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A Mild-Exercise Support Program and Its Affect on Physical Strength and Metabolic Improvement in the Elderly

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Abstract

In the present study, we investigated the effectiveness of a support program that involved sessions of mild exercise that lasted for approximately 90 minutes practiced over a period of 3 months by 26 healthy elderly men and women (66.8 ± 4.3 years of age) who had never had guidance on health-promoting exercise. Before and after the program, the subjects underwent examinations to assess the effects on their physical strength, blood, glucose metabolism, lipid metabolism, and oxidative stress. We also studied the effects of the continuation of physical training in 8 men and women (67.6 ± 4.7 years of age) who participated in a similar exercise program for an additional 12 months (15 months in total). The 3-month physical training improved the leg strength (measured as the consecutive number of steps made up onto and then back down from a footstool in 30 seconds) ($p < 0.01$), and significantly lowered the serum malondialdehyde-modified low-density lipoprotein (MDL-LDL) levels ($p < 0.01$). In the 8 subjects who continued the additional 12 months of training, the increased leg strength was retained throughout the 15-months ($p < 0.05$), and the time required to walk 400 m was significantly shortened from 279 ± 14 to 255 ± 24 seconds ($p < 0.05$). Among the blood biochemistry parameters tested, high-density lipoprotein cholesterol (HDL-C) showed an 11% increase from 62.8 ± 14.7 to 69.4 ± 13.0 mg/dl ($p < 0.05$). In addition, the plasma hydro peroxide concentration (derivatives of reactive oxygen metabolites [d-roms]) was decreased by 28% from 394 ± 52 to 284 ± 32 U.Carr ($p < 0.01$), showing a marked decrease in oxidative stress from a moderate level to a normal level. These results suggest that, when continued long term, even a mild exercise program that is easily implementable by elderly people can produce noticeable measures of better health, particularly with respect to walking ability and oxidative stress.

Introduction

Physical exercise for the elderly has long been considered an effective physical function against aging. Meanwhile, it is not fully understood what should constitute a safely implementable, mild-exercise program that will effectively produce significant changes in physical strength and metabolic parameters in elderly who have no exercise experience. For example, Pittaluga et al7). Found that the blood glutathione Redox ratio (GSSG/GSH), which indicates the oxidation state of tissues, was increased by 13.4% in elderly women (69.0 ± 2.7 years of age) when they exercised once, but then was decreased by 14.5% in the same subjects when they continued physical training for a month. This result indicates that it is the metabolic system enhancement that is brought on by continued physical exercise, rather than physical exercise per se, that is most effective for metabolic improvement. However, there is a report showing that no changes in the blood hydro peroxide concentration occurred after 3-months of physical training. Hence, the required duration of training has not been fully established.

When an exercise program is intended for the elderly, age-associated changes such as reduced trainability and decreased physical strength, must also be taken into consideration. In an attempt to propose an effective duration for a mild-exercise program, a so-called "health-promoting exercise," that would induce beneficial changes in physical strength, blood properties, glucose and lipid metabolism, and oxidative stress, we conducted physical training for 3 months in elderly subjects, which was followed by a longer-term training experiment to determine if

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further improvements in any of the aforementioned items would occur when the training period was extended.

Methods

Subjects

The subjects were recruited from participants in a health-promoting exercise class for the elderly that was held in the city of K in the prefecture of Chiba under the auspices of N University, the City Medical Association, and the Bone-Setters Association. A total of 35 men and women who had undergone a preliminary medical check to clear them as capable of physical exercise, participated in all sessions of the 3-month exercise program. At the start of the study, 26 healthy participants with no missing measurements were included as subjects in the analyses (66.8 ± 4.3 years of age; range: 61–76 years; 10 men and 16 women). None of the subjects had exercised on a daily basis for a long time and none had ever received guidance on health-promoting exercise. The first health-promoting exercise class was held once a week as part of a 3-month program (3-month participants). The program was based on a plan/management with a professor of N University serving as the director, and a health-promoting exercise instructor with an assistant provided the actual exercise guidance. The exercise program was conducted with approval from a committee working as the ethical review board of N University. Participants received adequate advance explanation, both spoken and in writing, detailing program participation, how measurements before and after the program were opportunities to improve overall health, and reassurances that participation was voluntary. The participants and their families pledged and agreed by means of signatures.

Exercise Program

Prior to each exercise session, we measured the participants' resting blood pressure and heart rate and conducted a medical interview to confirm that they were able to participate in the exercise class on that day. A typical session netted around 90 minutes of exercise, and all sessions were led by the instructor: (1) warm-up exercise (10 minutes), (2) flexibility exercise and stretching (10–15 minutes), (3) balance function exercise (5 minutes), (4) rhythm exercise and aerobic exercise (25 minutes), (5) muscle-strengthening exercises (15 minutes), (6) folk dancing (10–15 minutes), and (7) cooling-down (5 minutes). In addition to the programs in the health-promoting exercise class, the participants were instructed to walk either around their home or some other place for 20–30 minutes once a week in order to insure a twice-weekly routine of mild exercise.

Eight of the participants continued to participate in an equivalent exercise program for an additional 12 months (6-month program × 2), and they were analyzed as 15-month participants (67.6 ± 4.7 years of age; range: 61-73 years; 4 men and 4 women) to measure the effects of continued exercise. Measurements were performed before and at the end of participation in the exercise program (measurement interval was 74 days; values measured thereafter were referred to as post-exercise values). For the 15-month participants, values were measured at 9 and 15 months (277 days and 438 days after the pre-exercise measurement, respectively). Evaluation items included body height, body weight, body fat percentage, blood pressure, and physical strength-related measurement items that were determined by grip strength (dominant hand), time for a generalized reaction to photo stimulation, number of consecutive stepping-up/down movements on a footstool, and 400-m walking time. Note that the number of stepping-up/down movements on a footstool was counted using a 15-cm footstool in 30 second intervals with an intention to simulate the staircases and uneven walking surfaces that are encountered in everyday life. The stepping exercise was used to evaluate leg strength and muscle endurance.

Measurement of blood parameters

Blood sampling was performed between 9 am and 10 am after overnight fasting and before physical strength measurement. Blood samples were used to measure white blood cell count, red blood cell count, hemoglobin content, and hematocrit value as blood properties. All blood samples were taken with heparinized tube (with NaF + heparin for blood glucose). Samples were immediately subjected to centrifugation (3,000 rpm, 10 minutes) for separation into plasma, and these were stored frozen (-25 °C) for several days until analysis. As lipid metabolism parameters, we measured fasting hemoglobin A1c (latex agglutination method), plasma insulin concentrations [chemiluminescent enzyme immunoassay (CLEIA) method] and plasma glucose concentrations (enzyme method) as biochemical parameters related to glucose metabolism, and serum triglyceride concentrations (enzyme method), serum high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) concentrations (direct method). Oxidative stress was evaluated based on serum d-ROMs wherein hydro peroxide concentrations in lipids, proteins, and nucleic acids served as an index of overall oxidative stress. The amount of trivalent iron reduced by the addition of plasma [ferric reducing activity of plasma (FRAP) method] was used as an index of overall oxidative stress. In addition, high-molecular-weight adiponectin concentrations (CLEIA method), serum malondialdehyde-modified low-density lipoprotein (MDL-LDL) concentrations [enzyme-linked immunosorbent assay (ELISA) method], and serum hydroxyl radical production amounts (electron spin resonance method) were quantified before and after the first program.

Statistical Analysis

All data are expressed as the mean ± standard deviation. Differences in the mean values from pre-exercise values were tested using a paired t-test. The significance level was set at $p < 0.05$.

Results

Effects of the 3-Month Exercise Program (26 Subjects)

The pre- and post-training body weights of the 26 subjects who participated in the exercise program averaged 55.6 ± 8.9 kg and 56.4 ± 8.7 kg, with pre- and post-training body fat percentage averages of 30.2 ± 4.5% and 30.6 ± 4.6%, respectively; almost no changes were noted for either.

Results of physical strength measurement items are shown in Table 1. The grip strength averaged 28.4 ± 7.7 (men: 34.9 ± 7.1, female: 24.3 ± 4.8) kg before starting the training and 28.5 ± 7.6 (men: 35.0 ± 6.9, women: 24.4 ± 4.8) kg after the training. The values differed between men and women, but the rates of change were comparable. While there were no changes in the timeframe for a generalized response to walking 400 m, the number of steps up/down on a footstool was increased significantly from an average of 18.6 ± 3.6 times before the training to 21.2 ± 4.2 after the training ($p < 0.01$).

Table 1: Effects of training (3 months, 26 participants)

Grip Strength (dominant hand : Kg)		
	Pre	Post
Mean	28.4	28.5
SD	7.7	7.6
Whole body reaction time (sec)		
	Pre	Post
Mean	0.464	0.494
SD	0.153	0.148
Step test (times)		
	Pre	Post
Mean	18.6	21.2 **
SD	3.6	4.2
400m walk-time (m)		
	Pre	Post
Mean	278	273
SD	37	16

**P<0.01

No changes were observed in glucose/lipid metabolism-related items. Both pre- and post-training antioxidant capacities were also within normal ranges. The degree of oxidative stress (d-ROMs) averaged 390 ± 57 U.Carr, indicating a moderate level of oxidative stress, which did not decrease after training (386 ± 76 U.Carr); and, no differences were found in the amount of serum hydroxyl radical production.

Effects of the 15-Month Exercise Program (8 Of 26 Subjects)

For the 8 subjects who continued to exercise over a span of 15 months, body weight averaged 53.2 ± 9.4 kg before starting the training and 53.4 ± 8.8 kg after the training (day 74). Body weight averaged 52.8 ± 9.4 kg at 9 months and 52.6 ± 8.5 kg at 15 months, with almost no body weight changes were observed from training for these 8 subjects.

The grip strength was 27.9 ± 8.7 kg before the training, and remained almost unchanged at 27.3 ± 7.6 kg after 15 months of training. The timeframe to generalized reaction was 0.455 ± 0.107 seconds before starting the training and 0.428 ± 0.069 seconds after 15 months of training, showing no effects from the training or the duration of the training. Meanwhile, the 400-m walking time averaged 278.7 ± 14.2 seconds before starting the training, which decreased to 271.1 ± 9.4 seconds at the end of 3-months of training, then to 265.4 ± 14.2 seconds at 9 months, and finally to a statistically significant difference of 250.3 ± 20.9 seconds at 15 months ($p < 0.01$, Table 2). The number of steps up/down on a footstool was improved at all post-training points as well, from an average of 19 ± 2.5 times before the training to 22 ± 4.1 times by the end of the initial 3-month training, 24 ± 4.1 times at 9 months, and 22 ± 5.1 times at 15 months ($p < 0.05$).

Table 2: Effects of training (15 months, 8 participants)

Grip Strength (dominant hand : Kg)				
	Pre	**Post**	**9 months**	**15 months**
Mean	27.9	27.8	30.7	27.3
SD	8.7	8	3.1	7.6
Whole body reaction time (sec)				
	Pre	**Post**	**9 months**	**15 months**
Mean	0.455	0.494	0.43	0.128
SD	0.107	0.09	0.093	0.069
Step test (times)				
	Pre	**Post**	**9 months**	**15 months**
Mean	18.5	22.4**	24.2 *	22.4 *
SD	2.5	4.1	4.9	5.1
400m walk-time (m)				
	Pre	**Post**	**9 months**	**15 months**
Mean	279	273	269	255 *
SD	14	10	20	24

*p<0.05
**p<0.01

The effects of the exercise program for the 15-month participants are expressed as rates of change in Figure 1. Among the biochemical parameters related to lipid metabolism, no differences were observed in LDL-C concentrations, but the HDL-C concentration tended to increase from an average of 62.8 ± 14.7 mg/dL before starting the training to 66.1 ± 13.3 mg/dL at 3 months and 67.2 ± 12.3 mg/dL at 9 months, and reached a significantly increased level of 69.4 ± 13.0 mg/dL at 15 months ($p < 0.001$). The triglyceride concentrations averaged 96.1 ± 44.7 mg/dL before starting the experiment and fell to 95.5 ± 35.4 mg/dL by the end of the initial 3-months of exercise, then to 79.3 ± 22.4 mg/dL at 9 months, and finally reached 80.4 ± 24.1 mg/dL at 15 months, and showed no significant differences. The oxidative stress levels (Fig. 1) averaged 393.6 ± 51.5 U before starting the exercise program and fell to 376.9 ± 64.4 U by the end of 3 months on the program. Although the initial 3-month training produced no significant differences, the oxidative stress

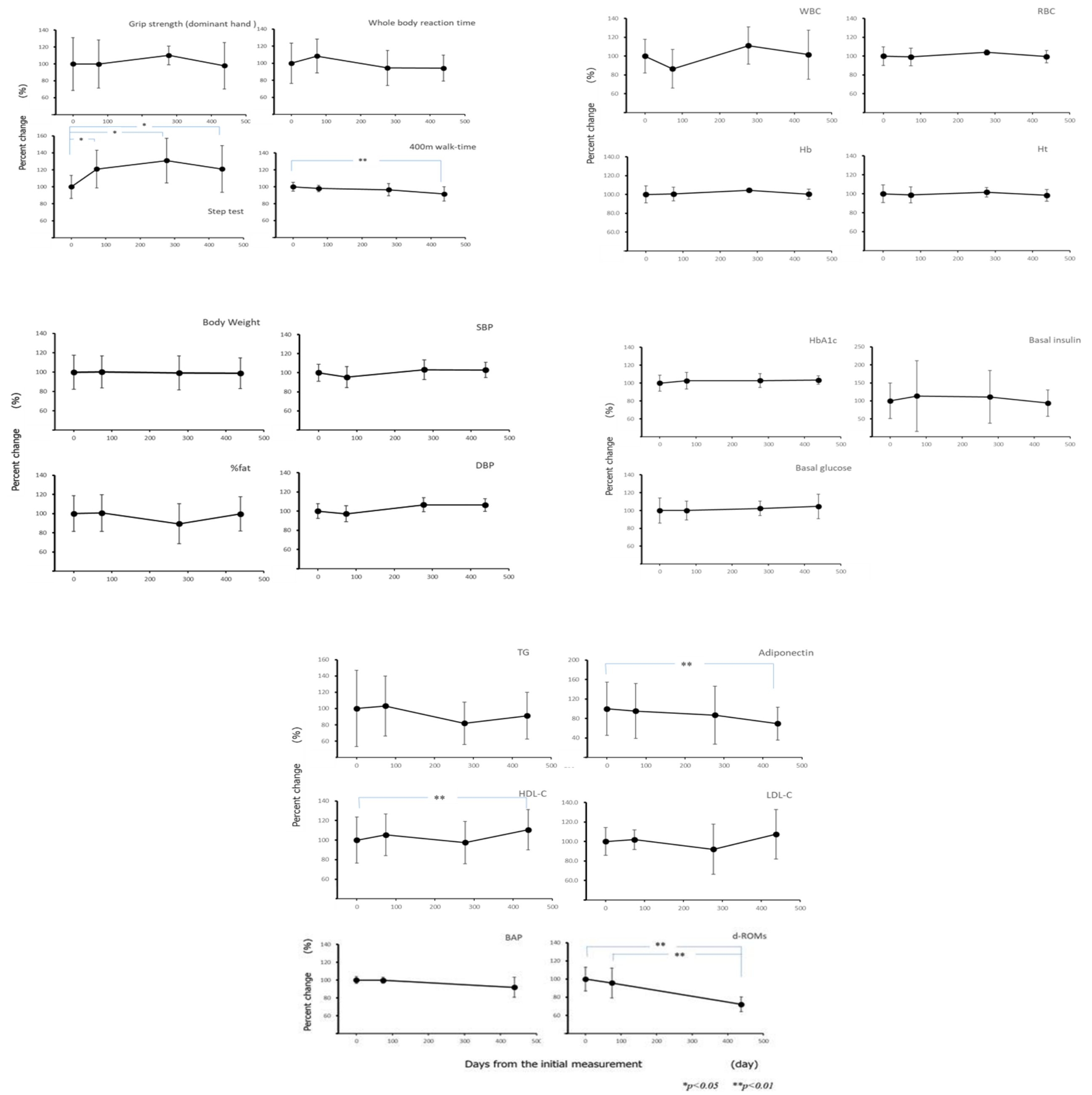

Figure 1: Variations in physical fitness, hematologic parameters, and oxidative stress for the 15-month exercise group.
SBP: systolic blood pressure, DBP: diastolic blood pressure, WBC: white blood cell, RBC: Red blood cell, Hb: hemoglobin conc., Ht: hematocrit, HbA1c: glycated hemoglobin, TG: triglyceride, HDL-C: HDL-cholesterol, LDL-C: LDL-cholesterol, BAP: biological antioxidant power, d-ROMs: diacron-reactive oxygen metabolites

after completion of the 15-month training was 283.9 ± 31.8 U, which amounted to a 27% decrease over 15 months ($p < 0.001$). The FRAP average values before exercise, at the end of the initial 3-months of exercise, and after 15 months of exercise were 2,694 ± 121 μmol/L, 2,719 ± 81 μmol/L, and 2,503 ± 303 μmol/L, respectively, all of which showed no significant changes.

Discussion

The importance of physical exercise for maintenance, promotion of health, and prevention of aging-associated problems and certain diseases is increasingly being recognized by the elderly. Meanwhile, for elderly people who have no previous exercise experience, it is considered of significance to provide opportunities to actually move the body along with knowledge of appropriate levels of exercise. The purpose of this study was to observe changes in physical strength and metabolism associated with twice weekly mild exercise and to evaluate the effects of the duration of exercise in elderly individuals who have no experience with regular exercise by providing an opportunity for them to acquire the habit of exercise.

In this study, the number of steps up/down on a footstool (in 30 seconds) was measured as an index of leg muscle strength. The significance of maintaining and improving muscle strength in the elderly is well known. Rantanen et al.*⍰ reported that grip strength measurement can serve as a predictor of mortality and is highly correlated with non-cancer mortality and health deterioration. In the present study, the number of steps up/down on a footstool was increased by 14% at the end of the initial 3-month routine of regular mild exercise (74 days, 26 subjects; $p < 0.01$). These increases were retained at later measurement points in the 8 subjects who continued the exercise, although no changes in grip strength were observed even after 15-months of training. This indicates that the strength of muscles relevant to stepping up/down stairs and other uneven places could be improved, and an improvement in the muscle strength of the legs by physical training is noticeable at a relatively early stage of regular exercise. In addition, the 400-m walking time was significantly shortened after 15 months of training ($p < 0.05$).

For the initial 26 participants (3-months of regular exercise), the mean HDL-C (63 to 62 mg/dL) or the LDL-C/HDL-C ratio (arteriosclerosis index; 1.90 to 1.92) was unchanged showing no effects of the training. For the 8 continuing participants (15-months of training), HDL-C increased by 10.5% ($p < 0.01$) after completion of the program, while the LDL-C/HDL-C ratio had decreased slightly (1.76 before starting the training to 1.72 at 15 months).

The hydro peroxide concentration (d-ROMs) was unchanged after the 3-month health-promoting exercise routine, but was significantly decreased following the 15-month continuation of exercise ($p < 0.001$, Fig. 1). Tanabe et al.10) have reported that muscle strength training combined with a 12-week 80% VT intensity pedaling exercise decreased GSSH/GSH by 73.2% in middle-aged and older women (59-69 years). A large improvement in oxidative stress levels along with improvement in whole-body endurance was also observed in the present study, although the size of the effect was not as remarkable as that in the aforementioned study. In terms of the metabolic improvement and oxidative stress-reducing effects gained in this study, twice-weekly mild physical training imparted oxidative stress-reduction benefits in the elderly individuals who continued the routine for a relatively long term, although they had no previous experience with regular exercise.

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