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Research Article

Work-Site Nutrition Education Decreases Metabolic Syndrome Factors

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Abstract

Metabolic syndrome is a crucial health issue for adults. Therefore, this study conducted an 8-week workplace nutrition education intervention to examine the effects of the intervention on metabolic syndrome factors associated with employees. A historical intervention was designed to recruit adults with a body mass index level of >22 and without any endocrine disorder from a community in Yilan, Taiwan. There were intervention and control groups. The intervention group (n = 158) was recruited between 2010 and 2012 and received an 8-week intervention, during which dietitians delivered a nutrition education session and a one-on-one dietary guidance session on a weekly basis. The age- and sex-matched control group (n = 34) was recruited between 2014 and 2015toanalyze the metabolic syndrome variables.After8-week nutrition education intervention, the intervention group experienced a significantly deeper reduction in the levels of metabolic syndrome factors than did the control group (P< 0.05). During the intervention period, the participants who had metabolic syndrome at baseline experienced more reduction in waist circumference, diastolic blood pressure, and blood lipid convention than did those without the syndrome (P< 0.01). Implementing an 8-week workplace nutrition education intervention by dietitians significantly reduces certain metabolic syndrome markers.

Keywords: Metabolic Syndrome; Nutrition Education; Work-Site

Abbreviations

BMI: Body Mass Index; DBP: Diastolic Blood Pressure; HDL-C: High-Density Lipoprotein-Cholesterol; LDL-C: Low-Density Lipoprotein-Cholesterol; SBP: Systolic Blood Pressure; TG: Triacylglycerol; WC: Waist Circumference

Introduction

Metabolic syndrome is a cluster of conditions include high blood pressure, abnormal blood sugar, and excess body fat around the waist, and increased cholesterol or triglyceride and also considered to be a primary risk factor for atherothrombotic complications [1]. The International Diabetes Federation estimated that one-quarter of the world's adult population have metabolic syndrome [1], which increases the risk of cardiovascular diseases, type 2 diabetes mellitus, and mortality [2-4]. A meta-analysis on 87 articles indicated that metabolic syndrome leads to a 2-fold increase in cardiovascular risk and a 1.5-fold increase in mortality risk [5].

The risk factors for metabolic syndrome include genetic background, diet, and sedentary lifestyle; diet and activity level are risk factors that can be changed [6]. Worksites are appropriate places for losing weight and reducing the risk of metabolic syndrome because most adults must work; at work, they develop social support, which is beneficial for weight control [7]. In 2009, the prevalence rate of metabolic syndrome among employees may reach 30% or more [8]. A meta-analysis report examined 22 studies and revealed that physical activity and dietary behavior interventions provided at work significantly reduced body weight and Body Mass Index (BMI) [9]. However, the report did not analyze the effects of nutrition education at work on metabolic syndrome; nevertheless, interventions on individuals' behaviors may result in more weight loss than do other types of interventions. A meta-analysis study indicated that a continuation of 4 weeks (or more) of lifestyle intervention significantly reduced body weight and glycosylated hemoglobin concentration; interventions administered by dietitians reduced body weight more effectively than did those by non dietitians [10].

Therefore, the present study employed an 8-week individualized nutrition education intervention in a workplace setting to change participants' lifestyles and examine its effects on their metabolic syndrome factors.

Materials and Methods

The participants of the present study were recruited from community residents in Yilan, Taiwan. We posted the advertisement to recruit participants. They were selected with the criteria of ≥ 18 years old and a BMI of ≥ 22. By contrast, those with a history of critical illness or having been diagnosed with at least one endocrine disorder that affects body weight, such as hypothyroidism, were excluded. All This study was registered at ClinicalTrials.gov and the National Clinical Trials number was CGH-LP 104002. This study, for which each participant provided written informed consent, was approved by the Institutional Review Board of Cathay General Hospital (Program number: OMCP-98-003, CT-P 100003, and CGH-LP104002).

For more clearly finding out the effect of nutrition education for decreasing metabolic syndrome factors, this study used historical intervention. A historical intervention was conducted from 2010 to 2012, during which 60 workers were recruited each summer as the

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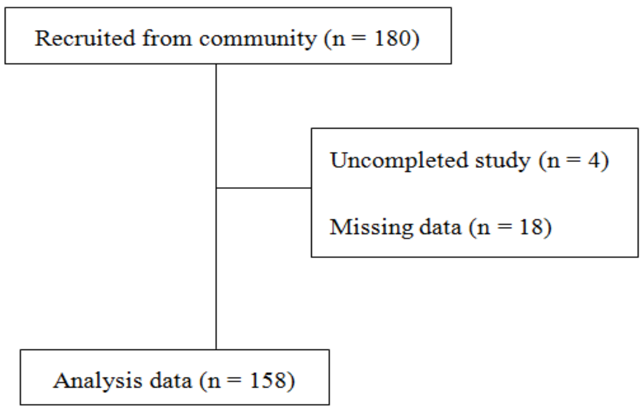

Figure 1: Flowchart of participants through the study.

intervention group through the Internet. Specifically, the first 10 workers who met the inclusion criteria were recruited from each of 6 work places, a total of 60 workers. Flowchart of participants through the study was shown in Figure 1. Eight weeks of intervention was administered, during which dietitians visited the worksites of the intervention group once a week to deliver a nutrition education session and provide dietary advice for each participant. The sessions were organized in the form of talks; each lasted 45-55 minutes. Table 1 lists the content of these talks, the content was decided according to the workbook published by Taiwan government for lose weight [11]. After each session, the dietitian provided one-on-one dietary guidance (which lasted 15-20 minutes) to each participant and offered them dietary advice according to the actual conditions they experienced. The control group was recruited between 2014 and 2015 from Lotung Poh-Ai Hospital. The members of the 2 groups were met the same criteria and paired according to sex and age. After excluding participants with any missing data, a total of 32 working adults were recruited for control group. During the 8-week intervention period, no dietary interventions or guidance were administered to them; however, body weight and biochemical data were collected at Weeks 0 and 8.

This study developed the questionnaire to collect sex, age, and disease history data in the baseline period. Besides, after an 8-hour fasting period, body height, body weight, body fat, waist circumference, blood pressure, and blood sample were collected at the same day during the baseline period, Week 8, and Week 14. Body weight was measured using a calibrated mechanical weight scale, and body height was measured using a stadiometer. The height and weight were measured to calculate BMI. The standard of the Ministry of Health and Welfare in Taiwan was adopted to classify the participants as normal-weight ($22 < BMI \le 24$ kg/m^2), overweight ($24 < BMI \le 27$ kg/m^2), and obese (27 kg/m^2 < BMI) [12]. Waist circumference was measured in the middle of the last rib and the highest of the ilium [13]. Body fat was measured by body composition monitor (TBF-300GS, TANITA, Tokyo, Japan). Before measuring blood pressure, participants must be calm and sit for 5 minutes. Blood pressure including systolic blood pressure and diastolic blood pressure were measured by blood pressure monitor.

Blood samples were analyze their level of serum Triacylglycerol (TG), serum total cholesterol, serum High-Density Lipoprotein-Cholesterol (HDL-C), serum low-density lipoprotein-cholesterol (LDL-C), blood sugar, and uric acid concentration. All blood measurement was determined with standard diagnostic methods (Roche, c501). Serum TG was determined with Wahlefeld method. Serum total cholesterol, HDL-C, and LDL-C were determined with the Homogeneous methods. Fasting blood sugar was determined with hexokinase.

The criteria of the National Cholesterol Education Program, Adult Treatment Panel III (NCEP, ATP III) were adopted to determine whether the participants had metabolic syndrome; the conventional ATP III waist circumference threshold had been modified to meet the standard of the Ministry of Health and Welfare. The participants who met at least 3 of the ATP III criteria were identified as having metabolic syndrome: central obesity (waist circumference for man ≥90 cm and for woman ≥80), low serum HDL-C (male *vs.* female: <40 mg/dL *vs.*<50 mg/dL), serum TG ≥150 mg/dL, fasting blood sugar ≥100 mg/dL, Systolic Blood Pressure (SBP) ≥130 mmHg, and Diastolic Blood Pressure (DBP) ≥85 mmHg [14].

SAS and SPSS statistical packages were employed for analysis; the results are displayed in mean ± standard deviation, 95% Confidence Interval (CI), or n (%). Categorical variables were analyzed using chi-squared testing. Continuous variables were analyzed with a Shapiro-Wilk test for normal distributions. If the normal distribution of a continuous variable was verified, t-testing was performed to compare group performance or to identify the differences observed during and after the intervention. In case of non normal distribution, the continuous variables were analyzed with a Wilcoxon rank sum test. After the intervention group members were classified according to whether they had metabolic syndrome; either t-testing or a Wilcoxon rank sum test was adopted to identify the differences observed during and after the intervention and to compare group performance. Because the mortality was higher in adults with more metabolic syndrome factors [15], this study used the combination between metabolic dysfunctions to classify participants in intervention group rather than the sum of each metabolic abnormality alone. A two-tailed p value of < 0.05 was considered statistically significant.

Results

As shown in Table 2, data were collected from a total of 158 participants in the intervention group, who were mostly female (113, 72% of the total group) and aged 40.6 ± 10.3 years on average. Other 22 participants did not complete the study or had at least one missing data of indicator of metabolic syndrome. The control group data were obtained from 34 participants, among whom 71% were female and the average age was 43.9 ± 7.7 years. The baseline data between the different sexes of both groups were then compared (see Tables S1 and S2). In the intervention group, significant between-sex differences were observed in all obesity and metabolic syndrome-related variables, except for serum total cholesterol and serum TG. In the control group, significant between-sex differences were detected in waist circumference, body fat, serum HDL-C, and serum TG. Therefore, sex was used as the correction factor when comparing group performance to identify the effects of the employed nutrition education intervention.

Compared with the control group, the intervention group was observed to have significantly higher levels of BMI (27.1 ± 4.3 *vs* 25.4

Table 1: Content of classes.

Weeks	Content
1	Things that you must know during the weight reduction study period
2	Daily individual calorie requirement: what are the main food groups?
3	How to record the daily diet after the weight reduction program
4	Food serving size and replacement
5	The principles of eating out
6	Physical activity advice (delivered with health education flyers to the participants)

Table 2: Baseline data between different groups (mean ± SD or *n* (%)).

Variables	Intervention (*n* = 158)	Control (*n* = 34)
Male (n [%])	45 [28%]	10 [29%]
Age (years)	40.6 ± 10.3	43.9 ± 7.7
BMI (kg/m^2)	27.1 ± 4.3	25.4 ± 3.2*
Waist circumference (cm)	88.1 ± 12.4	84.3 ± 8.8*
Body fat (%)	34.8 ± 6.8	31.4 ± 5.9*
SBP (mmHg)	126.4 ± 17.0	124.0 ± 15.1
DBP (mmHg)	82.5 ± 14.4	76.0 ± 11.0*
Fasting blood sugar (mg/dL)	94.0 ± 13.4	96.1 ± 10.1
Serum total cholesterol (mg/dL)	190.9 ± 36.6	216.5 ± 26.9*
Serum HDL-C (mg/dL)	45.5 ± 12.3	52.9 ± 14.5*
Serum LDL-C (mg/dL)	123.3 ± 30.5	153.4 ± 23.0
Serum TG (mg/dL)	110.6 ± 70.9	130.4 ± 52.3*
BMI 24-27 (n [%])	53 [34%]	12 [35%]
BMI > 27 (n [%])	55 [35%]	9 [26%]
Central obesity (n [%])[a)]	109 [69%]	13 [38%]
SBP ≥130 mmHg (n [%])	74 [47%]	9 [26%]
DBP ≥85 mmHg (n [%])	57 [36%]	8 [24%]
Fasting blood sugar ≥100 mg/dL (n [%])	36 [23%]	8 [24%]
Low serum HDL-C (n [%])[b]	98 [62%]	8 [24%]*
Serum LDL-C ≥100 mg/dL (n [%])	127 [80%]	34 [100%]*
Serum TG ≥150 mg/dL (n [%])	33 [21%]	11 [33%]
Metabolic syndrome (n (%))	79 [50%]	11 [32%]

[a] Central obesity: the waist circumference for man ≥90 cm and for woman ≥80.
[b] Low serum HDL-C: HDL-C for man <40 mg/dL and for woman <50 mg/dL
*Significant difference between the intervention group and control group and calculated by chi-square test and t-test.
BMI: Body Mass Index; DBP: Diastolic Blood Pressure; HDL-C: High Density Lipoprotein Cholesterol; LDL-C: Low Density Lipoprotein Cholesterol; SBP: Systolic Blood Pressure; TG: Triglyceride; WC: Waist Circumference.

± 3.2 kg/m^2), waist circumference (88.1 ± 12.4 *vs* 84.3 ± 8.8 cm), and body fat (34.8 ± 6.8 *vs* 31.4 ± 5.9%) (P<0.05), as well as significantly lower levels of serum total cholesterol (190.9 ± 36.6 *vs* 216.5 ± 26.9 mg/dL), serum HDL-C (45.5 ± 12.3 *vs* 52.9 ± 14.5 mg/dL), and serum TG (110.6 ± 70.9 *vs* 130.4 ± 52.3 mg/dL) (P <0.05). However, no significant differences in the proportion of overweight and obese participants were found between both groups.

Table 3 displays the changes of metabolic syndrome markers in both groups on Week 8 of the intervention. On average, the intervention group experienced decreases in BMI by 1.4 kg/m^2 (95% CI: 1.3-1.6), waist circumference by 5.4 cm (95% CI: 4.9-6.0), body fat by 3.3% (95% CI: 2.8-3.9%), SBP by 7.9 mmHg (95% CI: 5.8-10.0 mmHg), DBP by 5.2 mmHg (95% CI: 2.9-7.4 mmHg), fasting blood sugar by 1.9 mg/dL (95%CI: 0.4-3.5 mg/dL), serum TG by 16.3 mg/dL (95% CI: 7.6–25 mg/dL), serum LDL-C by 6.7 mg/dL (95% CI: 3.6-9.8 mg/dL), and serum HDL-C by 3.2 mg/dL (95% CI: 2.2-4.1 mg/dL). All of the differences reached statistical significance (P< 0.05). By contrast, the control group did not exhibit significant changes in these variables, except for fasting blood sugar, which rose significantly from 96.1 ± 10.5 to 100.1 ± 10.2 mg/dL (P < 0.05). A comparison of the changes in metabolic syndrome markers during the intervention between both groups revealed that except for serum TG, the levels of differences in all variables among the intervention group were significantly higher than those among the control group (P< 0.05). The sex-corrected results also indicated significant between-group differences in the changes of BMI, waist circumference, body fat, DBP, serum HDL-C, and serum LDL-C (P< 0.05).

A further classification of the intervention group by whether they had metabolic syndrome is presented in Table 4, which reveals that the participants who were classified as having metabolic syndrome exhibited significantly higher levels of BMI, waist circumference, SBP, DBP, serum HDL-C, serum LDL-C, and serum TG (P< 0.05) than did those not classified as having metabolic syndrome. The 8-week intervention resulted in significant reductions in the levels of all variables or influence factors in both groups (P< 0.05), except for the non significant reduction of fasting blood sugar observed in the participants without metabolic syndrome. After the effect of sex had been corrected, a comparison of the differences in all variables during the 8-week intervention revealed significantly lower levels of all obesity and metabolic syndrome markers in the participants with metabolic syndrome, except for serum LDL-C.

Discussion

The results of this study determined that the metabolic syndrome factors of the intervention group were significantly reduced though the dietitian-delivered nutrition education intervention over an 8-week period, during which weekly group sessions were provided along with an one-on-one dietary guidance session after each group session. Specifically, their levels of BMI, waist circumference, blood pressure, blood sugar, and serum lipid were reduced significantly. Compared with the intervention group participants classified as having metabolic syndrome at the baseline period, those who were classified as not having the syndrome were observed to have deeper reductions in BMI, waist circumference, DBP, and serum lipid at Week 8 of the intervention.

Obesity is one of the primary risk factors contributing to metabolic syndrome. A crucial strategy for lowering the risk of developing metabolic syndrome is to reduce body weight and waist circumference [16]. In the present study, delivering nutrition education, which included guidance regarding dietary habits and physical activity, in workplace significantly reduced the participants' body weight, BMI, and waist circumference. This result conforms to the findings of previous studies. A 2011 meta-analysis report on 22 studies published in 1980-2009 revealed that conducting a workplace intervention regarding dietary behaviors or physical activity or both significantly lowered the body weight, BMI level, and body fat of

Table 3: Changes of metabolic syndrome markers during intervention duration (mean ± SD or mean (95% CI)).

Variables	Intervention group			Control group			P value[a]	
	Week 0	Week 8	Difference	Week 0	Week 8	Difference	Unadjusted	Adjusted
BMI (kg/m^2)	27.1 ± 4.3	25.7 ± 4.1*	-1.4 (-1.6, -1.3)	25.4 ± 3.2	25.5 ± 3.3	0.1 (-0.2, 0.3)	<0.01	0.02
WC (cm)	88.1 ± 12.4	82.7 ± 11.9*	-5.4 (-6.0, -4.9)	84.3 ± 8.8	84.6 ± 8.8	0.3 (-0.8, 1.4)	<0.01	0.04
Body fat (%)	34.8 ± 6.8	31.5 ± 6.3*	-3.3 (-3.9, -2.8)	314 ± 5.9	31.8 ± 6.0	0.4 (-0.4, 1.2)	<0.01	<0.01
SBP (mmHg)	126.4 ± 17.0	118.5 ± 18.0*	-7.9 (-10.0, -5.8)	124.0 ± 15.1	125.2 ± 13.9	1.3 (-1.9, 4.4)	<0.01	0.41
DBP (mmHg)	82.5 ± 14.4	77.3 ± 12.1*	-5.2 (-7.4, -2.9)	76.0 ± 11.0	77.8 ± 13.9	1.8 (-1.0, 4.6)	<0.01	0.01
Fasting blood sugar (mg/dL)	94.0 ± 13.4	92.1 ± 11.0*	-1.9 (-3.5, -0.4)	96.1 ± 10.1	100.1 ± 10.2*	3.9 (1.4, 6.5)	<0.01	0.39
Serum total cholesterol (mg/dL)	190.9 ± 36.6	177.9 ± 33.5*	-13.1 (-16.8, -9.4)	216.5 ± 26.9	223.3 ± 30.7	6.8 (-0.7, 14.2)	<0.01	<0.01
Serum HDL-C (mg/dL)	45.5 ± 12.3	42.4 ± 12.8*	-3.2 (-4.1, -2.2)	52.9 ± 14.5	55.4 ± 13.0	2.6 (-0.4, 5.5)	<0.01	<0.01
Serum LDL-C (mg/dL)	123.3 ± 30.5	116.6 ± 28.6*	-6.7 (-9.8, -3.6)	153.4 ± 23.0	155.1 ± 28.7	1.6 (-4.8, 8.1)	0.02	<0.01
Serum TG (mg/dL)	110.6 ± 70.9	94.7 ± 59.8*	-16.3 (-25.0, -7.6)	130.4 ± 52.3	129.2 ± 60.4	-1.1 (15.5, 13.2)	0.07	0.13

[a] The difference in difference between intervention group and control group, and the adjusted model was the results adjusted by sex.
*Significant difference between the value in week 0 and week 8 in the same group and calculated by paired t-test (p<0.05).
BMI: Body Mass Index; DBP: Diastolic Blood Pressure; HDL-C: High Density Lipoprotein Cholesterol; LDL-C: Low Density Lipoprotein Cholesterol; SBP: Systolic Blood Pressure; TG: Triglyceride; WC: Waist Circumference.

Table 4: Changes of BMI and metabolic syndrome markers during intervention duration divided by different body sizes (mean ± SD) [a].

	With metabolic syndrome (n = 71)			Without metabolic syndrome (n = 87)			P value[b]	
	Week 0	Week 8	d	Week 0	Week 8	d	Unadjusted	Adjusted
BMI (kg/m^2)	29.30 ± 4.36	27.81 ± 4.17	-5.78 ± 3.41*	25.38 ± 3.44	24.05 ± 3.21	-5.14 ± 3.31*	0.23	<0.01
WC (cm)	95.47 ± 11.83	89.69 ± 11.96	-3.39 ± 4.54*	82.15 ± 9.34	77.01 ± 8.34	-3.29 ± 2.89*	0.88	<0.01
SBP (mmHg)	135.10 ± 17.11	124.20 ± 20.82	-10.96 ± 15.27*	119.30 ± 13.18	114.00 ± 13.79	-5.39 ± 11.39*	0.01	<0.01
DBP (mmHg)	89.85 ± 13.90	83.13 ± 12.93	-6.72 ± 18.30*	76.45 ± 11.81	72.54 ± 8.90	-3.90 ± 9.44*	0.24	<0.01
Fasting blood sugar (mg/dL)	100.20 ± 16.44	96.48 ±13.54	-3.76 ± 11.89*	88.94 ± 7.06	88.52 ± 6.49	-0.42 ± 7.53	0.04	<0.01
Serum HDL-C (mg/dL)	39.38 ± 7.86	36.79 ± 8.00	-2.59 ± 5.31*	50.53 ± 12.96	46.91 ± 14.12	-3.62 ± 6.64*	0.29	<0.01
Serum LDL-C (mg/dL)	129.00 ± 31.53	122.20 ± 31.00	-6.83 ± 22.06*	118.60 ± 28.94	112.00 ± 25.79	-6.66 ± 17.77*	0.96	0.11
Serum TG (mg/dL)	151.50 ± 60.35	125.90 ± 70.79	-26.61 ± 74.80*	77.87 ± 33.49	69.99 ± 32.87	-7.89 ± 29.78*	0.05	<0.01

[a] All value in week 0 and week 8 were significant difference between subjects with metabolic syndrome and subjects without metabolic syndrome.
[b] The difference between subjects with metabolic syndrome and subjects without metabolic syndrome was calculated by t-test, and the adjusted model was the results adjusted by sex.
*Significant difference between the value in week 0 and week 8 in the same group and calculated by paired t-test (p<0.05).
BMI: Body Mass Index; DBP: Diastolic Blood Pressure; HDL-C: High Density Lipoprotein Cholesterol; LDL-C: Low Density Lipoprotein Cholesterol; SBP: Systolic Blood Pressure; TG: Triglyceride; WC: Waist Circumference.

the participants by 1.19 kg, 0.34 kg/m^2, and 1.12 % [13]. However, these study results only represented the scenario of providing an intervention for both dietary behaviors and physical activity. The results of the present study confirmed that, compared with the interventions administered in the aforementioned meta-analysis reports, dietitian-delivered nutrition education was more effective in inducing favorable outcomes of lifestyle change (i.e., by lowering BMI, body fat, and waist circumference by 1.4 kg/m^2, 3.3%, and 5.4 cm, respectively).

Central obesity (excessive abdominal fat) and insulin resistance are the critical component of metabolic syndrome; they tend to cause blood sugar abnormities. The National Health and Nutrition Examination Survey suggested that, compared with adults in the United States in 1999-2000, those in 2009-2010 were observed with significantly lower prevalence rates of metabolic syndrome, hypo-HDL-C-cholesterolemia and hypertension; however, the prevalence rates of hyperglycemia and central obesity were significantly increased among US adults [17]. Changing lifestyles can effectively reduce central obesity and fasting blood sugar [18], thereby reducing the possibility of blood sugar level exceeding the standard threshold (for people with pre-diabetes) and lowering the risk of developing diabetes mellitus and cardiovascular diseases [19]. Employing dietitians to offer guidance for lifestyle change is a more cost-effective method for reducing body weight; this method leads to favorable outcomes of body weight loss [10]. For employees who work in offices, the workplace is an appropriate location for implementing weight loss measures. For instance, peers at the workplace can participate in weight loss interventions together to increase both the motivation for losing body weight and the probability of success [7]. By conducting the same intervention model for consecutive 3 years, the present study confirms that the employed model is feasible and can serve as an adequate method to conduct dietitian-delivered intervention for eliminating central obesity and metabolic syndrome factors.

Changes to dietary habits can reduce body weight, blood pressure, blood sugar, serum TG, and serum LDL-C, particularly for overweight and obese people [20-22]. The present study revealed that, during the weight loss process, the overweight and obese participants experienced significant reductions in both blood pressure and blood lipid levels. This result agrees with the findings of previous studies. For instance, delivering a 4-month nutrition education intervention at workplace to male employees significantly reduced their body weight, BMI, fasting blood sugar, serum LDL-C [23]. Earnest et al. administered a 10-week program for type 2 diabetes mellitus prevention to over 3,000 voluntary participants. The program included changing the participants' dietary habits. The outcomes of the program indicated that the participants exhibited significantly lowered levels of body weight, waist circumference, blood sugar, and blood pressure after the intervention [24]. Although this program was targeted at preventing type 2 diabetes mellitus, it was delivered by case managers, rather than professional dietitians. Dietary pattern is a critical factor affecting the development of metabolic syndrome. Dietitians who have received professional training can deliver adequate nutrition education and dietary plans. The program employed by the present study was delivered by registered dietitians, who were requested to offer professional nutrition education and individualized dietary plans. The results of the present study revealed that the intervention significantly reduced certain metabolic syndrome factors (i.e., waist circumference, blood pressure, fasting blood sugar, and serum TG) and the level of serum LDL-C. After the effect of sex had been corrected, deeper reductions in these markers were detected, particularly among the participants who had been classified as having metabolic syndrome at the baseline period. This outcome was expected because it matches those of previous studies [25]. For instance, significant between-sex differences were observed in 1,711 patients with metabolic syndrome who received a three-year intervention that involved lifestyle guidance [26]. The possible mechanisms behind the relationship between metabolic syndrome and cardiovascular disease were associated with the effects of estrogen and testosterone on blood sugar, blood lipid concentration, and insulin resistance [27], thus leading to significant between-sex differences.

The primary limitations of the present study were the fact that it did not adopt a randomized control trial as the research design and that significantly lower BMI and DBP levels and significantly higher serum HDL-C levels were observed in the control group than in the intervention group at the baseline period. The results of the present study indicated that, when the intervention group was further divided into subgroups by their baseline BMI levels, all subgroups experienced significantly lowered BMI and waist circumference levels after the intervention; this reduction was observed in even those whose BMI levels fell within the normal range. Only 158 participants completed the program; this number is quite small. Therefore, large-scale longitudinal studies with adequate research designs must be conducted in the future to confirm the effects of a dietician-delivered workplace intervention for changing lifestyles related to metabolic syndrome among employees. In addition, the present study observed that the 8-week intervention significantly lowered the average level of serum HDL-C, a phenomenon that occurred for unclear reasons. This phenomenon may be attributed to the significant reduction in serum total cholesterol (which fell from 190.9 ± 36.6 to 177.9 ± 33.5 mg/dL). This particular finding do not conform to those of previous studies, which have asserted that reductions in body weight [28] and serum TG concentration [29] are associated with increases in serum HDL-C. The possible mechanisms identified by this study must be verified by further studies.

Table S1: The baseline data between different sex in intervention group[1].

Variables	Male (n = 45)	Female (n = 113)	P value[2]
Age (years)	38.6 ± 11.0	41.4 ± 9.9	0.12
BMI (kg/m²)	29.7 ± 4.2	26.1 ± 4.0	<0.01
Waist circumference (cm)	99.4 ± 11.0	83.6 ± 9.9	<0.01
Body fat (%)	30.3 ±5.9	36.6 ± 6.4	<0.01
SBP (mmHg)	133.4 ± 11.7	123.7 ± 18.0	<0.01
DBP (mmHg)	80.0 ± 12.1	80.2 ± 14.7	<0.01
Fasting blood sugar (mg/dL)	97.4 ± 13.9	92.7 ± 13.0	0.04
Serum total cholesterol (mg/dL)	195.6 ± 35.7	189.1 ± 37.0	0.31
Serum LDL-C (mg/dL)	130.9 ± 24.1	120.3 ± 32.3	0.03
Serum HDL-C (mg/dL)	39.0 ± 7.6	48.1 ± 12.8	<0.01
Serum TG (mg/dL)	130.0 ± 83.4	103.4 ± 63.5	0.06

BMI: Body Mass Index; DBP: Diastolic Blood Pressure; HDL-C: High Density Lipoprotein Cholesterol; LDL-C: Low Density Lipoprotein Cholesterol; SBP: Systolic Blood Pressure; TG: Triglyceride; WC: Waist Circumference.
[1]Presenting as mean ± stand deviation or n (%)
[2]P value is the difference in difference between intervention group and control group, and calculated by t-test

Table S2: The baseline data between different sex in control group[1].

Variables	Male (n = 10)	Female (n = 24)	p value[2]
Age (years)	39.6 ± 7.9	45.6 ± 7.1	0.02
BMI (kg/m²)	25.9 ± 2.2	25.3 ± 3.6	0.38
Waist circumference (cm)	90.0 ± 8.1	81.9 ± 8.2	<0.01
Body fat (%)	26.3 ± 4.7	33.5 ± 5.1	<0.01
SBP (mmHg)	125.3 ± 6.7	124.3 ± 17.5	0.88
DBP (mmHg)	80.6 ± 6.9	74.1 ± 12.0	0.15
Fasting blood sugar (mg/dL)	97.4 ± 13.7	95.6 ± 8.5	0.91
Serum total cholesterol (mg/dL)	209.5 ± 30.6	219.5 ± 25.4	0.34
Serum LDL-C (mg/dL)	152.4 ± 26.6	153.9 ± 21.9	0.58
Serum HDL-C (mg/dL)	42.8 ± 10.3	57.0 ± 14.1	<0.01
Serum TG (mg/dL)	157.5 ± 48.3	119.0 ± 50.6	0.04

BMI: Body Mass Index; DBP: Diastolic Blood Pressure; HDL-C: High Density Lipoprotein Cholesterol; LDL-C: Low Density Lipoprotein Cholesterol; SBP: Systolic Blood Pressure; TG: Triglyceride; WC: Waist Circumference.
[1]Presenting as mean ± stand deviation or n (%).
[2]P value is the difference in difference between intervention group and control group, and calculated by Wilcoxon rank sum test.

Conclusion

In summary, this study observed that adopting 8 weeks of a dietitian-delivered workplace intervention, which included a group session and one-on-one dietary guidance session on a weekly basis, significantly reduced employees' body weight, metabolic syndrome factors, and serum LDL-C. The intervention was effective particularly for the participants with metabolic syndrome.

Supplementary Materials

Table S1. The baseline data between different sex in intervention group.

Table S2. The baseline data between different sex in control group.

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Authors' Contributions

Conceptualization: HCC, TSW, and LWD; Methodology, Investigation, and Data curation: HCC and TSW; Formal analysis: PYW, HCC and TSW; Writing-original draft preparation: PYW; Writing- review & editing and Project administration: PYW, HCC, TSW, LWD, TVD, SHY; Supervision: SHY. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

Before this study was conducted, it was approved by the Institutional Review Board of Cathay General Hospital (Program number: OMCP-98-003, CT-P 100003, and CGH-LP104002). Each participant provided written informed consent, and then they took part in this study. All participants were assigned a number to protect their identity. All records were labeled using codes.

Availability of Data and Materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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