

# Effectiveness of a Japanese-style health program in Minowa Town, Matsumoto city and Nagano city, Japan

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## Abstract

**Purpose** – This study aims to establish a Japanese-style healthcare program customized for Japan and Asia under ISO 9001: 2008 (ISO: International Organization for Standardization) to improve problem areas and to inspect the effectiveness of the program. Furthermore, the authors wanted to create this health program using the ISO widely available in Asian countries and make an international contribution.

**Design/methodology/approach** – The authors implemented a 6- to 10-month health program in Minowa Town, Matsumoto City and Nagano City in Japan. This study assessed findings from pedometer, anthropometric and blood pressure measurements and physical fitness, blood chemistry and brain function tests.

**Findings** – The comparisons were made by examining the interaction effects between groups of participants. Groups from three regions in Japan showed significant differences on the physical fitness tests; regarding the 10-meter obstacle walk, the results of the Minowa participants showed the greatest improvement and the Matsumoto participants showed the second greatest improvement. In the six-min walk, the time of the Minowa participants significantly improved.

**Research limitations/implications** – This health education program, which has been conducted by the Japanese authors since 1998, measures anthropometry, brain function and physical fitness and performs blood tests before and after the program and it measures energy consumption with a pedometer during the program. With the aim of improving exercise via encouragement from friends and a sense of community with fellow participants, participants learn together with hands-on training in tai chi and aerobics about the importance of ongoing exercise and proper nutrition. This health education met the Health Education ISO in 2014.

**Practical implications** – Since 2010, Nagano Prefecture, including Minowa Town, Matsumoto City and Nagano City, where our study was carried out, has been the area with the highest life expectancy rates in Japan.

**Social implications** – The authors want to make this health promotion through ISO widely available in Asian countries and an international contribution.

**Originality/value** – This study aimed to appropriately establish a Japanese-style healthcare program under the ISO 9001:2008 to improve problem areas and inspect its effectiveness.

**Keywords** Brain function, Health promotion, Pedometer, Physical fitness

**Paper type** Research paper

## 1. Introduction

In line with the increase in the aging population worldwide, the prevalence of adults greater than 65 years of age are expected to increase from 22.7% in 2010 to 35.6% in 2020 in Japan (United Nation, 2010). To adapt to the aging society, it is necessary to extend healthy life expectancy. Notably, the social system of preventive care for senior citizens is not in

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good order. Health promotion has become a global effort, as the Ottawa World Health Organization (WHO) Charter of 1986 (Kickbusch, 1986). Based on this charter, the “Kenko Nippon 21” program, formulated by the Japan Ministry of Health, Labor and Welfare (MHLW), in 2000, aimed to reduce mortality rates among late-middle-aged individuals, to prolong healthy lives, improve quality of life and promote regional health. “Kenko Nippon 21” states that a decrease in physical activity is a risk factor for obesity, lifestyle diseases and chronic diseases or infirmities among the elderly population (Ministry of health, labor and welfare, 2000). The Japanese MHLW introduced an idea for a national policy to improve the prevention of and treatment for metabolic syndrome, which included a provision to levy a penalty to the National Federation of Health Insurance Societies starting in 2013, in cases where residents do not fulfill the preventive criteria for the syndrome (Ministry of health, labor and welfare, 2018).

Since 2013, Japan’s MHLW has declared the “Second of Kenko Nippon 21” to promote public health, extend the healthy life expectancy, prevent lifestyle-related diseases, improve social life, improve the social environment as related to health and improve exercise and nutrition. In particular, regarding physical activity and exercise, in 2010, Japanese men 65 years of age and older took 5,628 steps and women took 4,584 steps. In response, the MHLW set a target of 7,000 steps for men years of age 65 and older and of 6,000 steps for women by 2022 (Ministry of health, labor and welfare, 2013).

The health education program, which has been administered by the Japanese authors since 1998, measures anthropometry, brain function and physical fitness, performs blood tests before and after participation in the program and measures energy consumption with a pedometer during the program. With the aim of improving exercise via encouragement from friends and a sense of community with fellow participants, participants learn together with hands-on training in tai chi and aerobics about the importance of ongoing exercise and proper nutrition. This health education program met the Health Education International Organization for Standardization (ISO) in 2014. We have been working jointly with Mahidol University in Thailand, Udayana University in Indonesia and Southwestern University in the Philippines to spread this health education program to the areas around the universities and to contribute internationally (Maruo *et al.*, 2015; Watanabe *et al.*, 2015; Murata *et al.*, 2015).

Since 2010, Nagano Prefecture, including Minowa Town, Matsumoto City and Nagano City, where our study was carried out, has been the area with the highest life expectancy rates in Japan. Research by the WHO (World health organization, 2016) showed that Japan had the highest longevity in the world in 2005 and 2015. Minowa Town, Matsumoto City and Nagano City are expected to be world-renowned areas with respect to longevity. This study aimed to appropriately establish a Japanese-style healthcare program under the ISO 9001:2008, to improve problem areas and inspect its effectiveness. Furthermore, we want to make this health promotion through ISO widely available in Asian countries and an international contribution.

## 2. Methods

### 2.1 General method

We implemented a 10-month health program (ISO 9001: 2008) from May 2011 to February 2012 in Minowa Town, Japan (Minowa), a 10-month health program from May 2012 to February 2013 in Matsumoto City, Japan (Matsumoto), a six-month health program from June to November 2013 in Nagano City (Nagano) and the areas under control of Nagano City (control). The different intervention years in this study are because of the time spent unifying the research conditions and the staff obtaining informed consent in the intervention area. The 46 Minowa subjects were  $62.7 \pm 4.7$  years of age (mean  $\pm$  SD), including 22 men of  $64.9 \pm 4.7$  years of age and 24 women of  $60.8 \pm 3.9$  years of age. The 69 Matsumoto subjects were  $66.0 \pm 5.8$  years of age, including 29 men of  $67.7 \pm 4.4$  years of age and 40

women of  $64.7 \pm 6.3$  years of age. The 35 Nagano subjects were  $5.2 \pm 4.6$  years of age, including six men of  $64.2 \pm 5.3$  years of age and 29 women of  $65.4 \pm 4.5$  years of age. The 7 control subjects were  $61.3 \pm 7.8$  years of age, including three men of  $66.0 \pm 5.0$  years of age and 4 women of  $57.8 \pm 9.5$  years of age. In three regions in Japan, during these health programs, the subjects received a series of seminars regarding recreational activities for 90-120 min once or twice per month (Table 1). Only Minowa subjects performed training and aerobic exercises once a week for 120 min. There were 46 Minowa subjects and approximately nine instructors, thus, reflecting a ratio of five to one. There were 69 Matsumoto subjects and five instructors, thus, reflecting a ratio of 13.3 to 1. There were 35 Nagano subjects and approximately one instructor, reflecting a ratio of 35 to 1. The seven control subjects did not participate in any health education programs. There were no instructors for the control group. The purpose of this seminar was for participants to gather, unite and encourage each other and to record the data from the pedometers. In addition, the contents of this seminar were made into a program by local staff based on the health education that the region had obtained so far so that the information could be used in the future. Instead, the study was conducted as follows: The study assessed findings from pedometric, anthropometric and blood pressure measurements and physical fitness, blood chemistry and brain function tests. An approximate target of 7,000 steps per day was set. Because the results of the brain function, physical fitness, body weight and blood chemistry test values are significantly improved by exercise comprising 7,000 or more steps (Maruo et al., 2015; Watanabe et al., 2015; Murata et al., 2015), the latest guidelines based on the Helsinki Declaration was adopted by Shinshu University (UMIN000009309). Written informed consents were obtained from all the participants.

## 2.2 Pedometry

The daily numbers of walking steps and the amount of energy expenditure was measured with a pedometer (Acos Co. Ltd., Japan; AM500NE). The step value in one day (daily steps) is the total number of exercise steps of greater than four Mets and normal steps of less than four Mets. Exercise steps are defined as steps taken during expenditure > four METs (METs

**Table 1** Program contents of the health education in Nihompattana, Minowa, Matsumoto and Nagano

Month	Minowa (month/once)	Matsumoto (month/once or twice)	Nagano (month/once)
January	Health education lecture and weekly 2 h exercise	2 h Balance up exercises	
February	Measurements after the health education	Measurements after the health education	
March			
April			Measurements before the health education
May	Measurements before the health education	Measurements before the health education	1.5 h lecture on health education and nutrition
June	Lifestyle-related disease lecture and weekly 2 h exercise	2 h aerobics and 2 h recreation	1.5 h practice of yoga and recreation
July	Recreation and weekly 2 h exercise	2 h camping and 2 h stretching exercises	1.5 h promoting the use of muscle strength and walking
August	Hiking and weekly 2 h exercise	2 h nature observation and 2 h computer lecture	1.5 h excursion in town and practical skill of tai chi
September	Dental hygiene lecture and weekly 2 h exercise	2 h cooking practice and 2 h tennis	Measurements after completion of the program
October	Walking and weekly 2 h exercise	2 h golf and 2 h health education lecture	
November	Tai chi and weekly 2 h exercise	2hr dance exercise	
December	Cooking practice and weekly 2 h exercise	High blood pressure lecture	

metabolic equivalent: energy expenditure during the acting amount of metabolite during sitting quietly). The pedometer enabled the data to be transferred and saved to the computer. These walking steps were measured from Jun 2013 to November 2014 in Japan. Notably, control did not wear a pedometer.

### ***2.3 Anthropometry and blood pressure measurements***

Weight and body mass index (BMI) were included in the anthropometry measurements. Weight measurement was determined by using body composition monitors with scales (Omron Healthcare Co., Ltd. JAPAN; HBF-359). Weight measurement was implemented at the time of fasting > 10 h from the last meal. Maximum and minimum blood pressures were measured through auscultation (mercury sphygmomanometer, Kenzumedico 0601B001, Japan) after the subjects had been sitting for 15 min in a room with an ambient temperature of 25°C and relative humidity of approximately 50%.

### ***2.4 Blood chemistry tests***

The blood chemistry assessment comprised five components, namely:

1. Fasting blood glucose.
2. Hemoglobin A1c (HbA1c).
3. High-density lipoprotein (HDL).
4. Low-density lipoprotein (LDL).
5. Triglycerides.

Blood chemistry measurements were taken after the fasting time, namely, > 10 h from the last meal. The subjects' blood chemistry was assessed before and after the health program.

### ***2.5 Physical fitness tests***

The physical fitness tests administered in this study were approved by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) ([Ministry of Education, Culture, Sports, Science and Technology, 1999](#)). The physical fitness test (target age: 65-79 years) included six physical assessments, namely:

1. Grip strength for muscle strength.
2. Sit-ups for muscle endurance.
3. Sit-and-reach flexibility for muscle flexibility.
4. Eyes-open single-leg stance for balance ability.
5. 10-meter obstacle walk for walking ability.
6. A six-min walk for endurance.

The subjects' physical ability was assessed before and after the health program.

### ***2.6 Brain function tests***

The go/no-go tasks ([Masaki and Moriyama, 1971](#); [Terasawa et al., 2014a, 2014b](#)), were used to estimate the inhibitory decision process and comprised three experimental stages, namely formation; differentiation and reverse differentiation. First, in the formation stage, subjects were instructed to squeeze a rubber ball in response to a red light that was randomly displayed. The formation stage consisted of five trials. Second, during the differentiation stage, subjects squeezed a rubber ball in response to a red light, but not a

yellow light, when a red or yellow light was randomly displayed. Third, during the reverse differentiation stage, subjects squeezed a rubber ball in response to a yellow light, but not a red light, when a red or yellow light was randomly displayed. In each of the differentiation and reverse differentiation stages, the subjects completed 20 trials. Red and yellow lights were equally randomly displayed 10 times each. In this article, the term “miss” indicates an incorrect response, when study subjects did not squeeze a rubber ball when it should have been squeezed. The term “mistake” means an incorrect response, when subjects squeezed the rubber ball when it was not supposed to be squeezed. We administered the go/no-go tasks to assess the participants’ brain function before and after the health program.

### 2.7 Statistical analyzes

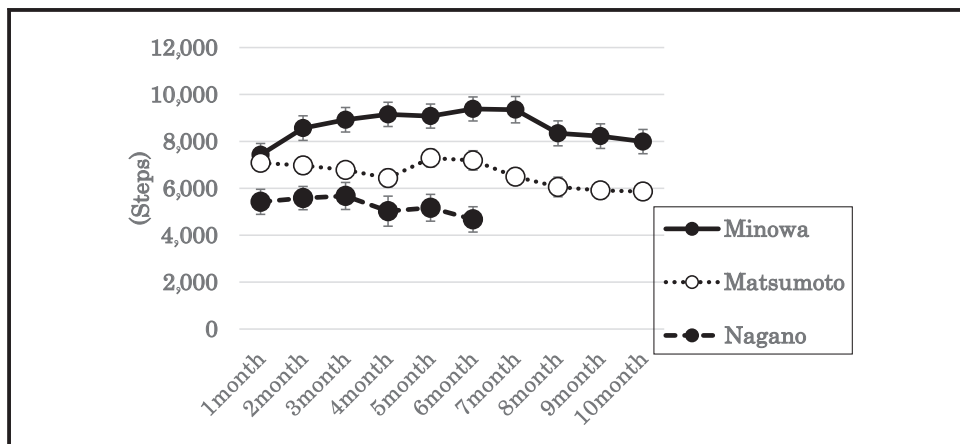
A 2 × 2 (before and after for each group: Minowa, Matsumoto, Nagano and control) two-way analysis of variance (ANOVA) with repeated measures was performed to evaluate the significance of the outcomes for anthropometry, blood pressure, physical fitness and the go/no-go task. When a significant interaction was found, a one-way ANOVA was performed to interpret the before and after results for the Minowa, Matsumoto, Nagano and control groups. Post hoc tests were performed by using the Tukey–Kramer correction. In addition, the number of steps for the Minowa, Matsumoto, Nagano and control groups and each difference between the before and after anthropometry measurements, blood pressure measurements, blood chemistry test results, physical fitness test results and brain function test results were analyzed with Pearson’s correlation coefficient. The level of significance was set at  $p < 0.05$ . The statistical analyzes were performed by using SPSS Ver. 26 statistical package (IBM SPSS Inc., Tokyo, Japan).

## 3. Results

### 3.1 Pedometry

Figure 1 shows the average walking numbers of daily and exercise steps for each month for the participants in Japan. The daily steps are the total of the exercise steps of more than four Mets and normal steps of less than four Mets. For the participants from Minowa Town in Japan, the numbers of daily and exercise steps per day were  $7,425.9 \pm 485.4$  and  $4,191.4 \pm 401.0$  in May;  $8,566.0 \pm 524.0$  and  $5,083.4 \pm 435.0$  in June;  $8,921.9 \pm 522.8$  and  $5,416.8 \pm 447.6$  in July;  $9,151.3 \pm 516.9$  and  $5,442.7 \pm 449.1$  in August;  $9,078.8 \pm 513.3$  and  $5,612.2 \pm 451.6$  in September;  $9,382.6 \pm 512.6$  and  $6,141.7 \pm 467.0$  in October;

**Figure 1** Average walking numbers of daily steps for each month for the participants in Minowa, Matsumoto and Nagano

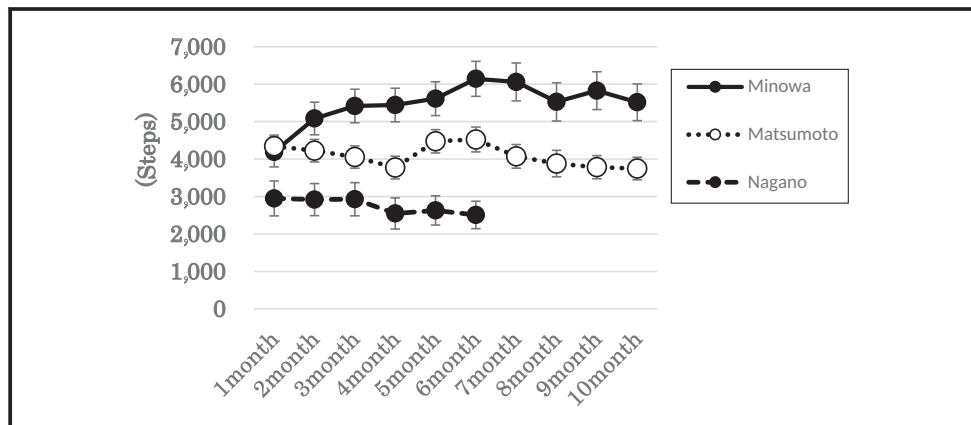


9,351.6 ± 562.4 and 6,059.1 ± 506.7 in November; 8,342.7 ± 531.8 and 5,527.1 ± 511.2 in December; 8,223.3 ± 524.1 and 5,826.1 ± 504.9 in January; and 7,991.4 ± 517.1 and 5,515.7 ± 489.4 in February, respectively. The average number of daily steps increased from May to October and decreased from November to February. Few changes in the average number of exercise steps, which ranged from 7,500-9,500 steps, were observed during any month. For the 10-month analysis, the average numbers of daily and exercise steps were 8,753.6 ± 492.3 and 5,592.2 ± 448.2, respectively.

For the participants from Matsumoto City in Japan, the numbers of daily and exercise steps per day were 7,048.6 ± 360.2 and 4,341.3 ± 297.6 in May; 6,973.6 ± 368.4 and 4,223.6 ± 301.1 in June; 6,784.3 ± 347.1 and 4,053.5 ± 296.3 in July; 6,433.7 ± 377.0 and 3,772.5 ± 302.5 in August; 7,289.1 ± 382.1 and 4,474.5 ± 311.6 in September; 7,190.2 ± 412.1 and 4,523.2 ± 332.1 in October; 6,494.5 ± 365.5 and 4,072.1 ± 315.9 in November; 6,057.0 ± 418.5 and 3,879.2 ± 354.1 in December; 5,909.4 ± 362.7 and 3,782.9 ± 309.1 in January; and 5,862.4 ± 351.8 and 3,746.5 ± 300.2 in February, respectively. The average number of daily steps increased from May to October and decreased from November to February. Few changes in the average number of exercise steps, which ranged from 6,000-7,000 steps, were observed during any month. For the 10-month analysis, the average numbers of daily and exercise steps were 6,529.4 ± 328.1 and 4,032.5 ± 275.8, respectively.

For the participants in Nagano, the numbers of daily and exercise steps per day were 5,423.5 ± 534.0 and 2,948.3 ± 466.5 in June; 5,583.4 ± 495.4 and 2,917.2 ± 428.5 in July; 5,673.5 ± 576.0 and 2,927.1 ± 443.1 in August; 5,025.5 ± 640.8 and 2,546.7 ± 415.1 in September; 5,170.2 ± 571.2 and 2,628.0 ± 390.5 in October; and 4,674.4 ± 539.7 and 2,507.7 ± 366.4 in November, respectively (Figure 2). The average number of daily steps increased from June to August and decreased from September to November. Few changes in the average number of exercise steps, which ranged from 4,500-5,500 steps, were observed during any month. There was a six-month period between the start to finish of the health education program and the average numbers of daily and exercise steps for Nagano participants were 5,258.4 ± 559.5 and 2,782.2 ± 544.3, respectively. Overall, the average number of daily steps and exercise steps were significantly higher in Minowa subjects than in Matsumoto subjects followed by Nagano subjects ( $p < 0.01$ ) (Table 2). The participants in Japan had a rainy season from summer to autumn, namely, from June to November. The rain probably had a negative effect on the participants' number of steps during that time.

**Figure 2** Average walking numbers of exercise steps for each month for the participants in Minowa, Matsumoto and Nagano





**Table 2** Pedometry comparison of the steps in Minowa, Matsumoto and Nagano

	<i>Minowa</i>	<i>Matsumoto</i>	<i>Nagano</i>	<i>Multiple comparison</i>	
Walking steps					
Walking/day (steps)	8,753.6 ± 492.3	6,529.4 ± 328.1	5,329.9 ± 597.0	Mi vs Ma, Mi vs Na, Ma vs Na	**
Exercise/day (steps)	5,592.2 ± 448.2	4,032.5 ± 275.8	2,782.2 ± 455.3	Mi vs Ma, Mi vs Na, Ma vs Na	**

Notes: Mi: Minowa, Ma: Matsumoto, Na: Nagano; \*\* $p < 0.01$

### 3.2 Anthropometry and blood pressure measurements

For the subjects in the Minowa group and Matsumoto, the results from before and after the program showed that weight (before: 59.5 kg ± 1.6; after: 58.5 kg ± 1.6,  $p < 0.006$  and before: 59.6 kg ± 1.3; after: 59.3 kg ± 1.3,  $p < 0.001$ , respectively) and BMI (before: 23.0 kg/m<sup>2</sup> ± 0.5; after: 22.7 kg/m<sup>2</sup> ± 0.5,  $p < 0.004$  and before: 23.1 ± 0.4; after: 23.0 kg ± 0.3,  $p < 0.001$ , respectively) significantly decreased after the program. Moreover, for the subjects in the Minowa group, the results from before and after the program showed that systolic blood pressure (before: 133.0 mmHg ± 1.9; after: 125.5 mmHg ± 2.0,  $p < 0.001$ ) and diastolic blood pressure (before: 80.4 mmHg ± 1.2; after: 76.1 mmHg ± 1.1,  $p < 0.001$ ) significantly decreased after the program. In subjects in the Nagano and control groups, for weight, BMI and blood pressure, no significant differences were observed after the program. The interaction of the two-way ANOVA was not significantly different for anthropometry and blood pressure measurements (Table 3).

### 3.3 Blood chemistry tests

For subjects in the Minowa group, a comparison of blood chemistry measurement results from before and after the program showed no significant differences in HDL, LDL and triglyceride levels. Fasting blood glucose (before: 103.1 mg/dl ± 2.7; after: 100.0 mg/dl ± 2.2,  $p = 0.015$ ) and HbA1c (before: 5.5% ± 0.1; after: 5.3% ± 0.1,  $p < 0.001$ ) significantly decreased after the program. For subjects in the Matsumoto group, a comparison of blood chemistry measurement results from before and after the program showed no significant differences. For subjects in the Nagano group, a comparison of blood chemistry measurement results from before and after the program showed that LDL (before: 130.9 mg/dl ± 5.5; after: 119.6 mg/dl ± 5.4,  $p = 0.003$ ) significantly decreased after the program. For subjects in the control group, a comparison of blood chemistry measurement results from before and after the program showed that HbA1c (before: 5.8% ± 0.1; after: 5.9% ± 0.1,  $p < 0.043$ ) significantly increased after the program. The interaction of the two-way ANOVA was not significantly different for the blood chemistry tests (Table 3).

### 3.4 Physical fitness tests

For subjects in the Minowa group, a comparison of the physical fitness test results from before and after the program showed no significant differences for the eyes-open single-leg stance ability and the grip strength (before: 33.6 kg ± 1.5; after: 37.3 kg ± 1.5,  $p < 0.001$ ), number of sit-ups (before: 11.9 times ± 0.9; after: 15.4 times ± 0.9,  $p < 0.001$ ), sit-and-reach flexibility (before: 42.6 cm ± 1.3; after: 47.4 ± 1.1,  $p = 0.002$ ) and 10-meter obstacle walk (before: 6.8 sec. ± 0.1; after: 5.2 sec. ± 0.1,  $p = 0.004$ ) and six-min walk (before: 622.8 m ± 6.9; after: 719.9 times ± 9.2,  $p = 0.005$ ) results significantly improved after the program. For subjects in the Matsumoto group, a comparison of the physical fitness test results from before and after the program showed no significant difference in grip strength and eyes-open single-leg stance ability and the number of sit-ups (before: 11.9 times ± 0.9; after: 13.9 times ± 0.9,  $p < 0.001$ ) and 10-meter obstacle walk (before: 4.7 sec. ± 0.1; after: 3.8 sec. ± 0.1,  $p < 0.001$ ) and six-min walk (before: 651.1 m ± 7.7; after: 679.9 times ± 9.5,

**Table 3** Comparison of before and after health program in Thai, Minowa, Matsumoto, Nagano and control group

	Mi/before	Mi/after	paired t-test	Ma/before	Ma/after	paired t-test	Na' before	Na' after	paired t-test	C/before
<i>Anthropometry measurements</i>										
Weight (kg)	59.5 ± 1.6	58.5 ± 1.6	0.006	59.6 ± 1.3	59.3 ± 1.3	0.001	56.3 ± 1.8	55.3 ± 1.5	0.133	53.3 ± 2.1
BMI (kg/m <sup>2</sup> )	23.0 ± 0.5	22.7 ± 0.5	0.004	23.1 ± 0.4	23.0 ± 0.3	0.001	22.6 ± 0.6	22.3 ± 0.5	0.109	21.4 ± 0.8
<i>Blood pressures measurements</i>										
Systolic blood pressure (mmHg)	133.0 ± 1.9	125.5 ± 2.0	0.001	129.5 ± 1.6	129.6 ± 1.6	0.878	132.1 ± 3.1	127.2 ± 3.2	0.086	126.7 ± 6.4
Diastolic blood pressure (mmHg)	80.4 ± 1.2	76.1 ± 1.1	0.001	75.6 ± 1.3	78.1 ± 1.2	0.054	80.0 ± 1.7	77.9 ± 1.7	0.197	75.8 ± 2.4
<i>Blood chemistry tests</i>										
Fasting blood glucose (mg/dl)	103.1 ± 2.7	100.0 ± 2.2	0.015	105.7 ± 1.9	104.3 ± 1.7	0.056	97.9 ± 2.8	98.7 ± 5.0	0.764	101.2 ± 3.6
HbA1c (%)	5.5 ± 0.1	5.3 ± 0.1	0.001	5.2 ± 0.1	5.3 ± 0.1	0.148	5.8 ± 0.1	5.9 ± 0.1	0.322	5.8 ± 0.1
HDL (mg/dl)	61.0 ± 2.2	61.1 ± 2.0	0.954	67.6 ± 1.9	68.0 ± 1.9	0.901	68.7 ± 3.6	67.9 ± 3.5	0.431	65.8 ± 6.2
LDL (mg/dl)	127.2 ± 4.1	127.6 ± 4.2	0.912	132.8 ± 4.2	131.6 ± 4.6	0.190	130.9 ± 5.5	119.6 ± 5.4	0.003	132.3 ± 11.8
Triglycerides (mg/dl)	118.2 ± 9.1	114.9 ± 9.4	0.617	100.6 ± 9.7	100.6 ± 6.1	0.997	96.5 ± 7.5	92.0 ± 8.0	0.393	121.3 ± 19.5
<i>Physical fitness tests</i>										
Grip strength (kg)	33.6 ± 1.5	37.3 ± 1.5	0.001	28.8 ± 1.0	28.3 ± 1.0	0.060	27.8 ± 1.2	28.2 ± 1.1	0.430	27.7 ± 2.1
Sit-ups (times)	11.9 ± 0.9	15.4 ± 0.9	0.001	11.9 ± 0.9	13.9 ± 0.9	0.004	9.6 ± 0.9	11.1 ± 1.1	0.035	9.5 ± 2.8
Sit-and-reach flexibility (cm)	42.6 ± 1.3	47.4 ± 1.1	0.002	44.2 ± 1.0	41.6 ± 1.1	0.001	41.5 ± 1.3	38.8 ± 1.6	0.058	37.7 ± 4.8
Eyes-open single leg stance (sec.)	106.0 ± 4.5	105.7 ± 4.5	0.917	92.2 ± 4.7	97.4 ± 4.4	0.062	94.7 ± 6.7	87.5 ± 7.3	0.194	92.5 ± 11.1
10-m obstacle walk (sec.)	6.8 ± 0.1	5.2 ± 0.1	0.004	4.7 ± 0.1	3.8 ± 0.1	0.001	5.2 ± 0.1	5.2 ± 0.1	0.772	5.1 ± 0.2
6 min walk (m)	622.8 ± 6.9	719.9 ± 9.2	0.005	651.1 ± 7.7	679.9 ± 9.5	0.001	639.3 ± 9.2	644.4 ± 18.9	0.768	625.8 ± 26.9
<i>Brain function tests (go/no)</i>										
<i>Response</i>										
Formation (ms.)	258.6 ± 7.5	241.6 ± 5.6	0.068	253.6 ± 11.4	240.4 ± 5.1	0.193	246.3 ± 7.5	248.0 ± 8.4	0.862	260.3 ± 21.3
Differentiation (ms.)	409.6 ± 8.6	380.1 ± 9.1	0.021	381.0 ± 6.8	402.8 ± 10.0	0.038	405.1 ± 10.3	405.3 ± 11.2	0.985	411.8 ± 23.7
Reverse Differentiation (ms.)	436.5 ± 10.0	413.2 ± 10.6	0.160	408.5 ± 7.1	428.2 ± 10.6	0.132	429.5 ± 12.5	412.6 ± 11.3	0.151	424.2 ± 34.1
Average (ms.)	392.8 ± 7.3	367.1 ± 8.0	0.020	367.3 ± 5.7	382.9 ± 8.4	0.102	386.2 ± 9.1	379.0 ± 9.2	0.330	388.8 ± 25.2
<i>Times</i>										
Total number of Misses (Times)	0.1 ± 0.0	0.2 ± 0.2	0.520	0.2 ± 0.1	0.3 ± 0.1	0.597	0.1 ± 0.0	0.2 ± 0.1	0.254	0.0 ± 0.0
Total number of Mistakes (Times)	2.8 ± 0.4	1.9 ± 0.3	0.001	4.2 ± 0.3	2.7 ± 0.4	0.001	2.5 ± 0.5	2.0 ± 0.3	0.176	1.7 ± 0.2
Errors (Times)	2.9 ± 0.4	2.1 ± 0.4	0.016	4.4 ± 0.3	3.0 ± 0.4	0.001	2.6 ± 0.5	2.2 ± 0.3	0.332	1.7 ± 0.2

Notes: B/A: main effect of before and after, Mi/Ma/Na/C main effect of Minowa, Matsumoto and Control group, Interaction: interaction effect between B/A and Mi/Ma/Na/C Mean ± SE (continued)



**Table 3**

	C/after	paired t-test	B/A	Two-way ANOVA			Tukey-kramer		
				Mi/Ma/Na/C	Interaction	T-B/A	Mi-B/A	Ma-B/A	Na-B/A
<i>Anthropometry measurements</i>									
Weight (kg)	53.0 ± 2.3	0.388	0.577	0.026	0.994				
BMI (kg/m <sup>2</sup> )	21.0 ± 1.0	0.538	0.442	0.152	0.993				
<i>Blood pressures measurements</i>									
Systolic blood pressure (mmHg)	132.2 ± 11.1	0.351	0.087	0.999	0.202				
Diastolic blood pressure (mmHg)	75.7 ± 4.9	0.950	0.567	0.337	0.067				
<i>Blood chemistry tests</i>									
Fasting blood glucose (mg/dl)	95.5 ± 6.3	0.215	0.431	0.061	0.881				
HbA1c (%)	5.9 ± 0.1	0.043	0.744	0.001	0.148				
HDL (mg/dl)	67.2 ± 6.6	0.509	0.986	0.016	0.993				
LDL (mg/dl)	126.2 ± 11.9	0.094	0.366	0.486	0.677				
Triglycerides (mg/dl)	105.3 ± 15.8	0.250	0.703	0.098	0.968				
<i>Physical fitness tests</i>									
Grip strength (kg)	27.5 ± 2.1	0.928	0.253	0.001	0.307				
Sit-ups (times)	8.5 ± 3.5	0.559	0.007	0.002	0.589				
Sit-and-reach flexibility (cm)	33.3 ± 3.2	0.454	0.502	0.001	0.007	NS	NS	NS	NS
Eyes-open single leg stance (sec.)	88.9 ± 18.0	0.618	0.944	0.047	0.711	NS	0.010	NS	NS
10-m obstacle walk (sec.)	5.4 ± 0.3	0.401	0.001	0.001	0.001	NS	0.010	NS	NS
6 min walk (m)	663.3 ± 19.1	0.259	0.001	0.037	0.001	NS	0.010	NS	NS
<i>Brain function tests (go/no)</i>									
<i>Response</i>									
Formation (ms.)	230.7 ± 9.4	0.185	0.091	0.098	0.707				
Differentiation (ms.)	405.3 ± 11.2	0.985	0.929	0.523	0.024	NS	NS	NS	NS
Reverse Differentiation (ms.)	431.0 ± 29.5	0.151	0.806	0.862	0.122				
Average (ms.)	371.6 ± 17.9	0.589	0.610	0.747	0.051				
<i>Times</i>									
Total number of Misses (Times)	0.0 ± 0.0	-	0.185	0.430	0.988				
Total number of Mistakes (Times)	2.5 ± 0.7	0.280	0.001	0.001	0.258				
Errors (Times)	2.5 ± 0.7	0.280	0.002	0.001	0.297				

$p < 0.001$ ) results significantly improved after the program. However, sit-and-reach flexibility (before:  $44.2 \text{ cm} \pm 1.0$ ; after:  $41.6 \pm 1.1$ ,  $p < 0.001$ ) significantly decreased after the program. For subjects in the Nagano group, a comparison of the physical fitness test results from before and after the program showed that only the number of sit-ups (before:  $9.6 \text{ times} \pm 0.9$ ; after:  $11.1 \text{ times} \pm 1.1$ ,  $p = 0.035$ ) significantly improved after the program. However, other results from before and after the program showed no significant differences. For subjects in the control group, a comparison of all of the results from before and after the program for the physical fitness tests showed no significant differences.

The sit-and-reach flexibility, 10-meter obstacle walk and six-min walk interactions in the two-way ANOVA were significantly different (sit-and-reach flexibility;  $p = 0.007$ , 10-meter obstacle walk;  $p < 0.001$  and six-min walk;  $p < 0.001$ ); thus, a one-way ANOVA was conducted to interpret the before and after results for all groups. The sit-and-reach flexibility results showed no significant differences; however, the 10-meter obstacle walk results for the Minowa participants significantly improved (10-meter obstacle walk before vs after, Minowa,  $p < 0.001$ ) and the six-min walk time for the Minowa and Matsumoto participants significantly increased (six-min walk before vs after, Minowa and Matsumoto,  $p < 0.001$ ).

### **3.5 Brain function tests**

For subjects in the Minowa group, a comparison of brain function as assessed by the go/no-go tasks from before and after the program showed no significant differences in formation and reverse differentiation. Differentiation reaction times (before:  $409.6 \text{ ms} \pm 8.6$ ; after:  $380.1 \text{ ms} \pm 9.1$ ,  $p = 0.021$ ) and average reaction times (before:  $392.8 \text{ ms} \pm 7.3$ ; after:  $367.1 \text{ ms} \pm 8.0$ ,  $p = 0.02$ ) significantly decreased after the program. In contrast, the total number of mistakes (before:  $2.8 \text{ times} \pm 0.4$ ; after:  $1.9 \text{ times} \pm 0.3$ ,  $p < 0.001$ ) and errors of miss and mistake (before:  $2.9 \text{ times} \pm 0.4$ ; after:  $2.1 \text{ times} \pm 0.4$ ,  $p < 0.016$ ) significantly decreased after the program. For subjects in the Matsumoto group, a comparison of brain function as assessed by the go/no-go tasks from before and after the program showed no significant differences in formation, reverse differentiation and average reaction times. Differentiation reaction times (before:  $381.0 \text{ ms} \pm 6.8$ ; after:  $402.8 \text{ ms} \pm 10.0$ ,  $p < 0.038$ ) significantly increased after the program. In contrast, the total number of mistakes (before:  $4.2 \text{ times} \pm 0.3$ ; after:  $2.7 \text{ times} \pm 0.4$ ,  $p < 0.001$ ) and errors (before:  $4.4 \text{ times} \pm 0.3$ ; after:  $3.0 \text{ times} \pm 0.4$ ,  $p < 0.001$ ) significantly decreased after the program. For subjects in the Nagano and control groups, a comparison of brain function as assessed by the go/no-go tasks from before and after the program showed no significant differences in reaction time and the total number of misses, mistakes and errors.

The interaction of the two-way ANOVA was not significantly different for the brain function tests (Table 3).

### **3.6 Pearson's correlation coefficient**

The number of steps for the Minowa, Matsumoto, Nagano groups and the differences between the before and after results for the anthropometry measurements, blood pressure measurements, blood chemistry tests, physical fitness tests and brain function tests were analyzed with Pearson's correlation coefficient. The results showed a significant relationship between the number of steps (average: 6,847) and systolic blood pressure ( $r = -0.33$ ,  $p < 0.001$ ), diastolic blood pressure ( $r = 0.34$ ,  $p < 0.001$ ) and grip strength ( $r = -0.34$ ,  $p < 0.001$ ). Additionally, the Minowa group showed a significant relationship between the number of steps (average: 8,754) and systolic blood pressure ( $r = -0.37$ ,  $p = 0.016$ ), diastolic blood pressure ( $r = -0.40$ ,  $p = 0.008$ ) and sit-ups ( $r = -0.35$ ,  $p = 0.022$ ), but the Matsumoto group did not. Although there was a correlation between the number of steps (average: 5,258) and the number of mistakes ( $r = -0.49$ ,  $p = 0.122$ ) and errors ( $r = -0.57$ ,  $p = 0.067$ ) in the go/no-go task in the Nagano group, no significant relationship was found.

## 4. Discussion

### 4.1 Pedometry

Walking improves the human body's defense against diseases and contributes to health improvement (Hamer and Chida, 2008; Kemoun *et al.*, 2010; Golay *et al.*, 2013; Pernar *et al.*, 2017; Hornbuckle *et al.*, 2016). The MHLW of Japan supports the current physical activity guidelines (Ministry of health, labor and welfare, 2000). There are no data for the control group in this study because it has been reported that the control group members who have a pedometer significantly increase their activity (Rooney *et al.*, 2003). However, in another study (Terasawa *et al.*, 2019), control group members were given pedometers with tapes that hid the monitor so they could not see the number of steps they took. They walked two weeks and the average number of steps was 5,220.

An investigation in 2011 by the Japanese MHLW showed that the average number of steps was 7,841 for men and 6,883 for women of 20-64 years of age and 5,628 for men and 4,584 for women of 65 years of age and over. "Kenkou Nippon 21" recommends 9,000 steps for men and 8,500 steps for women of 20-64 years of age and 7,000 steps for men and 6,000 steps for women of 65 years of age and over by 2020 (Ministry of health, labor and welfare, 2000). In the Minowa group (average age: 62.7), the average numbers of daily and exercise steps were  $8,753.6 \pm 492.3$  and  $5,592.2 \pm 448.2$ , respectively. In the Matsumoto group (average age: 66.0), the average numbers of daily and exercise steps were  $6,529.4 \pm 328.1$  and  $4,032.5 \pm 275.8$ , respectively. In the Nagano group (average age: 65.0), the average numbers of daily and exercise steps were  $5,258.4 \pm 559.5$  and  $2,782.2 \pm 544.3$ , respectively.

The number of steps in the Minowa and Matsumoto groups exceeded the target number of steps recommended by the MHLW for women, but in the Nagano group, both men and women fell short of the target. It has been reported that fast walking promotes the prevention of dementia (Nakamura *et al.*, 1996; Kemoun *et al.*, 2010; Babaei *et al.*, 2013); however, the Minowa group's number of exercise steps was 64% of normal walking, the Matsumoto group's was 62% of normal walking and the Nagano group's was 53% of normal walking. The Minowa group had the highest percentage of normal walking. However, in all areas, more than half of the normal walking included exercise steps.

### 4.2 Anthropometry and blood pressure measurements

The Minowa and Matsumoto groups showed significant decreases in weight and BMI, but the Nagano and the control groups did not. The Minowa group showed a significant decrease in systolic and diastolic blood pressure, but the Matsumoto, Nagano and control groups did not. There is a possibility that the above results reflect the number of daily and exercise steps of the Minowa, Matsumoto, Nagano and control groups:  $8,753.6 \pm 492.3$  and  $5,592.2 \pm 448.2$ ,  $6,529.4 \pm 328.1$  and  $4,032.5 \pm 275.8$  and  $5,258.4 \pm 559.5$  and  $2,782.2 \pm 544.3$ , respectively. That is, if the number of daily steps is more than 8,700, weight, BMI, systolic and diastolic blood pressure may show significant decreases and if the number of steps is more than 6,500, weight and BMI may show significant decreases.

### 4.3 Blood chemistry tests

The Minowa group showed significant decreases in fasting blood glucose and HbA1c, but the Matsumoto and control groups did not show significant differences in any of the blood test items. The Nagano group showed a significant decrease in LDL but no significant differences in the other items. In our previous surveys, there were cases that showed significant decreases in LDL corresponding to the number of steps. However, in this survey, the Nagano group showed a significant decrease in LDL, although the number of steps of the Nagano group was smaller than that of the Matsumoto group.

For subjects in control, HbA1c levels significantly increased after the program. Regular exercise improves blood glucose and lipid metabolism ([Balducci et al., 2010](#); [Zahra et al., 2010](#)).

#### 4.4 Physical fitness tests

The Minowa group showed significant improvement in grip strength, the number of sit-ups, sit-and-reach flexibility and 10-meter obstacle walk and six-min walk results but not in eyes-open single-leg stance ability. The maximum value for the eyes-open single-leg stance was set at 120 sec. The Minowa group's initial value for eyes-open single-leg stance was 102 sec, which was already a high value, the highest among all of the other areas. This may be the reason why it did not show significant improvement. The Matsumoto group showed significant improvements in the number of sit-ups, 10-meter obstacle walk and six-min walk, but sit-and-reach flexibility decreased. The Nagano group showed significant improvement in the number of sit-ups. The control group showed no significant improvement for any item.

The sit-and-reach flexibility, 10-meter obstacle walk and six-min walk interaction from the two-way ANOVA was significantly different; thus, a one-way ANOVA was conducted to interpret the before and after results for all groups. The sit-and-reach flexibility results showed no significant differences; however, regarding the 10-meter obstacle walk, the results of the Minowa participants improved significantly and more than any other group and the Matsumoto group had the second greatest improvement; In the six-min walk, the time of the Minowa participants significantly improved. We speculate that these results for the physical fitness measurements are related to the number of steps.

In addition, the walking speed and distance of the participants with dementia was significantly slower and shorter than the healthy participants ([Nakamura et al., 1996](#); [Kemoun et al., 2010](#); [Babaei et al., 2013](#)).

The Japanese MEXT has conducted physical fitness tests on people of 6-79 years of age since 1999. Physical fitness tests on people of 65-79 years of age included grip strength, sit-ups, sit-and-reach flexibility, eyes-open single-leg stance, 10-m obstacle walk and six-min walk. We have chosen these physical fitness tests for the healthy elderly people. In Japan, this test is called the "new physical fitness test," and it involves more than 5,000 data points from people 65 to 79 years old recruited every year from 2000 to the present, as a result of which this data set is unprecedented worldwide ([Ministry of Education, Culture, Sports, Science and Technology, 1999](#)). In addition, the Japanese MHLW conducts physical fitness tests for the care of people > 65 years, namely, grip strength, eyes-open single-leg stance, timed up and go test and six-m normal and maximum walk times ([Ministry of health, labor and welfare, 2009](#)). Increased exercise momentum leads to improved physical fitness tests results ([Leite et al., 2015](#); [Shao et al., 2014](#)).

#### 4.5 Brain function tests

Go/no-go tasks are frequently used to investigate response inhibition, an essential executive function implemented by the prefrontal cortex and these tasks recruit a variety of cognitive components in addition to response inhibition ([Masaki and Moriyama, 1971](#); [Terasawa et al., 2014a, 2014b](#); [Diamond, 2013](#); [Chikazoe, 2010](#)).

For subjects in the Minowa group, the go/no-go tasks from before and after the program showed no significant differences in formation and reverse differentiation. However, the differentiation reaction times and average reaction times significantly decreased after the program. In contrast, the total number of mistakes and errors significantly decreased after the program.

For subjects in the Matsumoto group, a comparison of brain function as assessed by the go/no-go tasks from before and after the program showed no significant differences in

formation, reverse differentiation and average reaction times. Differentiation reaction times significantly increased after the program. In contrast, the total number of mistakes and errors significantly decreased after the program.

For subjects in the Nagano and control groups, a comparison of brain function as assessed by the go/no-go tasks from before and after the program showed no significant differences in reaction time and total number of misses mistakes and errors.

Go/no-go tasks studies in the literature have suggested that a health program could improve brain function, including working memory (Masaki and Moriyama, 1971; Terasawa *et al.*, 2014a, 2014b; Diamond, 2013; Chikazoe, 2010); in those studies, subjects performed regular exercises in the first stage where go/no-go task reaction times increased significantly and the numbers of error responses decreased significantly. In the second stage, go/no-go task reaction times decreased significantly and the number of error responses decreased significantly.

The Minowa group's reaction time became significantly faster and the number of errors significantly decreased after the program, both of which are the characteristics of the second stage of improvement. The Matsumoto group's reaction time became significantly slower and the number of errors significantly decreased after the program, from which we speculate that the Matsumoto group was in the first stage of improvement. The average number of daily steps was 8,753.6 for the Minowa group, 6,529.4 for the Matsumoto group and 5,258.4 for the Nagano group. From the above results, there is a possibility that the improvement in the go/no-go results may not occur with a daily amount of activity of 5,258.4 steps.

#### **4.6 Pearson's correlation coefficient**

The number of steps for the Minowa, Matsumoto, Nagano groups and the differences between the before and after results for the anthropometry measurements, blood pressure measurements, blood chemistry tests, physical fitness tests and brain function tests were analyzed with pearson's correlation coefficient. The results showed a significant relationship between the number of steps and systolic blood pressure, diastolic blood pressure and grip strength. Additionally, the Minowa group showed a significant relationship between the number of steps and systolic blood pressure, diastolic blood pressure and sit-ups, but the Matsumoto group did not. Although there was a correlation between the number of steps and the number of mistakes and errors in the go/no-go task in the Nagano group, no significant relationship was found. The factors that led to this condition in Minowa may be that the subjects and the instructors had enough time to build positive and meaningful relationships, which led to increased motivation and thus, an increased number of daily steps. In the control condition, the subjects initially taped the pedometer so that the step value was invisible and not influenced by the instructor. Then, the instructors removed the tape from the pedometer, set the goal of the number of steps, printed out the number of steps on a graph and met with the subjects and provided individual guidance. As a result, the step value of the group gradually but significantly increased from 5,221 steps in the control condition to 8,457 steps in the final condition (Terasawa *et al.*, 2019). Only Nagano showed a significant correlation between the number of steps and the results of the go/no-go tests. Overall, in our previous surveys, the measured values of the go/no-go tests performed at the beginning of the intervention (before health education) show a short reaction time and a large number of errors in the first stage. In the second stage, after subjects continue to exercise, the results show a significantly longer reaction time and a significantly smaller number of errors. It has been reported that with further continued exercise, the results show a shorter reaction time and a significantly smaller number of errors in the third stage (Maruo *et al.*, 2015; Watanabe *et al.*, 2015; Murata *et al.*, 2015). It may be possible that Nagano followed the same second stage shown in the previous surveys and that the number of steps and the go/no-go test results showed a significant

correlation, while Matumoto and Minowa may have followed the same third stage shown in the previous surveys, with no significant correlation between the number of steps and the go/no-go test results.

## 5. Conclusions

This study aimed to appropriately establish a Japanese-style healthcare program under the ISO 9001:2008, to improve problem areas and inspect its effectiveness. Furthermore, we want to make this health promotion through ISO widely available in Asian countries and an international contribution. The 46 Minowa subjects was 46 were of  $62.7 \pm 4.7$  years of age (mean  $\pm$  SD). The 69 Matsumoto subjects were of  $66.0 \pm 5.8$  years of age. The 35 Nagano subjects were of  $65.2 \pm 4.6$  years of age. The seven control subjects were of  $61.3 \pm 7.8$  years of age. That study assessed findings from pedometric, anthropometric and blood pressure measurements and physical fitness, blood chemistry and brain function tests. In the Minowa group (average age: 62.7), the average numbers of daily and exercise steps were  $8,753.6 \pm 492.3$  and  $5,592.2 \pm 448.2$ , respectively. In the Matsumoto group (average age: 66.0), the average numbers of daily and exercise steps were  $6,529.4 \pm 328.1$  and  $4,032.5 \pm 275.8$ , respectively. In the Nagano group (average age: 65.0), the average numbers of daily steps were  $5,258.4 \pm 559.5$  and  $2,782.2 \pm 544.3$ , respectively. The factors that led to this condition in Minowa may be that the subjects and the instructors had enough time to build positive and meaningful relationships, which led to increased motivation and thus, an increased number of daily steps. Thus, the number of daily steps, which shows the amount of daily activity, was significantly correlated with blood pressure and the results of physical fitness tests in Minowa. Groups from three regions in Japan showed significant differences on the physical fitness tests; regarding the 10-meter obstacle walk, the Minowa participants showed the greatest improvement and the Matsumoto participants showed the second-largest improvement. On the six-min walk, the time of the Minowa participants significantly improved.

## 6. Future research issues

We could not fully control the following factors in this study. The participant groups in the 2 countries had differences in the size of the groups and in their surrounding environment, including customs, climate and culture. Further work is necessary to consider these differences and to examine larger and equally sized subject groups.

## 7. List of abbreviation

- ISO 9001:2008
- WHO
- The Japan MHLW
- Metabolic equivalent: energy expenditure during acting amount of metabolite during
- Sitting quietly (METs)
- BMI
- The Japanese MEXT
- HbA1c
- HDL
- LDL
- ANOVA



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Ethics approval and consent to participate.

The latest guidelines based on the Helsinki Declaration was adopted by the Institutional Ethics Committee of Shinshu University (UMIN000009309). Written informed consents were obtained from all the participants.

Consent for publication: Not applicable.

Availability of data and material: There is availability of data and materials.

Competing interests: There is no competing benefit.

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*Availability of data and material:* The data sets during and/or analyzed during the current study available from the corresponding author on reasonable request.

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