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The effects of a nurse-led lifestyle intervention program on cardiovascular risk, self-efficacy and health promoting behaviours among patients with metabolic syndrome: Randomized controlled trial ☆

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ABSTRACT

Background: Metabolic syndrome is a cluster of cardio-metabolic risk factors and a major burden for public health due to its increasing prevalence and adverse effects on cardiovascular health. Lifestyle modification is the first-line intervention for metabolic syndrome management. However, adopting healthy behaviours is challenging among patients with metabolic syndrome.
Objective: To examine the effects of a nurse-led lifestyle intervention program on cardiovascular risks, self-efficacy and the implementation of health promoting behaviours.
Design: A two-armed randomized controlled trial.
Settings and Participants: A total of 173 patients that satisfied the metabolic syndrome definition of International Diabetes Federation was recruited from a hospital in North China.
Methods: The participants were randomly assigned to either attend the lifestyle interventions ($n = 86$) or receive usual care from the study hospital ($n = 87$). The lifestyle intervention followed the framework of Health Promotion Model and consisted of one face-to-face education session (30–40 min), one educational booklet and six telephone follow-ups (bi-weekly, 20–30 min per call) in three months. The Framingham 10-year risk score was calculated to measure the participants' cardiovascular risks at baseline and 3-month. The Self-rated Abilities for Health Practices and Health Promoting Lifestyle Profile II was employed to measure the self-efficacy and health promoting behaviours at baseline, 1-month, and 3-month. The generalized estimating equation model was employed to examine the effects of the lifestyle intervention program.
Results: No difference was detected in the baseline characteristics between the two groups. Decreased cardiovascular risk was found in the lifestyle intervention group, but no significant group-by-time effect was detected. The self-efficacy for nutrition, stress dimension and sum score of health promoting behaviours revealed significant improvements at 1-month (all $p < 0.05$). Significant improvements were also detected in all subscales, total scale of self-efficacy, all dimensions and the sum score of health promoting behaviours at 3-month (all $p < 0.05$).
Conclusions: The nurse-led Health Promotion Model guided lifestyle intervention program effectively improved the self-efficacy and implementation of health promoting behaviours in patients with metabolic syndrome. We recommend that nurses apply lifestyle interventions in routine care for patients with metabolic syndrome.

☆ The study was registered in Chinese Clinical Trail Registry (ChiCTR-IPR-14005303).

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Tweetable abstract: The RCT revealed that nurse-led lifestyle intervention was effective to improve self-efficacy and healthy behaviours among 173 MetS patients.

What is already known about the topic?

- The adoption of health promoting behaviours is challenging in metabolic syndrome management.
- Few studies examined the outcomes of general cardiovascular risk or self-efficacy in metabolic syndrome management.
- The effects of a nurse-led theory-guided lifestyle intervention program on general cardiovascular risk, self-efficacy and health promoting behaviours among patients with metabolic syndrome remain largely unknown.

What this paper adds

- The nurse-led, Health Promotion Model-guided lifestyle intervention program did not significantly reduce cardiovascular risk among patients with metabolic syndrome in three months.
- The lifestyle intervention program effectively improved the self-efficacy and implementation of health promoting behaviours of patients with metabolic syndrome in three months.
- The nurse-led, Health Promotion Model-guided lifestyle intervention program was convenient for clinical application and should be incorporated into routine practice for patients with metabolic syndrome.

1. Introduction

Lifestyle is closely related with various metabolic and cardiovascular diseases, such as coronary heart disease, type 2 diabetes and metabolic syndrome (Larsen et al., 2018). Metabolic syndrome is characterised by the co-existence of central obesity, high blood pressure, hyperglycaemia and dyslipidaemia (International Diabetes Federation, 2006). With increase in physical inactivity and obesity worldwide, metabolic syndrome has become a global epidemic (Saklayen, 2018). In China, the prevalence of metabolic syndrome increased from 8.8% in 1991–1995 to 29.3% in 2011–2015, and has been continuously increasing (Huang et al., 2018b). Consistent with the adverse consequences of unhealthy lifestyles, metabolic syndrome increases individuals' risks for cardiovascular diseases, diabetes, cancer and even death (Huang et al., 2018a; Ju et al., 2017; Mottillo et al., 2010). Therefore, metabolic syndrome has represented a major burden for public health worldwide and in China.

The World Health Organization (2010) reported that almost 80% of cardiovascular diseases can be averted through healthy diet, increased physical activity level and smoking cessation. These behaviours are also known as health promoting behaviours (Pender et al., 2015). Healthy lifestyles are also the first-line intervention for metabolic syndrome prevention and management (Dunkley et al., 2012; International Diabetes Federation, 2006). However, the adoption of health promoting behaviours among patients with metabolic syndrome has always been challenging. According to a survey across 17 countries, only 4.3% of patients with coronary heart disease have adopted all of the guided health promoting behaviours (Teo et al., 2013). Nurses are the main members in cardiovascular care that play key roles in fostering healthy lifestyles and reducing cardiovascular risk (Chen et al., 2018). The feasibility, acceptability and effectiveness of nurse-led lifestyle interventions in metabolic syndrome management, have been consistently supported, especially in improving some cardiovascular risk factors, such as waist circumference, systolic blood pressure and triglyceride and the quality of life (Lin et al., 2014, 2016; Lo et al., 2017; Chen et al., 2018; Wong et al., 2020). Given that only few lifestyle interventions were guided by a specific theory, the effects of theory-based nurse-led lifestyle interventions in metabolic syndrome management require further investigation (Lin et al., 2014).

Health Promotion Model is a middle-range theory that provides a holistic conceptual framework to understand the engagement of health promoting behaviours (Pender et al., 2015). This model recognises that an individual's adoption of health promoting behaviours is mainly influenced by his/her behavior-specific cognition and affect, which also interacts with his/her characteristics and experiences. Self-efficacy is a key behaviour-specific cognitive factor contributing to the implementation of health promoting behaviours. A high level of perceived self-efficacy reduces the perceptions of barriers and improves the likelihood of engaging in health promoting behaviours (Bandura, 1985; Janz and Becker, 1984). Health Promotion Model has been widely applied in guiding the development of tailored lifestyle interventions among different populations (Dehdari et al., 2014; Eshah et al., 2010; Noroozi et al., 2011).

People with metabolic syndrome had increased risks for cardiovascular diseases and cardiovascular mortality (Ju et al., 2017; Mottillo et al., 2010). Besides controlling the individual cardiovascular risk factors, the general risk of cardiovascular disease incidence is also considered in metabolic syndrome management. Given the limited follow-up period, most interventional studies cannot observe the incidence of cardiovascular disease for 10 years or longer. Instead, the long-term estimation models of cardiovascular risk, such as the Framingham 10-year risk score, have been used by interventional studies (Maruthur et al., 2009; Rautio et al., 2015). Lifestyle interventions, including the nurse-led interventions, have been beneficial in reducing the cardiovascular risk scores among different populations (Saffi et al., 2014; Winster et al., 2007; Zhu et al., 2013). However, the effects of lifestyle interventions on cardiovascular risk score among patients with metabolic syndrome are rarely studied.

The behaviour outcomes of exercise and diet have been extensively examined in lifestyle research. The self-efficacy of patients to healthy lifestyles has been rarely studied, and most works focused on self-efficacy to one aspect of behaviour. A recent published study provided different exercise training to people with cardio-metabolic risks and found significant improvements in their self-efficacy to exercise in the Tai Chi group (Chen et al., 2018). Self-efficacy in implementing health promoting behaviours is a comprehensive and specific indicator to predict health promoting behaviours. However, this outcome was seldomly examined among patients with metabolic syndrome. A study among patients with coronary artery disease revealed improved self-efficacy to health promoting behaviours after attending a nurse-led transitional care program (Zhang et al., 2018).

This study is a two-armed randomized controlled trial that examined the effects of a nurse-led Health Promotion Model guided lifestyle intervention program among patients with metabolic syndrome in North China. The lifestyle intervention program revealed significant effects in losing weight, reducing depression levels and improving patients' quality of life, which had been reported (Wang et al., 2016). The effects of lifestyle intervention program on cardio-

vascular risks, self-efficacy and the implementation of health promoting behaviours were reported in this paper.

2. Methods

2.1. Study design and participants

The study design and procedures were fully described in the previous published trial (Wang et al., 2016). Chinese adults (≥ 18 years) diagnosed with metabolic syndrome were enrolled from a hospital in Qingdao, North China. The International Diabetes Federation definition for metabolic syndrome was employed, which revealed good performance in predicting cardiovascular diseases (Wang et al., 2014). This definition requires a must existence of central obesity, waist circumference ≥ 80 cm in women or 90 cm in men, or with body mass index ≥ 30 kg/m^2, and coexist with at least two of the following four risk factors: (1) elevated blood pressure ≥ 130/85 mmHg or already taking antihypertensive drugs; (2) elevated triglyceride ≥ 1.7 mmol/L or taking lipid-lowering drugs; (3) decreased high density lipoprotein cholesterol ≤ 1.03 mmol/L in men, or ≤ 1.29 mmol/L in women, or taking drugs for dyslipidaemia and (4) hyperglycaemia, fasting plasma glucose ≥ 5.6 mmol/L or taking anti-diabetic drugs (International Diabetes Federation, 2006). Participants with psychiatric illnesses, or terminal diseases (such as cancer and heart failure), with difficulties in taking moderate-intensity physical activity or communication in Chinese were excluded.

In the power analysis, at least 64 participants in each group were required for the study with 80% statistical power to obtain a moderate effect size of 0.5 on waist circumference at 5% significance level (Cohen, 1988; Yamaoka and Tango, 2012). Considering a 20% attrition rate, at least 80 participants were required in each group, with a total sample size of 160 in the current study.

2.2. Intervention

The participants were randomly assigned to either the lifestyle intervention program or control group by opening an opaque envelope containing a computer-generated randomised number. Patients with metabolic syndrome in the control group received usual care from the study hospital: the routine medical treatments and investigations, nursing care and discharge education. After discharge, no more intervention was provided to the control group. In addition to the usual care, the intervention group received a 3-month nurse-led discharge program. The program was delivered by a trained registered nurse with 5-year working experience in cardiovascular care. The nurse was familiar with metabolic syndrome related health education and communication.

The lifestyle intervention program was developed through intensive literature review, following clinical guidelines (Chinese Diabetes Society, 2014, Jensen et al., 2014, Joint Committee for Developing Chinese guidelines on Prevention and Treatment of Dyslipidemia in Adults, 2014) and considering the patients' needs through interviews (Wang et al., 2016). Following the framework of Health Promotion Model, the interventions focused on increasing the participants' cognition for taking health promoting behaviours. The intervention provided detailed metabolic syndrome related knowledge and adopted practical strategies for implementing health promoting behaviours in daily life (Table 1). On the day of discharge, one face-to-face education session (30–40 min), supplemented with a 10-chapter educational booklet, was provided by the nurse. After discharge, the nurse called the participants every two weeks (for a total of six calls, with 20–30 min per call) to monitor and support the implementation of these behaviours. Structured guidelines were developed for the education and telephone follow-up sessions. Thus, the nurse could implement the intervention in structured manners with the same dosage. Before the study, the lifestyle intervention program was validated by cardiac physicians and nurses, patients with metabolic syndrome and nursing researchers.

2.3. Study outcomes

The study outcomes included cardiovascular risk, self-efficacy and implementation of health promoting behaviours.

The cardiovascular risk was estimated by the lab-based prediction model of the Framingham 10-year risk score (D'Agostino et al., 2008). The predictors include age, total cholesterol, high density lipoprotein cholesterol, systolic blood pressure, use of antihypertensive medication, medical history of diabetes and current smoking status. This model revealed good discrimination statistic of 0.785 (95% confidence interval, 0.764–0.806) and a calibration Chi-square of 10.24. The sensitivity and specificity of this model for cardiovascular events in follow-up studies were 0.58 and 0.83, respectively (D'Agostino et al., 2008). According to the American Heart Association guidelines, an risk score ≥ 10% is at high risk for cardiovascular diseases (Mosca et al., 2011).

The Self-rated Abilities for Health Practices was employed to measure self-efficacy. The 28-item scale was developed to measure self-efficacy in implementing the four aspects of behaviours: nutrition (7 items), exercise (7 items), psychological well-being (7 items) and health responsibility (7 items) (Becker et al., 1993). Each item has 5-point choices, rating from "0=not at all" to "4=completely". Each subscale ranges from 0 to 28, and the total score is the sum of four subscales (range: 0–112). Higher scores indicate higher levels of perceived self-efficacy in performing health promoting behaviours. This scale has been widely used in different populations with satisfactory psychometric properties: Cronbach's α of 0.91 to 0.94 and a two-week test-retest reliability of 0.70 (Becker et al., 1993). The Chinese version of the scale also revealed good psychometric properties with a Cronbach's α of 0.92 to 0.95 (Hu and Zhou, 2012; Mao et al., 2007).

The Health Promoting Lifestyle Profile II was originally developed by Walter and colleagues to measure the implementation of health promoting behaviours under the Health Promotion Model (Walker et al., 1987). Following the clinical guidelines, metabolic syndrome management focuses on healthy diet, exercise and stress management (Dunkley et al., 2012; International Diabetes Federation, 2006). The current study applied the three dimensions of the instrument, namely, nutrition, exercise and stress management, for a total of 25 items. Each item has four choices, rating as "1=never, 2=sometimes, 3=frequently and 4=routinely". The sum score ranges from 25 to 100. A higher score indicates a better implementation of health promoting behaviours. This instrument has established good validity and reliability (Callaghan, 2003; Walker et al., 1987). The Chinese version of this instrument has been applied in various populations with a Cronbach's α of 0.83 to 0.95 for the whole scale and 0.76 to 0.82 for the dimensions (Cao et al., 2012; Lo and Wong, 2011).

2.4. Data collection

The study was performed in accordance with the Declaration of Helsinki. Ethical approval was obtained from the University Ethical Committee and the study hospital (no. CRE-2014.068). Potential participants were invited with detailed instruction of study aims and procedures. After written consent was obtained, participants' baseline data were collected. After study entry, the participants were randomised to the intervention or control group by opening an opaque envelope containing a computer-generated randomisation number. Single blind was employed in data collection. An independent research nurse with no knowledge of the group allo-

Table 1
The conceptual structure of the lifestyle intervention program.

Structure of health promotion model		Lifestyle interventions	Format
Individual characteristics and experience	Prior related behavior	-Assessment of previous behaviors	Face-to-face education (FTF-Edu)
	Personal factors	-Suitable language and communication styles based on personal factors	FTF-Edu
Behavior-specific cognition and affects	Perceived benefits	-Knowledge education; -Positive feedback to enhance the awareness of benefits	Booklet, FTF-Edu Telephone follow-ups (T-FUs)
	Perceived barriers	-Knowledge education; -Practical and tailored strategies to overcome barriers	FTF-Edu Booklet, T-FUs
	Perceived self-efficacy	-Education and demonstration. -Introduction of role models -Patient-directed goal settings. -Assessment,feedback and tailored suggestions.	FTF-Edu Booklet T-FUs
	Activity related affect	-Introduction of alternative lifestyle advises -Assessment of affect -Tailor-made advice based on affect	FTF-Edu Booklet T-FUs
	Interpersonal influences	-Education on importance of social support -Assessment of social support -Individualized advice to improve social support	FTF-Edu Booklet T-FUs
	Situation influences	-Culturally sensitive education -Assessment of environmental influence and resources -Tailor-made advice within social context	FTF-Edu Booklet T-FUs
Behavioral factors	Immediate competing demands	-Education on strategies -Assessment of competing demands and responsibilities -Tailored advice to cope with competing demands	FTF-Edu Booklet T-FUs
	Commitment to a plan	-Education on importance of adherence -Setting goals and plans with participants -Monitoring compliance -Strategies to increase adherence	FTF-Edu Booklet T-FUs

cation collected the baseline and follow-up data at 1-month and 3-month.

2.5. Statistical analysis

All data analyses were conducted by SPSS 20.0 (IBM Corp. Armonk, New York). The intention-to-treat principle was followed, and all participants' data were analysed. In the 1-month and 3-month measurements, missing data caused by incomplete measurements or drop-out were marked as missing and analysed. The mean and standard deviation, or median and interquartile range or number and percentage were employed for data description. Independent *t*-test, Chi-square tests and Fishers' exact test were used to explore the differences between groups at baseline. The generalized estimating equation model was conducted to examine the effects of lifestyle interventions on cardiovascular risk, self-efficacy and health promoting behaviours. This model can handle the randomly missing data mathematically and make the estimation closer to real practice (Ma et al., 2012). Any variable that had a $p < 0.1$ in between-group comparisons at baseline was regarded as the covariate in the adjusted generalized estimating equation model. A two-tailed significance level was set as 0.05.

3. Results

A total of 173 participants were recruited, and the intervention and control groups each had 86 and 87 participants, respectively. The study flow is presented in Fig. 1. The participants were mostly middle-aged (mean 55.62 ± 10.65), married (97.6%), employed (55.5%), with ≥ 12-year education (62.5%) and never smoked (63.6%). The participants had a 10-year cardiovascular risk of 21.12% and 22.51% in the intervention and control groups, respectively. Approximately 66.28% and 68.97% of the participants in the lifestyle intervention and control groups had high cardiovascular risk (> 10%), respectively. The total score for self-efficacy (range: 0–112) was 70.67 and 71.24 in the intervention and control groups, respectively. Among the four subscales of self-efficacy, both groups had the lowest score in self-efficacy for exercise (range: 0–28), with a score of 16.40 and 17.24 for the intervention and control groups, respectively. The participants reported the health promoting behaviour of 60.14 and 62.52 in the intervention and control groups (range: 25–100), respectively. Both groups had lower scores in exercise dimension than that of nutrition or stress management. No significant difference was detected in the baseline characteristics between groups (all $p > 0.05$). Detailed baseline characteristics of the participants are presented in Table 2.

With the effect of the lifestyle interventions on cardiovascular risk, only significant time effect was detected at the 3-month assessment ($\beta = -3.615$, 95% confidence interval: −6.263, −0.967; $p = 0.07$). However, no significant group-by-time interaction effect was observed ($p = 0.682$). As indicated by generalized estimating equation analyses, the self-efficacy for nutrition, health promoting behaviour in stress and sum score revealed significant interaction effects at 1-month (all $p < 0.05$). Significant group-by-time interaction effects were detected in all subscales and the total scale of self-efficacy and in all dimensions and the sum score of health promoting behaviour by the end of the study (all $p < 0.05$). The effects of the lifestyle intervention program on study outcomes are summarised in Table 3.

4. Discussion

As one of the few nurse-led lifestyle interventions applied Health Promotion Model for metabolic syndrome management, this study revealed the effectiveness of lifestyle interventions in improving patients' self-efficacy and health promoting behaviours in three months.

4.1. Baseline characteristics of the participants

The characteristics of the participants were consistent with previous findings among Chinese metabolic syndrome populations (Cao et al., 2013). The metabolic syndrome status increased their cardiovascular risks, with 67.6% of participants having a 10-year cardiovascular risk greater than 10%. Compared with those in the studies in Taiwan, Japan and South Korea (Chen et al., 2010;

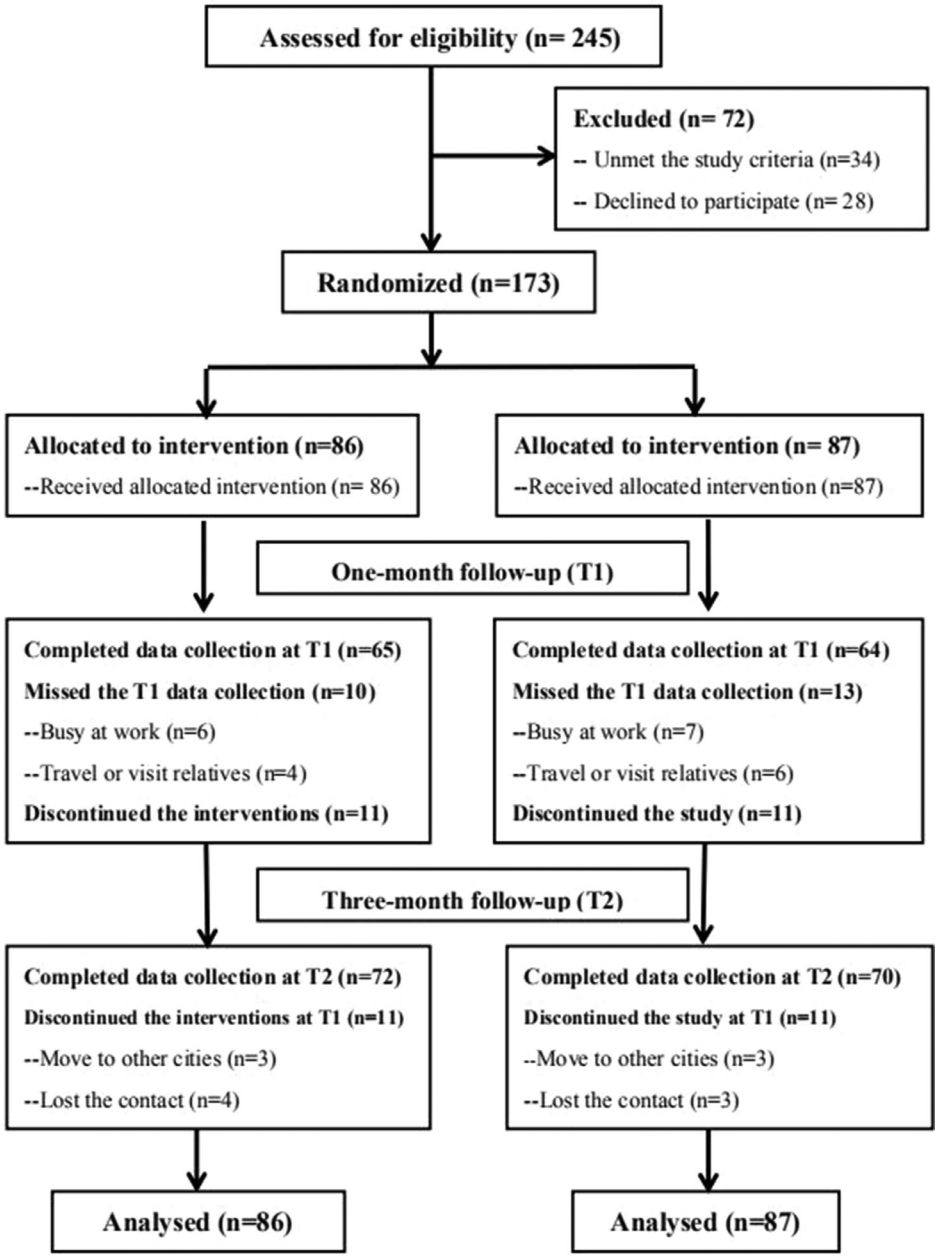

Fig. 1. CONSORT flow diagram of the sudy.

Fukumoto et al., 2011; Kang and Yoo, 2012), the current participants reported lower scores in health promoting behaviours, especially in exercise behaviour, and lower level of self-efficacy in exercise and nutrition. Baseline data indicated the urgent needs of lifestyle interventions in this high-risk population and the difficulties in their behavioural performances.

4.2. Effects of lifestyle interventions on cardiovascular risk

This study is the first to report a general cardiovascular risk among metabolic syndrome population. Although the cardiovascular risk reduction was greater in the intervention group (from 21.12% to 16.80%) than in the controls (from 22.51% to 18.90%), no significant group-by-time interaction effect was detected. Among the predictors of Framingham 10-year risk score, the modifiable factors include total cholesterol, high density lipoprotein cholesterol, systolic blood pressure and smoking status (D'Agostino et al., 2008). The intervention group showed no significant improvements in total cholesterol, high density lipoprotein cholesterol and blood pressure (Wang et al., 2016), directly leading to the non-significant changes in cardiovascular risk between groups. Contrary to the current findings, some lifestyle studies reported significant reductions in cardiovascular risk (Rautio et al., 2015; Saffi et al., 2014; Winster et al., 2007; Zhu et al., 2013). Given the differences in study participants and intervention design, direct comparisons are difficult to establish. Compared with the current study, studies with positive findings on cardiovascular risk commonly had a longer study period: ranging from six months to 18 months (Rautio et al., 2015; Saffi et al., 2014; Winster et al., 2007; Zhu et al., 2013). They also provided more extensive and interactive interventions, like group-format exercise sessions (Rautio et al., 2015; Zhu et al., 2013), individualized counselling sessions (Saffi et al., 2014; Zhu et al., 2013), more and longer (12 times, 60–120 min per time) face-to-face meeting (Saffi et al., 2014). The current lifestyle intervention

Table 2
Comparison of the demographic characteristics of the participants in the intervention and control groups.

Demographic characteristics		Intervention (n = 86)	Control(n = 87)	t/X^2	p
Age[a] (Range: 24–78)		55.22 (11.36)	56.01 (9.96)	−0.487	0.627
Gender	Male	40 (46.51%)	45 (51.72%)	0.47	0.493
	Female	46 (53.49%)	42 (48.28%)		
Marital status	Single/widowed	3 (3.49%)	1 (1.15%)	0.268	0.368*
	Married	83 (96.51%)	86 (98.85%)		
Education	≤ 6 years	6 (6.98%)	8 (9.20%)	0.343	0.952
	6–9 years	25 (29.07%)	26 (29.89%)		
	9 years	38 (44.19%)	37 (42.53%)		
	> 9 years	17 (19.77%)	16 (18.39%)		
Employment	Unemployed	6 (6.98%)	8 (9.20%)	2.777	0.596
	Retired	32 (37.21%)	31 (35.63%)		
	White collar	12 (13.95%)	19 (21.84%)		
	Blue collar	12 (13.95%)	11 (12.64%)		
	Farmer	24 (27.91%)	18 (20.69%)		
Smoking history	Current smoker	12 (13.95%)	19 (21.84%)	2.282	0.320
	Quit smoking	15 (17.44%)	17 (19.54%)		
	Never smoked	59 (68.60%)	51 (58.62%)		
Self-efficacy[a]					
	Nutrition	16.40 (5.54)	17.24 (5.53)	−1.005	0.316
Psychological well-being		17.67 (5.17)	18.01 (6.50)	−0.377	0.707
	Exercise	17.67 (4.97)	16.99 (6.99)	0.743	0.458
	Health responsibility	18.93 (5.05)	19.00 (6.39)	0.080	0.937
	Total score	70.67 (16.93)	71.24(22.64)	−0.186	0.852
Health Promoting Behaviors[a]					
	Nutrition	23.79 (2.68)	24.03 (4.16)	−0.458	0.647
	Stress management	20.92 (3.44)	21.17 (4.04)	−0.444	0.657
	Exercise	15.43 (5.41)	17.32 (6.05)	−2.161	0.032
	Sum score	60.14 (8.39)	62.52 (11.89)	−1.525	0.129
Cardiovascular risk (%)[a]		21.12 (17.26)	22.51 (18.43)	−0.513	0.609

[a] Presented as mean and standard deviation, and tested by t-test; * Fisher's exact test.

program lasted for three months, which may be extremely short to observe significant changes in the 10-year cardiovascular risk. Given that all participants were discharged from the study hospital with clinical treatments, the control group also revealed reductions in cardiovascular risk, thus limiting the difference between groups. Future studies are recommended to design a long-term study with extensive and interactive lifestyle interventions to observe the effects on cardiovascular risk.

4.3. Effects of lifestyle interventions on self-efficacy to health promoting behaviours

The current lifestyle interventions revealed significant improvements in self-efficacy to health promoting behaviours. Self-efficacy for the four aspects of behaviours has been rarely reported. Previous studies only measured the general self-efficacy (Oh et al., 2010) or self-efficacy for specific behaviour, for example, physical activity (Bosak et al., 2010; Olson and MaAuley, 2015), diet (Frerichs et al., 2020) and self-care behaviour (Kim et al., 2014). Our findings were consistent with another nurse-led transitional care program among patients with coronary artery disease, which revealed significant effects on self-efficacy (Zhang et al., 2018). Different behavioural theories provided similar strategies to improve self-efficacy, such as social persuasion, modelling and mastery of experience (Olson and MaAuley, 2015; Pender et al., 2015). Guided by Health Promotion Model, the current interventions employed the following strategies to improve self-efficacy levels. Firstly, the education session provided detailed information and practical skills by using demonstration, patient-directed goal setting and introducing the experience of role models that facilitated the participants' confidence in performing health promoting behaviours. Secondly, in the follow-up sessions, the nurse provided verbal persuasion and praise for participants' progress, which enhanced their recognition of success and mastery of experience. On-going support and practical advice helped the participants overcome the anticipated and perceived barriers in lifestyle changes. Therefore, Health Promotion Model guided lifestyle interventions contributed to improving self-efficacy.

4.4. Effects of lifestyle interventions on the implementation of health promoting behaviours

The lifestyle interventions significantly improved the individual dimensions and overall health promoting behaviours at the end of the study. The stress management dimension and sum score also revealed significant interaction effects at 1-month measurement. These findings were consistent with previous lifestyle interventions (Bosak et al., 2010; Chen et al., 2018; Olson and MaAuley, 2015) and in line with the changes in self-efficacy in the current study. As a critical cognitive predictor of health promoting behaviours (Pender et al., 2015), the improved self-efficacy definitely increased the participants' confidence and initiative for implementing healthy diet, regular exercise and effective stress management. The current findings supported the relationship between self-efficacy and health promoting behaviours in Health Promotion Model.

The content of this lifestyle intervention program also contributed to the improvements in health promoting behaviours. Detailed knowledge and practical skills to improve behaviours were included in every component of the interventions. For example, the local diet prefers fried food, pickles and heavy sauces. Healthy cooking methods, such as steaming and stewing, and the use of vinegar or ginger instead of salty seasoning were advised. To improve physical activity levels, the study set exercise goals with the patients and taught strategies to incorporate exercise into daily

Table 3
Effects of the lifestyle intervention program on study outcomes.

Study outcomes	Intervention group (n = 86)		Control group (n = 87)		Group* Time interaction effects in the GEE models[a]		
	Mean	SD	Mean	SD	β	95% CI	p
Cardiovascular risk (%)							
Baseline	21.12	17.26	22.51	18.43			
3-month	16.80	12.43	18.90	14.61	−0.706	(−4.085, 0.673)	0.682
Self-efficacy							
Nutrition							
Baseline	16.40	5.54	17.24	5.53			
1-month	19.72	4.84	18.11	5.72	2.330	(0.469,4.191)	0.014*
3-month	20.29	4.21	18.10	4.36	2.943	(1.403, 4.484)	<0.001***
Psychological well-being							
Baseline	17.67	5.17	18.01	6.50			
1-month	19.31	5.63	18.17	5.73	1.119	(−0.993, 3.232)	0.299
3-month	20.28	4.73	18.10	5.37	2.497	(0.798, 4.196)	0.004**
Exercise							
Baseline	17.67	4.97	16.99	6.99			
1-month	20.17	5.48	19.00	6.51	0.558	(−1.506, 2.622)	0.596
3-month	20.26	4.96	17.67	6.49	1.884	(0.013, 3.755)	0.048*
Health responsibility							
Baseline	18.93	5.05	19.00	6.39			
1-month	22.08	5.96	20.73	6.42	1.322	(−0.851, 3.496)	0.233
3-month	21.46	4.72	19.01	4.74	2.585	(0.786, 4.383)	0.005**
Total score							
Baseline	70.67	16.93	71.24	22.64			
1-month	81.28	18.82	76.02	21.40	5.283	(−1.644,12.209)	0.135
3-month	82.29	16.37	72.89	17.87	9.891	(4.161, 15.621)	0.001**
Nutrition							
Baseline	23.79	2.68	24.03	4.16			
1-month	25.97	3.45	25.41	4.24	0.879	(−0.421, 2.179)	0.185
3-month	27.50	3.46	25.61	3.64	2.103	(0.857, 3.349)	0.001**
Stress							
Baseline	20.92	3.44	21.17	4.04			
1-month	23.02	3.53	22.02	3.93	2.224	(0.373, 4.076)	0.019*
3-month	23.96	3.04	22.54	3.49	2.783	(1.187, 4.378)	0.001**
Exercise							
Baseline	15.43	5.41	17.32	6.05			
1-month	19.83	4.80	19.80	5.78	1.153	(−0.183, 2.489)	0.091
3-month	19.61	4.20	18.67	4.67	1.670	(0.498, 2.842)	0.005**
Sum score							
Baseline	60.14	8.38	62.52	11.89			
1-month	68.82	9.50	67.22	11.25	4.327	(0.920, 7.734)	0.013*
3-month	71.07	8.14	66.83	9.29	6.558	(3.607, 9.509)	<0.001***

GEE: generalized estimating equation. SD: standard deviation. CI: confidence interval.
[a] Adjusted generalized estimating equations model after controlling the covariate variables of low density lipoprotein cholesterol and total cholesterol at baseline assessment.*$p < 0.05$; ** $p < 0.01$; ***$p < 0.001$.

life, for example, walking or cycling instead of riding the bus, and standing when watching TV.

The improvements in self-efficacy and health promoting behaviours did not significantly reduce the cardiovascular risks, which was possibly due to the short study period. Additionally, the findings indicated the complexity of cardiovascular risk that is influenced by various factors besides self-efficacy and behavioural factors (D'Agostino et al., 2008; Soares et al., 2014; Rautio et al., 2015). Another interesting finding was that the changes in self-efficacy and health promoting behaviours during the first month showed the greatest proportion of the 3-month changes. Although the improvements were sustained throughout the study period, the increments slowed down with continuous interventions. The slow improvement in self-efficacy and health promoting behaviours was consistent with that in weight loss (Wang et al., 2016). This finding implies that the participants may have exhibited the greatest motivation and commitment in the early stage of the study. Effective strategies for maintaining the participants' motivation and commitment in the long term should be explored.

4.5. Limitations

This study has some limitations. Firstly, the study examined only the 3-month effects of the lifestyle interventions among patients with metabolic syndrome. Whether the improvements in self-efficacy and behaviours could be sustained or the changes in cardiovascular risks could achieve significant difference in long term should be further explored. Secondly, all participants were recruited from one hospital in North China. Given the differences in custom and lifestyles, participants' characteristics should be considered when generalising the findings to other populations. Additionally, the cost-effectiveness of the nurse-led intervention was unclear, although the current lifestyle intervention program was convenient for application. Therefore, a multiple-centre study design and economic evaluation indicators were recommended for future studies.

4.6. Implications for nursing practice

Given the increasing prevalence of metabolic syndrome and great challenges in behavioural changes, providing effective lifestyle interventions for this huge population is critical in clinical practices. The findings indicated the nurse-led lifestyle intervention program effectively improved self-efficacy and the health promoting behaviours for patients with metabolic syndrome. The booklet, discharge education and telephone follow-ups were easy and convenient to apply in nursing practice. Nurses are recommended to attend training sessions on how to deliver the

lifestyle interventions and apply it in routine care for patients with metabolic syndrome.

5. Conclusion

The nurse-led lifestyle intervention program was developed under the framework of Health Promotion Model and included a lifestyle booklet, one face-to-face education and six telephone follow-ups. Patients with metabolic syndrome who attended this program revealed higher levels of self-efficacy and better implementation of health promoting behaviours compared with the controls. We recommend that nurses apply this lifestyle intervention program in routine care for patients with metabolic syndrome.

Declaration of Competing Interest

The authors declare no conflict of interest.

CRediT authorship contribution statement

Xujuan Zheng: Funding acquisition, Formal analysis, Writing - original draft, Writing - review & editing. **Hongbo Yu:** Investigation, Project administration, Writing - review & editing. **Xichenhui Qiu:** Funding acquisition, Formal analysis, Writing - review & editing. **Sek Ying Chair:** Conceptualization, Formal analysis, Methodology, Project administration, Supervision. **Eliza Mi-Ling Wong:** Conceptualization, Formal analysis, Methodology, Project administration, Supervision. **Qun Wang:** Conceptualization, Investigation, Formal analysis, Methodology, Project administration, Writing - original draft, Writing - review & editing.

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