized controlled trial investigating the effects of a 12-week home-based bench step exercise program in 62 elderly females (Ohta et al., 2008). The study design (Ohta et al., 2008, 2012), anthropometric indices (weight, height, body mass index [BMI]), blood pressure, LT (Ohta et al., 2008) and serum lipids (total cholesterol [TC], high-density lipoprotein cholesterol [HDL-C], low-density lipoprotein cholesterol [LDL-C] and triglycerides [TG]) in a portion of the current participants (bench step exercise group [$n = 13$], control group [$n = 13$]) have been reported (Ohta et al., 2012). In these two previous papers, the levels of inflammatory cytokines were not investigated. The nine inflammatory cytokines mentioned below were newly measured in the current study in order to analyze the associations between exercise-induced changes in the levels of inflammatory cytokines and serum lipids. Written informed consent was obtained from all participants, and the current study was approved by the ethics committee of the University of Occupational and Environmental Health, Japan.

2.2. Subjects

The current subjects included healthy postmenopausal females, that were members of the same population as in one of the above

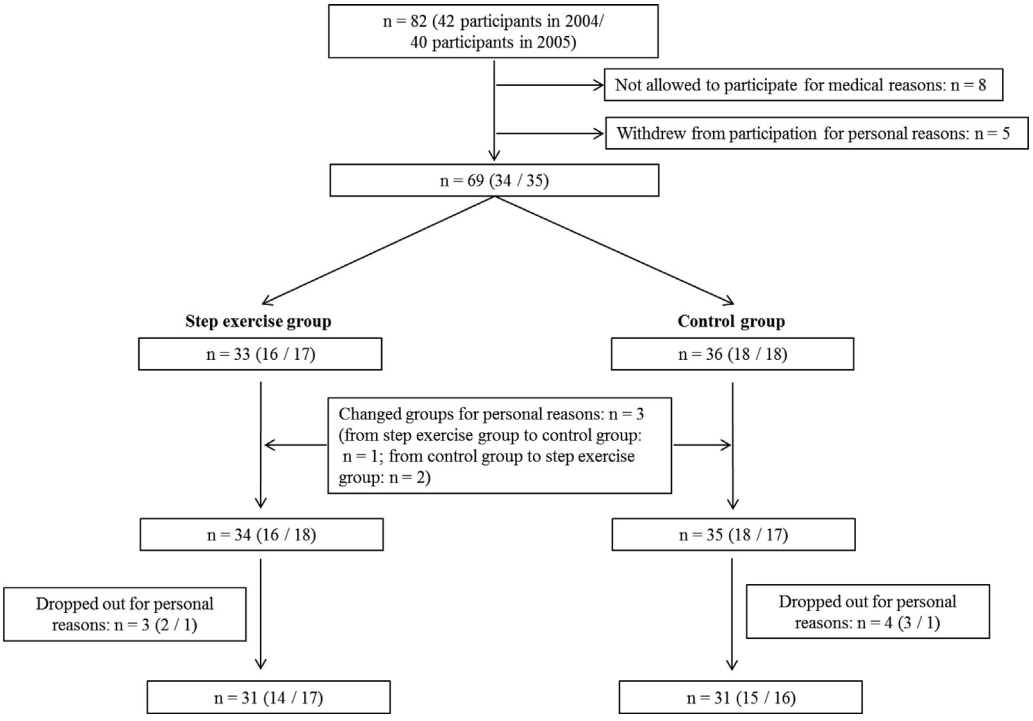

Fig. 1. Participant flow diagram. The number of subjects is shown separately according to the year (2004 or 2005) during which the subjects participated in the present study (shown in parentheses, number of participants in 2004/number of participants in 2005). Sixty-nine participants (34/35) were randomized to the bench step exercise group or control group. After excluding dropouts, a total of 31 participants in the step exercise group and 31 participants in the control group remained for the analysis.

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