〈Original Article〉

Improvement in arteriosclerosis parameters and lower limb muscle strength in middle aged and elderly people attending diabetes prevention program

Akihiko Tajima, Yoshinori Kitabatake, Takashi Yasojima and Kazunori Kayaba

Summary

Purpose: This study aimed to assess the improvement in arteriosclerosis-related parameters in the preliminary group of diabetes mellitus attending the 3-month educational program on diabetes prevention.

Materials and methods: This study included 41 patients (9 males and 32 females; age, 65.6 ± 7.2 years). Body weight, body composition, blood tests, cardio-ankle vascular index, lower limb muscle strength and visceral fat area were assessed before and after the educational program on diabetes prevention.

Results: Significant improvements in lower limb muscle strength (both legs), body fat percentage, lean body mass, total body water, visceral fat area and high density lipoprotein cholesterol were observed.

Conclusion: The result of this study demonstrated that the intensity and type of daily physical exercise employed in this study was effective enough to increase lower limb muscle strength and high density lipoprotein cholesterol and decrease body fat percentage.

Key words: Diabetes, Arteriosclerosis, Leg strength, CAVI, HDL

1. Background

Japan is one of the most rapidly aging countries with low fertility rate in the world and we are facing a turning point in health insurance policy. Our primary policy has been changing from the early diagnosis and disease treatment to health preservation. Health Japan 21 (1st edition) aims to reduce the number of deaths of people in the prime of their life, prolong healthy years of life, and improve people's quality of life in order to become a vigorous society in which all citizens can live in good health both physically and mentally[1]. Some studies have already reported the effect of exercise programs in ideal circumstances, although, only a handful of researches conducted by municipal officials have investigated the quality of

Department of Health Sciences, School of Health and Social Services, Saitama Prefectural University
820 Sannomiya, Koshigaya-shi, Saitama 343-8540, Japan
Received for Publication March 26, 2015
Accepted for Publication June 17, 2015

Author for correspondences: Akihiko Tajima.
Department of Health Sciences, School of Health and Social Services, Saitama Prefectural University
820 Sannomiya, Koshigaya-shi, Saitama 343-8540, Japan

regional government health care services. Here, this study investigated people living at the Takesato apartments, Kasukabe, Saitama (Figure 1). The population of once popular high-rise estates in 1960 decreased to 9,431 and 38.8% of the residents are the elderly.

Aging and de-population are affecting regional towns and health policy all over Japan. This study suggests the importance of community engagement initiatives collaborated with Kasukabe city and Saitama Prefectural University to support aging society.

2. Purpose

As a counter measure against the increasing population aging rate in Kasukabe city, this study aimed to investigate the effect of 3-month diabetes prevention program in the preliminary group of diabetes mellitus living at the Takesato apartments. Since diabetes mellitus, which is one of life-related diseases, greatly influences quality of life, this study assessed the improvement in glucose, body fat percentage, muscle mass, risk factors and exercise tolerance capacity after the educational lectures, including exercise courses and nutrition counselling.

3. Materials and methods

This study included Takesato apartment residents aged <75 years with the high glucose levels suggested by their family doctors; they were stratified into the preliminary group of diabetes mellitus. We first recruited the study participants among the residents at the Takesato apartments; then, Kasukabe City Health Center advertised the recruitment. Forty-seven residents enlisted the study; finally, 41 participants (9 males; 32 females; mean age of 65.6 ± 7.2 years) attended the all diabetes prevention programs for 3 months, including the opening lecture on diabetes mellitus by a physician, 2-times nutrition counselling and 4-times exercise courses. On the first and last days of the series of lectures, the participants answered the questionnaires. In addition, the following parameters were obtained for detailed evaluation: 1) body weight and body composition; 2) blood test, including total cholesterol, high density lipoprotein (HDL) cholesterol, low density lipoprotein cholesterol, triglyceride, glucose and HbA1c; 3) cardio ankle vascular index (CAVI) using VS-3000 (Fukuda Denshi, Ltd., Japan); 4) lower limb muscle strength using μTas F-1 (Anima, Ltd., Japan); and 5) visceral fat area using

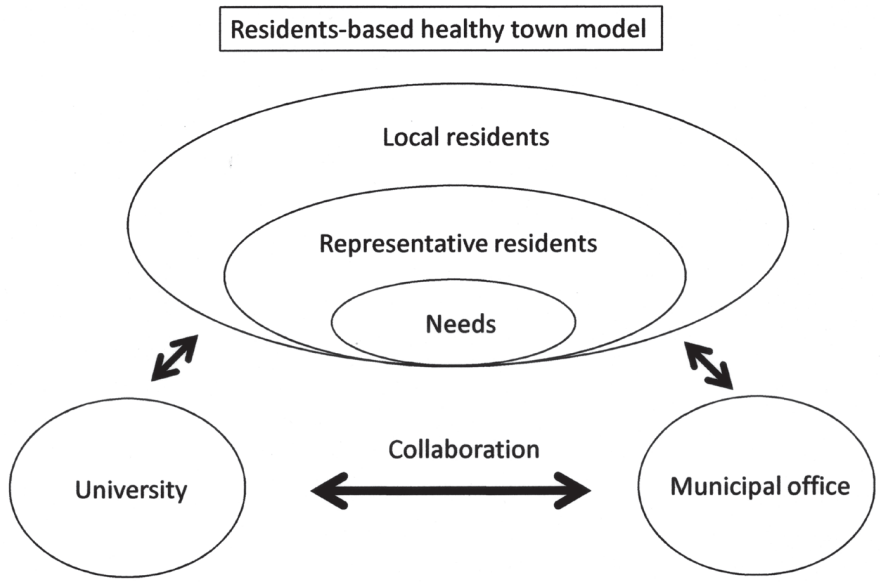

Fig. 1 Healthy municipalities collaborated with residents, municipal office and university.
This figure shows mutual understanding between different organizations and collaboration to achieve the common goal.

HDS-2000 (Omron Colin, Ltd., Japan). The nutrition counselling provided the importance of nutritional status and the method of calculating calorie intake. In the 1st and 2nd exercise courses, the participants performed the strength training, such as draw-in and sit-up for trunk function, rowing for upper back muscle and squat for lower limb muscle. This training consisted of 3 sets of 8 to10 repetitions a day. In the 3rd and 4th exercise courses, the participants performed the above mentioned exercise, walking drills (tandem walk and long slide walk) and step drills using a ladder. Since each exercise course was held in every 2 to 4 weeks, the participants were asked to do some home workout according to the home workout program. They chose certain exercise from the program and performed 3 sets of 5 to 7 repetitions of each exercise 2 to 3 times per week. The nature and purpose of this study and the risks involved were explained to all participants before their enrollment. Written informed consent to participation in the study was obtained. The study protocol was approved by the Ethics Committee of Saitama University.

Statistical analysis

The paired t-test was used to compare the means obtained at the first and last lectures. Statistical significance was set at $p < 0.05$.

4. Results

1. The attendance of lectures

Of the 47 enlisted residents, 6 residents dropped out from the study; the lecture attendance rate was 87.2% (n = 41). All dropouts were female and no association was found between gender and age.

2. Parameters (Table 1, Figure 1)

1) Right and left lower limb muscle strength (Figure 2)

Significant increases in right and left lower limb muscle strength were observed before (259.6 ± 91.4 N and 244.5 ± 88.2 N) and after (282.0 ± 76.2 N and 276.0 ± 84.4 N) the educational lectures ($p < 0.05$ and $p < 0.01$).

2) Body composition (Figure 3)

Body composition revealed a significant decrease before and after the lectures (body fat percentage: 30.6 ± 8.1% and 29.6 ± 8.6%, $p < 0.01$; lean body mass: 40.9 ± 7.9 kg and 41.5 ± 8.1, $p < 0.05$; total body water: 29.2 ± 5.1 kg and 28.7 ± 5.1 kg, $p < 0.05$).

3) Visceral fat area (Figure 4)

Visceral fat area also significantly decreased before (81.3 ± 44.2 cm^2) and after (74.3 ± 35.8 cm^2) the lectures ($p < 0.05$).

Table 1 Comparison before and after diabetes prevention program

Parameters	n = 41	Pre-diabetic program M	Pre-diabetic program SD	Post-diabetic program M	Post-diabetic program SD	Variation	CI lower	CI upper	p value
Weight (kg)		59.8	12.8	59.7	12.8	−0.1	−0.19	0.53	0.345
Body mass index (kg/m²)		24.9	4.6	24.8	4.6	−0.1	−0.07	0.24	0.282
Body fat percentage (%)		32.3	8.4	31.6	8.7	−0.7	0.17	1.12	0.009 *
Quantity of fat (kg)		19.8	9.4	19.6	9.3	−0.2	−0.02	0.59	0.070
Lean body mass (kg)		39.8	6.9	40.3	7.1	0.5	−0.98	0.05	0.052
Muscle mass (kg)		37.6	6.5	38.1	6.7	0.5	−0.94	0.02	0.059
Total body water (kg)		28.7	4.9	28.3	4.6	−0.4	0.02	0.82	0.038 *
Visceral fat area (cm²)		81.1	44.4	76.2	38.2	−4.9	0.69	9.01	0.023 *
Total cholesterol (mg/dl)		211.1	28.7	214.0	30.2	2.9	−9.95	4.06	0.400
High density lipoprotein cholesterol (mg/dl)		55.6	12.1	60.7	11.1	5.1	−7.74	−2.46	<0.001 *
Low density lipoprotein cholesterol (mg/dl)		119.1	22.9	121.4	22.7	2.3	−6.65	2.08	0.297
Triglyceride (mg/dl)		167.8	104.0	140.7	82.3	−27.1	−4.68	58.70	0.093
Glucose (mg/dl)		117.4	31.0	125.6	49.9	8.2	−23.04	6.63	0.270
HbA1c (%)		6.4	0.8	6.5	0.8	0.1	−0.14	0.04	0.261
Leg strength (N)	right	242.4	96.5	270.2	95.1	27.8	−49.24	−6.31	0.013 *
	left	230.6	88.6	259.2	93.3	28.6	−46.48	−10.68	0.002 *
Cardio ankle vascular index	right	8.0	1.4	8.0	1.5	0.0	−0.34	0.45	0.515
	left	7.9	1.3	8.1	1.4	0.2	−0.51	0.13	0.242

M, mean; SD, standard deviation. * : $p < 0.05$

4) Biochemical changes (Figure 4)

HDL cholesterol significantly increased (before, 55.0 ± 11.7 mg/dl; after, 60.1 ± 9.7 mg/dl). The triglyceride and glucose levels were also improved, although, no statistically significant differences were found before and after the lectures.

5. Discussion

The prevention program in the preliminary group of diabetes mellitus aimed to normalize the glucose levels, decrease body fat percentage, increase muscle mass and improve risk factors and exercise tolerance capacity. The result of this study demonstrated signif-

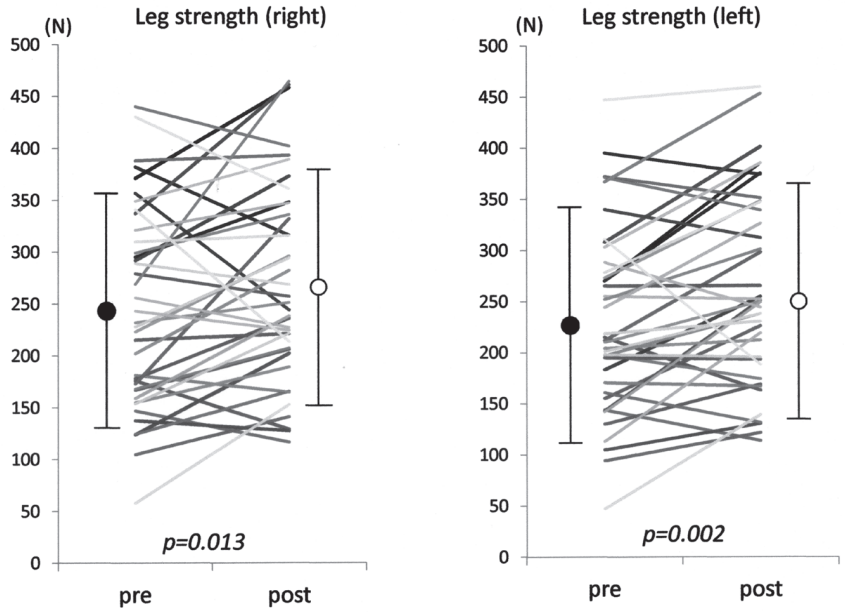

Fig. 2 Comparison of muscle strength before and after lectures.
Right and left lower limb muscle strength significantly increased.

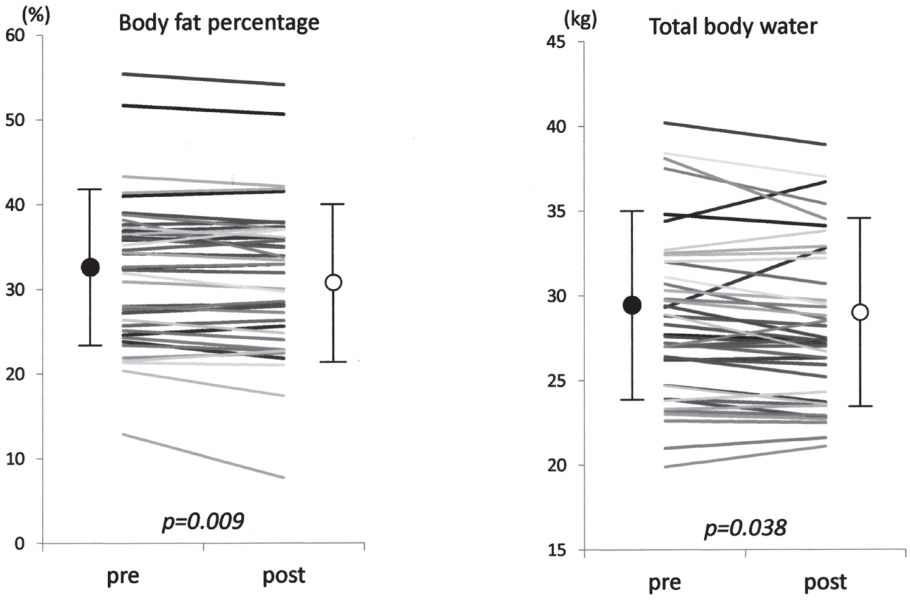

Fig. 3 Comparison of body composition before and after lectures.
A significant decrease was found after the prevention program.

icant improvement in lower limb muscle strength (both legs), body fat percentage, lean body mass, total body water, visceral fat area and HDL cholesterol. One study has reported that exercise in a patient suffering from diabetes mellitus and in a person corresponding to pre-diabetes is closely associated with decreases in visceral fat and skeletal muscle tissue volume[2]. Energy consumption by exercise is lower than that by dieting. Dietary cure decreases lean body mass, although, it may not improve insulin resistance. Therefore, taking exercise is vital to maintain lean body mass. The result of this study demonstrated significant changes in body fat percentage and lean body mass before and after the diabetes prevention program, suggesting that these educational lectures might selectively decrease body fat while maintaining skeletal muscle mass. In the biochemical changes, not significant difference in the triglyceride or glucose level was found; however, lower trend before and after the lectures was observed. In addition, HDL cholesterol significantly increased after the lectures. For eight cases who reported very low physical activity level at home, HDL cholesterol levels decreased during the exercise intervention. A variety of changes in HDL cholesterol levels could partially be explained by the difference of momentum at the home. No significant differences in glucose at fasting state or HbA1c were found between before and after the lectures. George et al.[3] conducted a comparative study in the persons taking exercise (exercise group) and those not taking exercise (no-exercise group). Their study result demonstrated that the exercise group significantly improved total cholesterol, the total cholesterol to HDL cholesterol ratio, low density lipoprotein cholesterol and triglyceride. Since the levels of triglyceride, glucose and HDL cholesterol were improved in our study, the exercise courses in our educational lectures possibly reduced cardiovascular events and risk factors for lifestyle related diseases. Of note, HDL cholesterol was improved earlier than the other parameters.

Computed tomography measurements of the cross section areas at L4 levels are typically utilized to quantify visceral fat accurately[4]. This method provides quantitative measurements of both visceral and subcutaneous fat, leading to clinical diagnosis in the degree

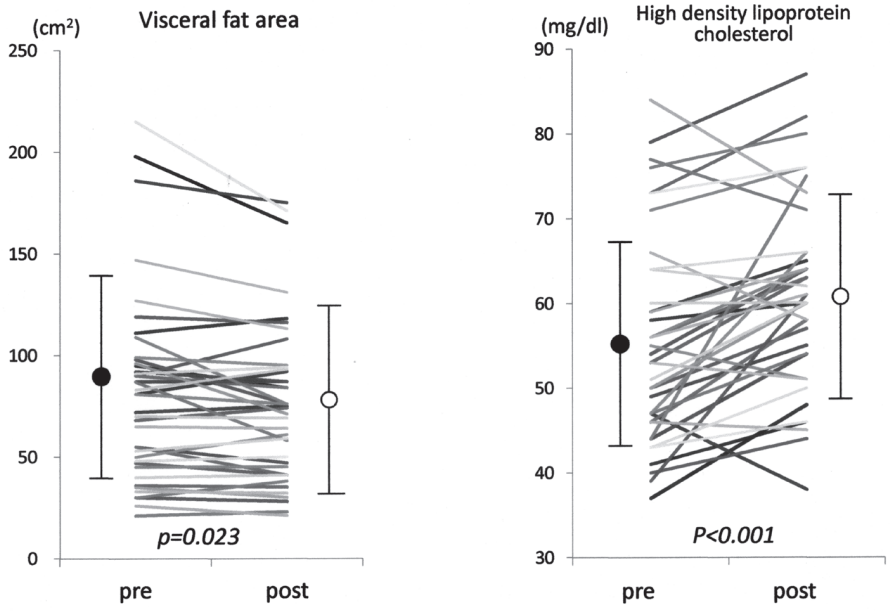

Fig. 4 Comparison of visceral fat area and high density lipoprotein cholesterol before and after lectures.
Visceral fat area significantly decreased after the prevention program. High density lipoprotein cholesterol significantly increased; triglyceride and glucose improved, although, no statistically significant differences were found before and after the prevention program.

of exercise effect. In our study, the impedance method instead of computed tomography was used to measure visceral fat area[5] and resulted in a significant decrease before and after the prevention program. No weight loss was observed in our study population, although, the improvement in not only body fat percentage and lean body mass but also visceral fat area contributed to increased muscle mass and selectively decreased fat.

Both left and right leg muscle strength revealed significant changes before and after the prevention program. The intensity and type of daily physical exercise employed in this study was seemed to be strong enough to increase lower limb muscle strength.

6. Study limitations

This study has several study limitations. Since this study did not compare the findings in the exercise and no-exercise groups, our study result did not properly demonstrate the effect of exercise. However, the increased HDL cholesterol level was presumed to be the effect of exercise. Further studies with more exercise courses and a series of daily physical activities and its assessment are thus called for.

Acknowledgements

We would like to thank all participants and staff who cooperated with our study; particularly, Ms. Ayana Ishijima, Ms. Tomomi Ishihara, Ms. Mayako Nomura and Ms. Ayako Fujii for their technical assistance. This study was funded by Saitama Prefectural University grants.

References

1. Health Japan 21 evaluation crew.「Health Japan 21」final assessment, 2011. http://www.mhlw.go.jp/stf/houdou/2r9852000001r5gc-att/2r9852000001r5np.pdf
2. Haoyong Yu, Jianzhong Di, Yuqian Bao, et al.: Visceral fat area as a new predictor of short-term diabetes remission after Roux-en-Y gastric bypass surgery in Chinese patients with a body mass index less than 35 kg/m2. Surgery for Obesity and Related Diseases, 11(1): 11-13, 2015.
3. George A, Kristi S: Impact of progressive resistance training on lipids and lipoproteins in adults: A meta-analysis of randomized controlled trials. Preventive Med, 48: 9-19, 2009.
4. Ohshima S, Yamamoto S, Yamaji T, et al.: Development of an automated 3D segmentation program for volume quantification of body fat distribution using CT. Nihon Hoshasen Gijutsu Gakkai Zasshi, 64(9): 1177-1181, 2008.
5. Ida M, Hirata M, Odori S, et al.: Early changes of abdominal adiposity detected with weekly dual bioelectrical impedance analysis during calorie restriction. Obesity, 21(9): 350-353, 2013.