Original Article

Nutrition education guided by Dietary Guidelines for Chinese Residents on metabolic syndrome characteristics, adipokines and inflammatory markers

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Objective: The objective of this study was to test whether "*Dietary Guidelines for Chinese Residents*" have beneficial effects on anthropometric and metabolic variables, adipokines and inflammatory markers in metabolic syndrome patients. Methods & Procedures: A multi-stage sampling method was applied to select metabolic syndrome patients in two districts of Shanghai. Two hundred and seventy-two metabolic syndrome patients were divided into control and intervention groups according to their district. Nutrition education guided by "*Dietary Guidelines for Chinese Residents*" was performed in the intervention group for one year. Results: Nutrition-related knowledge, attitudes and behavior were improved in the intervention group. Potassium intake and food to total energy ratio for grain, vegetable and fruit increased while sodium intake as well as fat to total energy ratio decreased in the intervention group compared to the control group (p<0.05). Correspondently, the intervention group significantly improved its waist circumference, waist to hip ratio, high-density lipoprotein cholesterol, adiponectin, leptin and tumor necrosis factor-α compared to the control group (p<0.05). Waist circumference changes from baseline to end of the study in the intervention and the control groups were -3.9±0.3 and -2.3±0.4 cm respectively. There was a significant difference between the two groups (p=0.004). Means of waist circumference, waist to hip ratio, leptin and tumor necrosis factor-α were lower, and high density lipoprotein-cholesterol was higher in the intervention group than the control group (p<0.05). Conclusion: This study confirmed "*Dietary Guidelines for Chinese Residents*" had beneficial effects on anthropometric, lipids, adipokines and inflammatory markers in metabolic syndrome patients.

Key Words: the metabolic syndrome, nutrition education, adiponectin, leptin, tumor necrosis factor-α

INTRODUCTION

Dietary pattern have been correlated with chronic non-communicable diseases. High intakes of vegetables, fruits, legumes, whole grains, fish, and poultry have been connected with lower risk of cardiovascular diseases, while high intakes of red meat, processed meat, refined grains, sweets and dessert, French fries, and high-fat dairy products have been connected with higher risk of cardiovascular diseases.[1,2]

The metabolic syndrome, which is a cluster of obesity, high glucose, dyslipidemia and high blood pressure has been noticed for a long time.[3] It has been identified as a risk factor of cardiovascular diseases and type 2 diabetes.[3,4] Nutrition education intervention can help to improve the health status of metabolic syndrome patients. In Italy, metabolic syndrome patients improved their health status by adopting a Mediterranean-style diet and two years nutrition education.[5] Mediterranean diet was rich in fruits, vegetables, nuts and olive oil. After two years, the metabolic syndrome patients reduced their body weight, high sensitivity C reactive protein, interleukin-6, interleukin-7, interleukin-18 as well as insulin resistance. Nutrition education intervention using "Dietary Approaches to Stop Hypertension"[6] as a guideline also helped to lower blood pressure and had suitable effects on blood lipids.[6,7] The Dietary Approaches to Stop Hypertension also reduced most of the metabolic risks in metabolic syndrome patients.[8] The diet had reduced energy, saturated fat, total fat, cholesterol and Na and increased amounts of fruits, vegetables, low-fat dairy and whole grains consumed.

Currently, there are few nutrition education programmes using "*Dietary Guidelines for Chinese Residents*" as guidance in international journals. Also, there are few reports about the effect of "*Dietary Guidelines for Chinese Residents*" on the metabolic syndrome. Therefore, this study was initiated to test whether "*Dietary Guidelines for Chinese Residents*" have beneficial effects on anthropometric and metabolic variables in patients with the metabolic syndrome. Besides traditional markers associated with the metabolic syndrome, there are several adipokines and inflammatory markers that have been correlated with the

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metabolic syndrome, such as adiponectin, tumor necrosis factor-α, leptin and C-reactive protein.[9,10] The effects of nutrition education on these adipokines and inflammatory markers were also investigated.

MATERIALS AND METHODS

Subjects

A multistage sampling method was used to select metabolic syndrome participants in 2 urban districts in Shanghai. Two thousand and eight hundred participants aged 30-65 were randomly selected from candidates listed in the residential registration record. All participants provided written informed consents. The protocol was approved by the School of Public Health Ethics Committee of Fudan University.

Data of demographic variables (age), health (weight, height, waist circumferences, any known diseases) and medical history were collected to screen possible metabolic syndrome patients using a standardized questionnaire by home interview. Home interview was conducted by public health postgraduate students of Fudan University and public health workers of community hospitals.

A total of 622 eligible participants further took a physical examination and their blood were taken for further lab measurements at the local health stations after a home interview. Participants were required to fast overnight. The eligibility of the participants was defined as those free from the following conditions: 1) severe psychological disorders, physical disabilities, cancer, cardiovascular diseases, Type 1 diabetes, Alzheimer's disease, or dementia or 2) currently diagnosed with tuberculosis, AIDS, and other communicable diseases.

Two hundred and seventy-two subjects were diagnosed with the metabolic syndrome through physical exam and lab measurements. Metabolic syndrome patients in one district were chosen as the intervention group (n=130), and the other as the control group (n=142). Nutrition education was performed in the intervention group for one year (From May 2007 to May 2008). Two hundred and thirty-five patients completed the entire year of study (n=115 in the intervention group, n=120 in the control group).

Definition of metabolic syndrome

The metabolic syndrome was defined according to the International Diabetes Federation guidelines: abdominal obesity (waist circumference, WC ≥90cm for men and ≥80cm for women) and any two of the following four factors: 1) triglyceride (TG) ≥1.7 mmol/L or specific treatment for this lipid abnormality; 2) high-density lipoprotein-cholesterol (HDL-C) <1.03 mmol/L for men and <1.29mmol/L for women or specific treatment for this lipid abnormality; 3) systolic blood pressure (SBP) ≥130 mmHg or diastolic blood pressure (DBP) ≥ 85 mmHg or treatment of previously diagnosed hypertension; 4. fasting glucose (FG) ≥ 5.6 mmol/L, or previously diagnosed type 2 diabetes.

Anthropometric and biochemical measurements

Weight and height were assessed with participants in lightweight clothing and without shoes. Waist circumference was measured midway between lower costal arch and iliac crest, and hip circumference was measured at the widest point over the buttocks. All measurements were performed by the same trained public health worker. Blood pressure was assessed with a mercury sphygmomanometer. The body mass index (BMI) and waist to hip ratio (WHR) were then calculated as weight/(height)^2, and as waist circumference/hip circumference, respectively.

Blood samples were collected after fasting overnight. Fasting glucose and lipids were determined with an automatic analyzer (Hitachi 7180 Japan) using reagents from Shanghai Fenghui Med-Tech, Inc. Insulin was measured with SN-695 Counter (Shanghai Hesuo Rihuan Photoelectric Instrument Co., Ltd) using radioimmune assay kit from Beijing Chemclin Biotech Co. Ltd. The Homeostasis model assessment of insulin resistance (HOMA-IR) was then calculated with the formula: FG (mmol/L) × Fasting insulin (μIU/mL)/22.5. Human adiponectin, tumor necrosis factor-α, leptin and C reactive protein in serum were determined with ELX-800 enzyme-linked analyzer (BIOTEK) using an enzyme linked immunosorbent assay kit from Beijing Tianlai Med-Tech, Inc (adiponectin only) and Jingmei Biotech Co., Ltd.

Nutrition education description

Patients in the intervention group were educated based on "*Dietary Guidelines for Chinese Residents*" composed by Chinese Nutrition Society,[11] in which energy intake was recommended (according to age range and physical activity), and quantities and kinds of food for each energy intake level were suggested. The recommended energy intake for light activity was as follows: 2200 kcal for men, 1800 kcal for women under the age of 60, and 2000 kcal for men, 1600 kcal for women over 60. Quantities and food groups for each energy intake level are shown in Table 1.

Moreover, patients in the intervention group were advised to reduce sodium, simple sugar and fat intake (especially cooking oil and pork lard), increase the intake of whole grain (for example using corn or oat to replace refined rice), deep colored vegetables and fruits (the intake of colored vegetables and fruits should account for half of the total vegetables and fruits that they take). The recommended composition of the dietary regimen was as follows: carbohydrates, 55% to 60%; proteins, 12% to 15%; total fat, less than 30%; saturated fat, less than 10%; cholesterol consumption, less than 300 mg per day.

After two kick-off lectures held by a professor and a

Table 1. Recommended food intake for different energy level (g/d)[11]

Food group	1600 kcal	1800 kcal	2000 kcal	2200 kcal	2400 kcal
Grain	225	250	300	300	350
Soybean and nut	30	30	40	40	40
Vegetable	300	300	350	400	450
Fruit	200	200	300	300	400
Meat	50	50	50	75	75
Milk	300	300	300	300	300
Egg	25	25	25	50	50
Fish	50	50	75	75	75
Cooking oil	20	25	25	25	30
Salt	6	6	6	6	6

lecturer in Nutrition, patients in the intervention group were given an education lesson and a nutrition consultation once every month. There was one educator responsible for training. The educational material was validated by the corresponding author. The educator and her coworker conducted home interviews. Alternatively, they made phone calls or mailed the educational material if patients did not attend the class. For each education class, the educator met over 80% of the patients who did not drop out of the study.

Patients in the control group received instructions on choosing healthy food every four months but were not offered individualized consultation.

24-hour dietary recall interviews for 3 days including two weekdays and one weekend day were performed, both at the beginning of the study and at the end of the one year study period. Nutrient intakes from the dietary recalls were calculated using the SY Nutrients Analysis software programmed by the Fudan University Department of Nutrition, according to the Chinese food nutrients.[12]

Nutrition education was evaluated through a "knowledge, attitude and practice" (KAP) questionnaire, and physical activity survey was performed using translated "International Physical Activity Questionnaire-Short" (IPAQ-s). The questionnaires were performed both at baseline and one year [13,14] Knowledge section of KAP included 14 questions related to "what was the proper amount for cooking oil/salt intake", "food nutrition" and "impact of food/nutrition on health". Attitude section of KAP survey included "It is important to sustain a rational weight", "I can not change weight, as I am born fat or slim", "I can eat whatever I like", "Healthy lifestyle can prevent cardiovascular disease", "It is important for me to use rational amount of sugar", "Attitude towards consuming more vegetables and fruits", "Attitude towards reducing fat intake". Practice section was to know frequency of good dietary habits, such as "Intentionally control in using cooking oil, salt and sugar", "Consuming more fish/birds (like chicken or duck) to replace livestock meat", "Taking vegetables and fruits", "Avoid taking obvious fat", "Taking legumes and milk".

During the intervention, the importance of taking medication for hypertension on time was also addressed, patients were advised to see doctors if they had questions about medication. As there was a fairly high possibility that patients went to see doctors, those who made any changes in medications would be excluded in further evaluation.

Statistical analysis

Statistical analysis was performed using Stata 8.0 by Stata Co. Variables were presented as means±SD or others as stated. The Pearson chi-square test was used to test the male/female difference between the two groups. Wilcoxon rank sum test was used to test the age difference between groups. Linear mixed-effects model using the XTREG procedure in Stata software was fitted to test

Table 2. KAP and physical activity at baseline and one year

	Time point	Control group	Intervention group	Comparison between group *p* value	Change difference between group *p* value
KAP-knowledge, %					
Right answers	baseline	65.5±22.6	62.8±20.4	0.359	<0.001
	one year	66.7±20.8	76.1±15.6***	0.001	
Wrong answers	baseline	17.0±11.6	18.8±10.9	0.257	0.071
	one year	15.4±9.9	13.4±8.2***	0.198	
Reply as "not sure"	baseline	17.5±23.1	18.4±21.5	0.762	0.017
	one year	17.9±19.7	10.4±15.3***	0.012	
KAP-Attitude toward healthy diet, %					
Answers agree	baseline	68.6±21.1	67.6±21.3	0.854	0.175
	one year	72.0±20.5	76.6±17.4***	0.120	
Answers not agree	baseline	16.9±16.2	14.0±14.5	0.163	0.943
	one year	14.5±16.3	11.6±11.9	0.178	
Reply as "not sure"	baseline	14.5±14.5	18.4±15.6	0.096	0.059
	one year	13.5±14.6	11.8±12.7***	0.424	
KAP- Healthy diet practice, %					
Often	baseline	64.5±26.3	54.4±25.3	0.004	<0.001
	one year	65.4±19.9	69.1±22.0***	0.309	
Sometimes	baseline	20.1±19.2	24.6±20.6	0.123	0.078
	one year	20.1±16.6	17.7±17.8**	0.400	
Seldom	baseline	15.4±17.6	21.0±20.5	0.031	0.026
	one year	14.5±16.0	13.2±15.1***	0.634	
Physical activity, hours					
Vigorous activity/week	baseline	0.6±1.7	1.6±6.0	0.074	0.096
	one year	0.5±2.0	0.3±1.4**	0.748	
Moderate activity/week	baseline	2.9±5.3	3.0±6.3	0.668	0.926
	one year	2.4±3.8	2.9±6.5	0.594	
Walking/week	baseline	7.7±6.6	9.4±11.4	0.193	0.781
	one year	9.2±7.5	10.6±9.1	0.314	
Sitting/day	baseline	5.4±3.0	5.0±2.4	0.337	0.479
	one year	4.5±2.1*	4.4±2.2*	0.901	

* for *p* range when comparing the difference within group.* $p < 0.05$;** $p < 0.01$;*** $p < 0.001$

differences of change between groups. These models included random intercepts to accommodate the repeated measures gathered from each study participant as well as terms for the fixed effects of time, study group, and the interaction between time and study group. So, changes within each study group during the study, and the difference between groups at each time point were also tested by estimation of the parameter in linear mixed-effects model. Significance was defined at the level of $p<0.05$.

RESULTS

KAP and physical activity changes

Knowledge, attitude, and practice improved in the intervention group, as shown in Table 2. For knowledge in the

Table 3. Daily nutrients intakes at baseline and one year

Nutrient	Time point	Control group	Intervention group	Comparison between group *p* value	Change difference between group *p* value
Energy, kcal	baseline	1708±509	1609±472	0.119	<0.001
	one year	1712±464	1909±521***	0.002	
Fiber, g	baseline	7.6±10.8	7.4±6.0	0.820	0.078
	one year	7.6±5.0	9.6±5.6*	0.030	
Carbohydrate, g	baseline	207±72	194±73	0.185	<0.001
	one year	219±75	255±67***	<0.001	
Protein, g	baseline	57.6±23.8	49.4±23.4	0.006	<0.001
	one year	54.9±18.6	61.1±23.9***	0.037	
Fat, g	baseline	70.8±26.6	68.5±26.8	0.513	0.169
	one year	66.1±25.2	69.7±29.6	0.314	
Cholesterol, mg	baseline	218±158	207±227	0.671	0.160
	one year	213±170	251±237	0.153	
Saturated, g	baseline	14.6±7.4	13.9±7.2	0.485	0.112
	one year	13.4±6.6	14.7±8.5	0.204	
MUFA, g	baseline	23.6±10.8	20.5±10.9	0.029	0.062
	one year	20.7±10.5*	20.9±11.2	0.898	
PUFA, g	baseline	24.0±13.4	28.9±13.2	0.005	0.117
	one year	24.2±13.4	25.6±12.5*	0.408	
ω-6 PUFA, g	baseline	20.3±12.2	24.8±11.6	0.004	0.126
	one year	20.7±12.2	22.2±11.1	0.336	
ω-3 PUFA, g	baseline	2.1±2.2	2.9±2.2	0.003	0.054
	one year	1.7±1.9*	1.9±1.7***	0.401	
Vitamins					
Vitamin A, μgRE	baseline	313±505	207±227	0.027	<0.001
	one year	278±250	412±414***	0.006	
Vitamin B-1, mg	baseline	1.2±0.5	1.0±0.5	0.061	<0.001
	one year	1.2±0.5	1.4±0.5***	0.001	
Vitamin B-2, mg	baseline	0.7±0.4	0.6±0.3	0.011	0.003
	one year	0.7±0.3	0.8±0.5***	0.214	
Vitamin B-3, mg	baseline	13.1±7.0	10.8±6.9	0.007	<0.001
	one year	12.2±5.1	14.0±6.6***	0.029	
Vitamin C, mg	baseline	60.0±41.1	41.7±35.6	0.002	<0.001
	one year	61.9±43.0	77.4±52.5***	0.006	
Vitamin E, mg	baseline	33.9±21.2	42.5±19.9	0.001	0.098
	one year	32.5±21.6	36.0±16.3**	0.178	
Minerals					
Ca, mg	baseline	355±225	267±186	0.001	0.003
	one year	324±197	341±233**	0.546	
Fe, mg	baseline	14.5±29.2	12.4±11.4	0.377	0.011
	one year	11.7±6.4	18.1±16.5*	0.007	
Zn, mg	baseline	7.9±3.3	6.7±3.1	0.002	<0.001
	one year	7.4±2.5	8.4±3.1***	0.015	
Se, μg	baseline	37.4±30.5	39.8±38.9	0.561	0.244
	one year	35.7±22.5	43.8±33.8	0.051	
Cu, mg	baseline	1.4±0.5	1.3±0.6	0.092	<0.001
	one year	1.4±0.5	1.6±0.6***	0.002	
Mn, mg	baseline	4.0±3.1	3.5±1.9	0.112	<0.001
	one year	3.6±1.6	4.7±2.0***	<0.001	
Mg, mg	baseline	198±103	171±83	0.015	<0.001
	one year	188±66	215±81***	0.017	
Na, g	baseline	3.3±1.6	3.7±1.6	0.091	0.094
	one year	3.4±2.2	3.2±1.4*	0.497	
K, g	baseline	1.3±0.6	1.2±0.6	0.186	0.007
	one year	1.3±0.5	1.5±0.6***	0.057	

* for *p* range when comparing the difference within group.* p <0.05;** p <0.01;*** p <0.001. MUFA, mono-unsaturated fatty acid; PUFA, poly-unsaturated fatty acid

intervention group, right answers rate ($n_{\text{right answers}} \times 100\%/n_{\text{knowledge question}}$) increased from 62.8 to 76.1；wrong answers rate ($n_{\text{wrong answers}} \times 100\%/n_{\text{knowledge question}}$) decreased from 18.8 to 13.4；Reply as "not sure" rate ($n_{\text{answers as "not sure"}} \times 100\%/n_{\text{knowledge question}}$) decreased from 18.4 to 10.4. For attitude in the intervention group, answers as "agree" ($n_{\text{answers agreeing with healthy diet}} \times 100\%/n_{\text{attitude questions}}$) increased from 67.6 to 76.6, answers as "not sure" ($n_{\text{answers as "not sure"}} \times 100\%/n_{\text{attitude questions}}$) decreased from 18.4 to 11.8. Healthy dietary practice in the intervention group followed the positive changes in knowledge and attitude: ($n_{\text{answers as "often"}} \times 100\%/n_{\text{practice questions}}$) increased from 54.4 to 69.1. No changes in knowledge, attitude or practice were observed in the control group.

Physical activity changes were also shown as reported in Table 2. Sitting hours decreased similarly in both groups during the study, but no differences were observed between two groups.

Nutrients and diet structure changes

Nutrient intake analysis revealed that means of energy intake, fibers, carbohydrates and proteins increased significantly and were higher in the intervention group compared to that in the control group during one year period as shown in Table 3. PUFA, ω-3 PUFA decreased in the intervention group. ω-6 PUFA also decreased though it was not significant at $p<0.05$ level ($p=0.061$).

Vitamins (A, B-1, B-2, B-3, C) and minerals (Ca, Fe, Zn, Cu, Mn, Mg, K) intakes increased and were significantly higher in the intervention group than in the control group at the end of one year, with the exception of a significant decrease in vitamin E ($p=0.003$), and a modest decrease in Na ($p=0.037$) in the intervention group. Neither vitamin nor mineral intakes changed in the control group during study period.

Nutrients energy to total energy ratio and food to total energy ratio are shown in Table 4. Nutrients energy to total energy ratio was defined as $\text{energy}_{\text{nutrient}}$*100%/total energy intake. Thus, fat energy to total energy ratio was "energy from fat"*100%/"total energy intake". Food to total energy ratio was defined as $\text{energy}_{\text{certain food category}}$*100%/total energy intake. Thus, vegetable to total energy ratio was "energy from vegetable"*100%/ "total energy intake".

In one year study period, carbohydrates energy to total energy ratio increased and fat energy ratio decreased in two groups. However, the carbohydrate energy to total energy ratio was significantly higher and fat energy to total energy ratio was significantly lower in the intervention group than in the control group. The vegetable to total energy ratio and fruits to total energy ratio were significantly higher in the intervention group than they were in the control group. Other food (Table 4) was defined as a category of food other than grains, beans, vegetables, fruits, meats, fish, eggs and milk. The "other food" to total energy ratio decreased in the intervention group.

Changes of anthropometric and metabolic variables

Anthropometric, metabolic variables and medication status of metabolic syndrome patients at baseline and at end of one year were shown in Tables 5 and 6.

At baseline, no differences were observed between the two groups except for higher cholesterol levels in the control group. During the study, the total cholesterol decreased in the control group, but increased in the intervention group. However, the means of total cholesterol in both groups were lower than 5.2 mmol/L ($p<0.001$) at the end of one year.[15]

After one year of nutrition education, the BMI improved similarly in both groups. But significant differences in waist circumference and waist to hip ratio were observed between two groups. The following results are

Table 4. Dietary structure at baseline and one year

Nutrients to total energy ratio/Food to total energy ratio	Time point	Control group	Intervention group	Comparison between group *p* value	Change difference between group *p* value
Nutrients to total energy ratio					
Carbohydrate	baseline	48.4±9.5	48.3±11.4	0.946	0.040
	one year	51.1±10.2*	54.2±9.1***	0.015	
Protein	baseline	13.3±3.3	12.1±3.6	0.007	0.086
	one year	13.0±3.3	12.7±3.0	0.519	
Fat	baseline	37.8±9.5	38.6±10.3	0.495	0.026
	one year	34.9±8.8**	32.3±8.5***	0.033	
Food to total energy ratio					
Grain	baseline	46.5±12.5	47.1±13.8	0.708	0.677
	one year	49.1±12.6	50.6±12.7*	0.377	
Bean	baseline	3.1±5.1	2.5±4.8	0.361	0.595
	one year	3.2±6.6	2.1±4.4	0.100	
Vegetable	baseline	3.6±3.2	2.9±2.7	0.146	0.010
	one year	3.3±2.8	4.3±4.9**	0.040	
Fruits	baseline	1.4±2.1	1.0±2.0	0.285	0.004
	one year	1.9±2.7	2.6±2.7***	0.015	
Meat, fish, egg and milk	baseline	18.2±10.7	15.1±10.3	0.023	0.344
	one year	17.5±10.2	16.0±9.4	0.251	
Other food	baseline	27.2±11.5	31.3±12.9	0.008	0.019
	one year	24.9±11.5	24.4±10.7***	0.741	

* for *p* range when comparing the difference within group.* $p<0.05$;** $p<0.01$;*** $p<0.001$. Nutrients to total energy ratio was defined as $\text{energy}_{\text{nutrient}}$*100%/total energy intake. Food to total energy ratio was defined as $\text{energy}_{\text{certain food category}}$/total energy intake.

Table 5. Anthropometric, and metabolic variables at baseline and one year

Variables	Time point	Control group	Intervention group	Comparison between group *p* value	Change difference between group *p* value
Sex, male/female	--	41/79	34/81	0.449†	--
age	baseline	53±6	56±6	<0.001‡	--
BMI, kg/m^2	baseline	26.8±2.9	26.9±3.3	0.676	0.910
	one year	26.5±2.9**	26.7±3.2*	0.645	
Waist circumference, cm	baseline	93.9±7.5	92.7±7.9	0.198	0.004
	one year	91.7±7.6***	88.8±8.5***	0.005	
Waist to hip ratio	baseline	0.92±0.06	0.91±0.05	0.354	<0.001
	one year	0.92±0.06	0.89±0.06***	<0.001	
Blood pressure, mmHg					
Systolic	baseline	130±14	134±17	0.060	0.615
	one year	132±15	134±15	0.166	
Diastolic	baseline	86±9	88±9	0.204	0.491
	one year	86±9	88±9	0.048	
Glucose, mmol/L	baseline	5.6±1.8	5.3±1.7	0.120	0.683
	one year	5.5±1.6	5.1±1.4	0.064	
Insulin, μIU/L	baseline	11.7±5.2	11.7±7.6	0.920	0.501
	one year	12.8±8.2	12.2±7.0	0.528	
HOMA-IR	baseline	3.0±2.0	2.9±3.1	0.907	0.372
	one year	3.2±2.6	2.9±2.1	0.267	
Serum lipids, mmol/L					
Triglyceride	baseline	2.1±1.3	2.1±1.2	0.658	0.703
	one year	1.9±1.0**	1.7±1.2***	0.451	
Total cholesterol	baseline	5.6±1.0	4.4±1.0	<0.001	<0.001
	one year	4.9±0.9***	4.7±0.8***	0.162	
HDL-C	baseline	1.2±0.4	1.2±0.4	0.417	0.044
	one year	1.2±0.2	1.4±0.3**	0.001	

* for *p* range when comparing the difference within group.* p <0.05;** p <0.01;*** p <0.001. †Pearson χ^2 test. ‡ Wilcoxon rank sum test.
BMI, body mass index; HOMA-IR, homeostasis model assessment of insulin resistance; HDL-C, high density lipoprotein-cholesterol

Table 6. Medication status at baseline and one year

Variables	Control group		Intervention group	
	Baseline	One year	Baseline	One year
Medication -To control hypertension, no				
No treat	85	83	56	49
Irregular treat	7	5	9	4
Regular treat	28	32	50	62
Medication - To control diabetes, no				
No treat	105	102	101	97
Irregular treat	1	1	0	2
Regular treat	14	17	14	16
Medication - To control hyperlipidemia, no				
No treat	107	110	98	91
Irregular treat	0	0	0	0
Regular treat	13	10	17	24

given in mean ± Standard Error of the Mean. Changes in waist circumference were -3.9±0.3 and -2.3±0.4 cm for the intervention and control groups, respectively, and were significantly different between groups (p=0.004). Waist circumference at the end of one year was 88.8±0.8 cm for the intervention group and 91.7±0.7cm for the control (p=0.005). The improvement of waist to hip ratio was only found in the intervention group. Changes in waist to hip ratio were 0.02±0.00 and 0.01±0.00 for the intervention and control groups, respectively (p<0.001). Mean of waist to hip ratio was lower in the intervention group at the end of one year.

Both groups showed some improvement in TG, but mean of TG was still greater than 1.7 mmol/L in the control group (p=0.039), while not higher than 1.7 mmol/L in the intervention group (p=0.324) at one year. HDL-C increased only in the intervention group. This change was significantly different compared to the control group (p=0.044). Means of HDL-C at one year were 1.4 ±0.0 and 1.2±0.0 mmol/L for the intervention and control groups, respectively (p=0.001).

Adiponectin (1.A), leptin (1.B), tumor necrosis factor-α (1.C), and C reactive protein (1.D) at baseline and at the end of one year were shown in Figure 1. Mean adiponectin increased significantly from 4.1±0.3 to 5.3±0.4 ug/mL in the intervention group, and the change was significantly different compared to the control group (p=0.040). Leptin and tumor necrosis factor-α decreased in both groups. But the change of tumor necrosis factor-α in the intervention group was significantly different compared to that of the

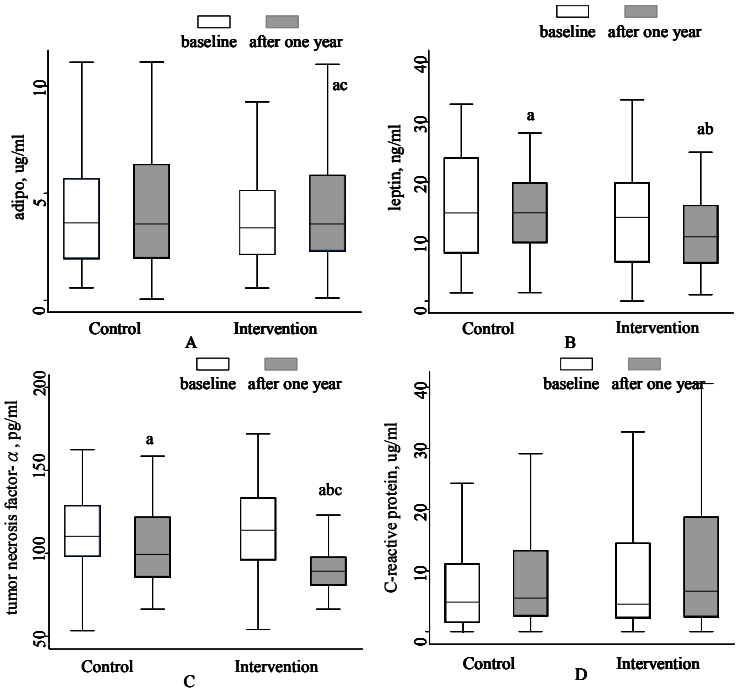

Figure 1. Comparison of adiponectin (A), leptin (B), tumor necrosis factor-α (C), C-reactive protein at baseline and after one year between groups. Note: Data shown in median, 25(75) percentile, smallest, and biggest adjacent value; n=120 in control group, n=115 in intervention group; a, significantly different for self comparison; b, significantly different for between group comparison; c, significantly different for between group comparison of change.

Table 7. Anthropometric, metabolic variables with medication changed patients excluded

Variables	Time point	Control group	Intervention group	Comparison between group *p* value	Change difference between group *p* value
Sex, male/female	--	35/68	23/51	0.685†	--
age	baseline	52±6	56±5	<0.001‡	--
BMI, kg/m^2	baseline	26.7±2.9	27.0±3.1	0.639	0.869
	one year	26.5±2.9*	26.7±3.0*	0.687	
Waist circumference, cm	baseline	93.9±7.9	92.4±7.6	0.211	0.001
	one year	91.9±7.6***	88.4±8.1***	0.003	
Waist to hip ratio	baseline	0.92±0.06	0.90±0.05	0.261	<0.001
	one year	0.92±0.06	0.89±0.06***	<0.001	
Blood pressure, mmHg					
Systolic	baseline	129±14	130±15	0.340	0.489
	one year	130±14	130±15	0.782	
Diastolic	baseline	86±9	87±9	0.383	0.721
	one year	85±9	87±10	0.216	
Glucose, mmol/L	baseline	5.5±1.7	5.4±1.7	0.637	0.193
	one year	5.4±1.5	5.1±1.1*	0.146	
Insulin, μIU/L	baseline	11.7±5.0	12.7±9.2	0.500	0.429
	one year	12.7±8.1	12.5±7.3	0.846	
HOMA-IR	baseline	2.9±2.0	3.3±3.8	0.508	0.239
	one year	3.1±2.6	2.8±2.0	0.489	
Serum lipids, mmol/L					
Triglyceride	baseline	2.1±1.2	2.0±1.2	0.450	0.330
	one year	1.9±1.0*	1.6±1.0***	0.119	
Total cholesterol	baseline	5.5±1.0	4.3±1.1	<0.001	<0.001
	one year	4.9±0.9***	4.6±0.8**	0.081	
HDL-C	baseline	1.2±0.4	1.2±0.4	0.332	0.343
	one year	1.2±0.2	1.3±0.3	0.028	
Adiponectin, ug/mL	baseline	4.8±3.7	4.2±2.9	0.283	0.176
	one year	4.9±4.3	5.2±4.2*	0.784	
Leptin, ng/mL	baseline	15.9±9.1	14.4±8.7	0.202	0.052
	one year	14.9±6.8	11.4±6.3***	0.003	
CRP, ug/mL	baseline	8.6±11.2	9.1±11.4	0.804	0.821
	one year	8.5±11.0	9.3±14.0	0.609	
TNF-α, pg/mL	baseline	112±23	117±30	0.171	<0.001
	one year	106±23*	90±13***	<0.001	

*for *p* range when comparing the difference within group.* p <0.05;** p <0.01;*** p <0.001. †Pearson χ^2 test. ‡ Wilcoxon rank sum test. BMI, body mass index; HOMA-IR, homeostasis model assessment of insulin resistance; HDL-C, high density lipoprotein-cholesterol; CRP, C-reactive protein; TNF-a, tumor necrosis factor-α

control group (p<0.001). Means of tumor necrosis factor-α (p<0.001) and leptin (p=0.001) in the intervention group at the end of the one year period were lower than they were in the control group.

Since there was a fairly high possibility that patients went to see doctors, those who made any change on medications were further excluded for evaluation. This exclusion did not affect the anthropometric and metabolic variables as shown in Table 7.

DISCUSSION

In this study, nutrition education guided by "*Dietary Guidelines for Chinese Residents*" improved the metabolic syndrome patients' health status. After intervention, the decrease of waist circumference, waist to hip ratio and tumor necrosis factor-α in the intervention group were significantly different compared to that of the control group. Similarly, the increase of high-density lipoprotein cholesterol, adiponectin in the intervention group were significantly different than that of the control group. Therefore, "*Dietary Guidelines for Chinese Residents*" education proved to be an effective strategy to improve the metabolic syndrome patients' health status.

Adiponectin was found to be inversely related to obesity and unequivocally associated with insulin resistance, and dyslipidaemia.[16,17] And the more the factors of metabolic syndrome are present in a patient, the lower the adiponectin levels.[18,19] Adiponectin is believed to have anti-inflammatory and antiatherogenic properties.[20-22] Increased adiponectin may help to reduce the inflammatory markers —the decrease of tumor necrosis factor-α was significantly different in the intervention group compared to the control group. Tumor necrosis factor -α was thought to play a major role in the pathophysiology of insulin resistance in rodents,[23] and had been proved to stimulate lipolysis.[24]

Leptin acted in the central nervous system and promoted weight loss by decreasing appetite and increasing energy expenditure.[25] However, plasma leptin is strongly correlated with tissue adiposity.[26] More stored TG resulted in greater production of leptin,[27] and the release of leptin was significantly increased when adipocytes were exposed to insulin and glucose.[28,29] Thus an assumption was postulated that there was a kind of leptin resistance, because these subjects despite high circulating levels of leptin remained obese.[30] At the end of one year, leptin was lower in the intervention group than in the control group, which may allow us to presume that leptin resistance was lower in the intervention group.

C-reactive protein is an acute-phase reactant that is synthesized in the liver and activates the classical pathway of complement through the immune system. C-reactive protein was found to be acutely elevated in stress, illnesses, infections, and vascular events like myocardial infarction and unstable angina.[31] However, C-reactive protein did not change in this study.

Nutrition education improved patients' knowledge, attitude in nutrition and their dietary behavior. The increase in energy, carbohydrate, protein, fiber, vitamins (except vitamin E) and minerals (except Na and Se) were significantly different in the intervention group compared to the control group. At the same time, PUFA, ω-6PUFA, vitamin E decreased in the intervention group, which may be explained by the decreased use of cooking oil. Corn oil, soy oil, peanut oil and polly seed oil are popular cooking oils in the Chinese market. These oils are rich in ω-6 PUFA. Decreased consumption of these oils lead to decreased consumption in PUFA and ω-6 PUFA, which has positive effects.[32] However, ω-3 PUFA consumption decreased as well.

In this study, metabolic syndrome patients might have under reported the food they actually consumed. The IPAQ-s survey showed that energy expenditure increased in both groups (sitting hours reduced) but there was no difference between groups both at baseline and at one year. The energy intake recorded by the 24h food record increased in the intervention group even though the decrease in waist circumference and of the waist to hip ratio were significantly different in the intervention group than in the control group. This violates the mass equivalence law at first sight, since weight loss would happen when energy intake is lower than energy expenditure.[33] It is not unusual that obese people under report food intake.[34] The data of this study suggested that metabolic syndrome patients in both groups under-reported their food intake at baseline, but not the intervention group at one year.

If under-report stayed in our study, the decrease of PUFA, ω-6PUFA, vitamin E in the intervention group would be greater. But the increase of energy, carbohydrate, protein, fiber, vitamins (except vitamin E) and minerals (except Na and Se) that are higher in the intervention group than in the control group would not be observed anymore. However, data of food to energy ratio and KAP survey allowed us to conclude that healthy dietary behavior persisted in the intervention group, and was significantly different compared to the control group.

To our knowledge, no studies investigated a specific diet in the treatment of metabolic syndrome patients in China. This study confirmed that "*Dietary Guidelines for Chinese Residents*" had beneficial effects on anthropometric, lipids, adipokines and inflammatory markers in patients with the metabolic syndrome.

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AUTHOR DISCLOSURES

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Original Article

Nutrition education guided by Dietary Guidelines for Chinese Residents on metabolic syndrome characteristics, adipokines and inflammatory markers

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以中国居民膳食指南为指导的营养教育对代谢综合征患者体征、脂肪因子及炎症因子影响的研究

目的：本研究探讨中国居民膳食指南是否对代谢综合征患者的体格、生化指标、脂肪因子以及炎症因子有改善作用。方法与步骤：通过多阶段抽样在上海市的两个城区筛选出代谢综合征患者 272 名。将筛选出的患者按照区域划分为对照组和干预组。在干预组进行为期一年的以“中国居民膳食指南”为指导方针的营养教育。结果：干预组营养相关知识，态度及行为均有改善。 与对照组比较，干预组钾摄入量、谷物供能比、蔬菜供能比、水果供能比上升，而钠摄入量和脂肪供能比下降(p<0.05)。同時，干预组腰围、腰臀比、高密度脂蛋白胆固醇、脂联素、瘦素及肿瘤坏死因子-α 均较对照组有所改善 (p<0.05)。干预组和对照组的腰围变化值分别为 -3.9±0.3 和 -2.3±0.4 cm，腰围变化值在两组间具有显著的统计学差异(p=0.004)。干预组腰围、腰臀比、瘦素和肿瘤坏死因子-α 低于对照组，高密度脂蛋白胆固醇高于对照组 (p<0.05)。结论：本研究证实“中国居民膳食指南”对代谢综合征患者的体格、血脂、脂肪因子及炎症因子均有改善作用。

關鍵字：代谢综合征、营养健康教育、 脂联素、 瘦素、肿瘤坏死因子-α