Title

Health Behavior Adherence in a Metropolitan-Based Metabolic Syndrome Management Program during the COVID-19 Pandemic.

Journal

Journal of Obesity & Metabolic Syndrome, 33(2)

Authors

Park, Sungwon
Quinn, Lauretta
Park, Chang
et al.

Publication Date

2024-06-30

DOI

10.7570/jomes23039

Journal of Obesity & Metabolic Syndrome 2024;33:166-176
https://doi.org/10.7570/jomes23039

Original Article

jomes
pISSN 2508-6235
eISSN 2508-7576

Health Behavior Adherence in a Metropolitan-Based Metabolic Syndrome Management Program during the COVID-19 Pandemic

Sungwon Park[1,*], Lauretta Quinn[2], Chang Gi Park[2], Eileen Collins[2], Oi Saeng Hong[3], Carol Estwing Ferrans[2]

[1]Department of Health Behavior and Biological Sciences, School of Nursing, Michigan Society of Fellows 2022-2025, University of Michigan, Ann Arbor, MI; [2]College of Nursing, University of Illinois at Chicago, Chicago, IL; [3]Occupational and Environmental Health Nursing Graduate Program, University of California San Francisco, School of Nursing, San Francisco, CA, USA

Background: The COVID-19 pandemic increased the worldwide prevalence of metabolic syndrome. The purpose of this study was to assess health behavior adherence during the pandemic in adults who had engaged in a metabolic syndrome management program for at least 6 months. This assessment included an evaluation of health behavior changes, factors influencing adherence, and clinical parameters. The city-wide program was operated by the Seoul Metropolitan Government.

Methods: Baseline and follow-up data were compared in 116 participants who engaged in the program for at least 6 months prior to the pandemic. Health behaviors and clinical parameters were examined. Generalized estimating equation analysis was used to identify sociodemographic variables influencing health behavior adherence over time.

Results: Systolic blood pressure, waist circumference, and blood glucose improved (all $P<0.05$), and risk factors decreased ($P<0.001$) from baseline to follow-up (mean±standard deviation, 1.13±0.91 years). All six health behaviors, physical activity and weight control, eating habits, alcohol consumption and smoking, stress management, sleep and rest, and medication compliance and medical examination improved (all $P<0.001$) from baseline to follow-up (2.37±1.05 years). Smoking and employment negatively influenced adherence to health behaviors ($P<0.05$). Participants felt the most beneficial part of the program was receiving sequential medical examination results with follow-up consultations by public health professionals without charge.

Conclusion: Our study demonstrated the durability of the impact of the Seoul Program on all six targeted health behaviors as well as clinical parameters. Findings encourage participation in such broad-based programs and development of novel approaches to facilitate success for smokers and employed participants.

Key words: Metabolic syndrome, Health behavior, Disease management, Guideline adherence, Republic of Korea

Received June 21, 2023
Reviewed August 3, 2023
Accepted December 18, 2023

*Corresponding author
Sungwon Park

https://orcid.org/0000-0003-0251-5772

Department of Health Behavior and Biological Sciences, School of Nursing, Michigan Society of Fellows 2022-2025, University of Michigan, 400 North Ingalls Street, Ann Arbor, MI 48109, USA
Tel: +1-312-788-4850
E-mail: sungwonp@umich.edu

INTRODUCTION

Metabolic syndrome affects about one-third of the world's population and the prevalence is increasing.[1-3] Metabolic syndrome can include hypertension, high blood glucose levels, excessive body fat around the waist, and abnormal cholesterol or triglyceride levels. This syndrome increases risk of stroke, heart disease, and type 2 diabetes mellitus and heightens the health risks of coronavirus disease 2019 (COVID-19).[4,5] Managing metabolic syndrome is challenging as the disease results from a combination of social, economic, occupational, psychological, and genetic factors along with unhealthy behaviors such as smoking, alcohol consumption, poor diet, and

inadequate exercise.[6-10]

Metabolic syndrome poses a major public health problem globally, including in South Korea. In 2021, 21.3% of South Koreans had metabolic syndrome.[1] In Seoul, the country's largest city, the Metropolitan Government has operated a comprehensive metabolic syndrome management program (the Seoul Program) for over 10 years. This program is accessible to the city's entire population and provides assessments of participants' clinical parameters over time and provides simple lifestyle action plans to help decrease metabolic syndrome risk.[11] The Seoul Program is similar to the Lifestyle Change Programs of the United States National Diabetes Prevention Program; both programs aim to teach participants to make sustainable lifestyle changes that include healthier eating habits, performing daily physical activity, and enhancing coping skills.[12,13]

The COVID-19 pandemic forced governments throughout the world to implement social restrictions that negatively affected individuals' daily lives and lifestyles, resulting in an increased prevalence of metabolic syndrome and other chronic illnesses.[14-16] For example, restrictive lockdowns in Italy affected not only elderly people at high-risk of COVID-19 infection, but also young and healthy people. Auriemma et al.[14] reported that routine physical exercise was limited to brief in-house workouts or was abandoned entirely. Also, access to fresh, healthy food was reduced; and social isolation and loneliness increased, lifestyle patterns were disrupted, and circadian rhythms altered.[14] As a result, obesity, dyslipidemia, and metabolic syndrome significantly increased after the lockdowns.[14]

Prior to the pandemic only a few studies had evaluated the Seoul Program's outcomes, and these focused exclusively on clinical parameters, risk factors, or dietary adherence.[11,17,18] All were limited to 12 months of participation although participants are allowed to continue participating in the program as long as desired. To our knowledge, no studies have reported outcomes longer than 1 year from baseline or comprehensively addressed all six areas of health behavior change, physical activity and weight control, eating habits, alcohol consumption and smoking, stress management, sleep and rest, and medication compliance and medical examination. Also, these studies have not characterized the impact of the COVID-19 pandemic on adherence. The purpose of this study was to assess health behavior adherence during the pandemic in adults who had engaged in the Seoul Program for at least 6 months. Our focus was on health behavior changes, factors influencing adherence, and clinical parameters. This study examined the durability of the program effects after being suspended for the pandemic. Based on the Information-Motivation-Behavioral Skills model,[19] we predicted that the health behavior information, motivational training, and skills provided by the Seoul Program, which were designed to reduce metabolic syndrome risk factors, would improve targeted health behaviors.

METHODS

Study design

Using a pretest-posttest design, baseline and follow-up data were compared in 116 participants of the Seoul Program for a minimum of 6 months. This participation in the Seoul Program occurred prior to the suspension of the program due to the pandemic. Health behaviors and clinical parameters and the influence of nine sociodemographic variables were examined.

Sample

Inclusion criteria were: (1) participated in the Seoul Program a minimum of 6 months; (2) had at least one risk factor for metabolic syndrome during Seoul Program participation; (3) provided the results of metabolic syndrome diagnostic tests from the start and end of program participation; (4) had not been pregnant since starting the program; (5) were able to communicate by telephone and to read and write in Korean.

The target sample size for the study was calculated using the G*Power 3.1 program. A significance level of 0.05, an effect size of 0.15, a power of 80%, and six expected predictors were assumed for this calculation. The calculated sample size of 98 was adjusted to allow for a 10% dropout rate. Therefore, the final target sample size was 108 making our sample size of 116 sufficient to meet our calculation assumptions. Fig. 1 presents the flow diagram for recruitment and data collection.

Description of the Seoul Program

Since 2009, the Seoul Metropolitan Government has operated the city-wide Seoul Program to prevent and manage metabolic syndrome.[20] Table 1 presents the components of the program. Minimum

participation in the program is normally 12 months with the option to continue for as long as desired and eligible. Eligibility was restricted to those having at least one risk factor for metabolic syndrome. Counseling and testing were provided at baseline, 3–6 months, and 12 months. Results from metabolic syndrome tests and other information were provided to participants along with one-on-one counseling and lifestyle action plans by public health professionals (e.g., public health nurses, physicians, nutritionists, and personal trainers). Motivational messages are provided by a smartphone via a short message service.[20-22]

Measures

Clinical parameters and metabolic syndrome risk factors

Metabolic syndrome risk factors were defined by the modified National Cholesterol Education Program-Adult Treatment Panel III for Koreans.[23] Risk factors were evaluated using six clinical parameters (metabolic syndrome test results) collected by the Seoul Program at entry into the program (baseline) and at the last visit (follow-up). These parameters were: systolic blood pressure, diastolic blood pressure, blood glucose level, triglyceride level, high-density lipoprotein cholesterol level, and waist circumference.

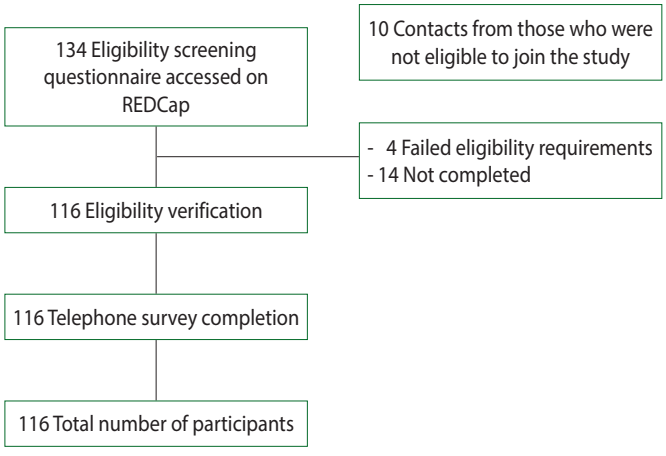

Figure 1. Recruitment and data collection.

Health behaviors and health behavior adherence

Health behaviors were evaluated using Kang's[24] Lifestyle Evaluation Tool for Patients with Metabolic Syndrome. This 36-item instrument measures health behaviors in six categories: physical activity and weight control, eating habits, alcohol consumption and smoking, stress management, sleep and rest, and medication compliance and medical examination. Health behaviors were rated on a 5-point Likert scale ranging from "not at all times" to "always." Higher scores indicated better adherence to recommended behaviors. For this study, the reliability of the instrument was supported by a Cronbach's α of 0.92 at baseline and 0.93 at follow-up.

Participant feedback on the Seoul Program

Two open-ended questions were asked to elicit feedback on the program: "what were the most helpful parts of the program" and "what do you need to be able to make healthy changes in your life?"

Data collection procedures

Due to the pandemic, the 25 public health centers that administer the Seoul Program were closed and the program was suspended in February 2020. Data collection for this study began in November 2020 and ended in September 2021. Participants were recruited by electronic study fliers distributed by 482 participating companies, non-government organizations, and community welfare centers. These participating organizations were provided by the public health centers to the principal investigator (SP). In addition, social media platforms, e.g., Instagram, Kakaostory, and Facebook, and snowball sampling were used to recruit participants. Partici-

Table 1. Seoul metabolic syndrome project components

Procedure	(1) Completion of questionnaires regarding metabolic syndrome and metabolic syndrome diagnostic tests. (2) One-on-one counseling with a registered nurse or physician, including medical examination results; dietary consultation with a nutritionist; physical activity consultation with a personal trainer; and simple lifestyle action plans. (3) Receipt of health information 2–4 times per month via SMS.
Times of counseling/testing	Baseline and every 3–6 months up to 12 months for all participants. After 12 months, participants are given the opportunity to stop or to continue participating.

SMS is automatically delivered via smartphone using the public health center data system after registration in the Seoul Metabolic Syndrome Project.
SMS, short message service.

pants received an e-gift card worth about $50 USD as compensation for their time.

Clinical parameters and metabolic syndrome risk factors

Participants submitted their program-issued metabolic syndrome test results for two time points: (1) baseline, at their start in the Seoul Program and (2) follow-up, at their completion of the program. These test results were collected by the Seoul Program using standard medical procedures (blood pressure readings, waist circumference, and blood test specimens) taken in-person by a trained health care professional. The standard laboratory analyses that followed were of blood glucose, triglyceride, and high-density lipoprotein cholesterol levels. Participants submitted test results using a research electronic text message data capture link, and all the information was secured using a password and encrypted.

Health behaviors and health behavior adherence

Health behaviors, sociodemographic characteristics, and dates of program participation as confirmed by the clinical parameter data were collected by telephone interview. Health behaviors were assessed at baseline and follow-up. For baseline health behaviors, participants used program notes and diagnostic test results as memory aids for their health behavior at the start of the program. For follow-up health behaviors, participants reported their current health behaviors during the COVID-19 pandemic.

Because metabolic test results were all completed prior to the telephone interview, follow-up metabolic syndrome test results were asynchronous with follow-up health behavior data. The mean ± standard deviation (SD) time difference between the follow-up test results and follow-up health behavior data was 1.26 ± 0.44 years, ranging from 0 to 2 years.

Data analysis

Stata 17.0 was used for all analyses. In addition to descriptive statistics, changes in clinical parameters and health behaviors from baseline to follow-up were compared using paired *t*-tests whenever variables were normally distributed; otherwise, the Wilcoxon signed rank test was used. Generalized estimating equation (GEE) analysis was used to identify variables influencing adherence to recommended health behaviors over time. *Post hoc* analyses were conducted using GEE to identify which of the six health behavior subscales contributed to the identified relationships.

Ethical considerations

This study was conducted with the approval of the Institutional Review Board at the University of Illinois at Chicago approval (IRB No. 2020-1139). All participants were provided with an explanation of the study purpose and procedures, the risks and benefits of par-

Table 2. Participant sociodemographic characteristics at baseline (n = 116)

Variable	No. (%)	Mean ± SD
Age		52.50 ± 12.29
Gender		
Male	21 (18.1)	
Female	95 (81.9)	
Marital status		
Married	89 (76.7)	
Divorced or separated, widowed	8 (6.9)	
Never married	19 (16.4)	
Educational level		
≤ High school graduate	42 (36.2)	
≥ Bachelor's degree	74 (63.8)	
Work status		
Full-time regular worker	43 (37.1)	
Other categorized worker	33 (28.4)	
Unemployed	40 (34.5)	
Working hours per week*		35.22 ± 10.90
Working years in the entire life*		16.56 ± 10.54
Description of work*		
Office worker	8 (10.5)	
Professional	8 (10.5)	
Service industry worker	34 (44.7)	
Self-employed	5 (6.6)	
Technician	2 (2.6)	
Other	19 (25.0)	
Diseases		
Yes	63 (54.3)	
No	53 (45.7)	
Smoking		
Former/current smoker	23 (19.8)	
Non-smoker	93 (80.2)	
Consume alcohol		
Yes	92 (79.3)	
Never	24 (20.7)	

*Employed individuals (n = 76).
SD, standard deviation.

ticipation, the right to leave the study at any time, compensation, and protection of personal information.

RESULTS

Sociodemographic characteristics and program participation

Table 2 presents sociodemographic characteristics at baseline. Most participants were middle-aged (52.50 ± 12.29 years; range, 24 to 69), female (82%), married (77%), and held a bachelor's degree (64%). Regarding work status, 37% of the participants were full-time regular workers, and 28% were workers in other categories. These other categories included hourly work, part-time jobs, temporary/contract employment, or other non-standard employment. The remaining 35% were unemployed. Working hours among the 76 working participants averaged 35.22 ± 10.90 hours per week (range, 8 to 63), and their working years averaged 16.56 ± 10.54 years (range, 0.5 to 40). Approximately 45% were service industry workers. Among all participants, 54% reported having one or more chronic illnesses, 80% were non-smokers, and about 80% reported alcohol consumption.

All participants had engaged in the Seoul Program for at least 6 months. The length of active engagement in the program averaged 1.13 ± 0.91 years (range, 0.5 to 4.5). Eighty percent had completed engagement prior to the pandemic onset; 20% were still actively engaged in the program at program suspension. Participants completed program engagement for a mean of 1.26 ± 0.44 years (range, 0 to 2) prior to taking part in our study.

Clinical parameters and risk factors

Table 3 presents the mean values for clinical parameters at baseline and follow-up with a mean of 1.13 ± 0.91 years (range, 0.5 to 4.5) between the two time points. Comparisons between baseline and follow-up showed significant improvements in systolic blood pressure, blood glucose level, and waist circumference ($P < 0.05$), but not in diastolic blood pressure, triglyceride levels, or high-density lipoprotein cholesterol levels. However, the number of risk factors decreased significantly (t = 5.34, $P < 0.001$) from baseline (1.93 ± 0.09) to follow-up (1.45 ± 0.11) with the majority (58%) having no or one risk factor at follow-up.

Table 3. Changes in clinical parameters and risk factors from baseline to follow-up (n = 116)

Clinical parameter	Study participants			
	Paired t-test			Wilcoxon signed rank test
	Baseline	Follow-up	t	z
Systolic blood pressure (mmHg)	123.57 ± 13.18	120.96 ± 13.27		2.72*
Diastolic blood pressure (mmHg)	77.03 ± 10.49	76.74 ± 9.89		0.57
Blood glucose level (mg/dL)	98.19 ± 14.56	95.09 ± 11.19	2.49†	
Triglyceride (mg/dL)	136.66 ± 86.87	130.87 ± 87.30	0.80	
High-density lipoprotein cholesterol (mg/dL)	54.12 ± 15.15	56.91 ± 15.28		–1.83
Waist circumference (cm)	80.60 ± 8.62	79.12 ± 8.10	3.35*	
No. of risk factors	1.93 ± 0.99	1.45 ± 1.15	5.34*	
0	-	26		
1	49	41		
2	37	27		
3	20	15		
4	9	7		
5	1	-		

Values are presented as mean ± standard deviation. Although there are five metabolic syndrome risk factors, for the assessment of clinical parameters systolic blood pressure and diastolic blood pressure were considered separately. Risk factors for metabolic syndrome, defined by the modified National Cholesterol Education Program-Adult Treatment Panel III for Koreans: (1) waist circumference over 35 inches (90 cm) for male, over 33 inches (85 cm) for female; (2) blood pressure over 130/85 mmHg; (3) fasting triglyceride level over 150 mg/dL; (4) fasting high-density lipoprotein cholesterol level less than 40 mg/dL (male) or 50 mg/dL (female); and (5) fasting blood glucose level over 100 mg/dL.
*$P < 0.001$; †$P < 0.05$.

Table 4. Changes in six health behavior categories from baseline to follow-up (n = 116)

Health behavior category		Study participants			
		Paired t-test			Wilcoxon signed rank test
		Baseline	Follow-up	t	z
HB1	Physical activity and weight control	2.15 ± 0.86	2.90 ± 0.77	–8.83*	–7.24*
HB2	Eating habits	2.51 ± 0.67	3.32 ± 0.55	–14.68*	–9.13*
HB3	Consuming alcohol and smoking	3.41 ± 0.70	3.73 ± 0.50	–6.92*	–6.62*
HB4	Stress management	3.30 ± 0.79	3.63 ± 0.60	–4.70*	–4.84*
HB5	Sleep and rest	2.84 ± 0.95	3.44 ± 0.74	–7.14*	–6.11*
HB6	Medication compliance and medical examination	2.84 ± 0.82	3.40 ± 0.65	–10.20*	–8.32*
Total HB		17.09 ± 3.19	20.44 ± 2.79	–13.40*	–8.78*

Values are presented as mean ± standard deviation.
*$P < 0.001$.
HB, health behavior.

Health behaviors and health behavior changes

To examine health behavior changes, total scores, and subscale scores for the six health behavior categories were compared for baseline and follow-up (Table 4). All scores showed normality except for the sleep and rest subscale and total health behavior score at baseline. As a result, Wilcoxon signed rank tests were performed for confirmation purposes along with paired t-tests. The means for the total health behavior score and all six subscale scores for the health behavior categories improved significantly from baseline to follow-up ($P < 0.001$).

To examine the relationship between length of time participating in the Seoul Program and health behavior adherence, we calculated a correlation using the health behavior total score. The correlation was negative and relatively weak (r = –0.37) indicating that those who had participated in the Seoul Program for a longer time tended to be less adherent, but the relationship was not a strong one.

Participant feedback on the Seoul Program

When asked to identify the most helpful parts of the program, almost half (47%) of participants stated receipt of multiple sequential medical examinations with follow-up consultations from public health professionals at no charge (Table 5). The next most common answer was learning about unhealthy eating habits (28%). Twenty-two percent identified increasing physical activity. When asked to identify what improvements were still needed to make healthy changes in their lives, the most common answer was the willingness to perform healthy behaviors (33%). The next most common answer was regular monitoring of health behaviors by health professionals as in the Seoul Program (25%), and the third was performing healthy behaviors with someone (18%). Overall, participants found receiving assistance with managing their health behavior by continuously participating in the program and/or co-managing with health professionals most valuable.

Influence of demographic and lifestyle variables on health behavior adherence

GEE analysis was used to identify variables that influenced adherence over time based on changes in health behavior scores between baseline and follow-up. Nine demographic and lifestyle variables were considered (age, gender, educational level, marital status, number of people currently living in the household, work status, diagnosed diseases, smoking, and alcohol consumption). First, bivariate correlations of these nine variables with total health behavior scores were examined. Only five variables were correlated > 0.30 with total health behavior: gender, educational level, work status (unemployment vs. employment), smoking, and alcohol consumption. These five variables were included in the GEE analysis simultaneously so that the results were adjusted for all five. The GEE analysis showed that only two variables significantly influenced total health behavior over time: smoking and work status. Compared to non-smokers, health behavior adherence over time was lower for former/current smokers (b = 1.80, standard error [SE] = 0.67, z = 2.68, and $P = 0.007$). Also, compared to unemployed participants, health behavior adherence over time was lower for employ-

Table 5. Seoul Program: most helpful aspects and continuing needs (n = 116)

Assessment question	Most helpful aspects and continuing needs	Frequency (%)
What were the most helpful parts of the program?*	Most helpful aspects of the Seoul Program	
	1. Free, sequential medical examinations (including body composition and clinical parameters) with follow-up consultations from public health professionals	55 (47)
	2. Precautions regarding unhealthy eating habits and benefits of changing to healthy ones	32 (28)
	3. Warnings about participating in healthy behaviors generally to maintain health	30 (26)
	4. Increasing physical activity/adherence to exercise	26 (22)
	5. Improving metabolic syndrome test results and overall health	21 (18)
	6. Learning how to eat healthy	14 (12)
	7. Motivation for exercise	9 (8)
	8. Learning how to exercise effectively	9 (8)
	9. Awareness of need for regular medical examination	8 (7)
	10. Motivation for losing weight	6 (5)
	11. Warning/ learning about metabolic syndrome risks, how to manage them	6 (5)
	12. Continuous follow-up contact from public health professionals at public health center	6 (5)
	13. Easy to obtain support (e.g., check-ups, occupational health nurses' efforts)	6 (5)
	14. Appreciation and positiveness about life	1 (1)
What do you need to be able to make healthy changes in your life?*	What participants still need	
	1.My willingness to do healthy behaviors	38 (33)
	2. Regular monitoring of health behavior by health professionals, as in the Seoul Program	29 (25)
	3. Doing healthy behaviors with someone	21 (18)
	4. Managing health behaviors continuously	17 (15)
	5. Learning customized healthy behaviors (e.g., exercise that can be done at home)	14 (12)
	6. Get help to do health behaviors in person (e.g., PT at gym; encouragement; various health programs)	12 (10)
	7. More free time	12 (10)
	8. Lack information/accurate information how to perform healthy behaviors	11 (9)
	9. Good environment for exercise and eating healthy foods (e.g., gym; good weather; a good meal plan at work)	10 (9)
	10. More diagnostic tests	5 (4)
	11. Easy healthy food recipes	3 (3)
	12. Positive mindset	3 (3)
	13. Ease of access to program providers (e.g., distance)	2 (2)
	14. Financial support	1 (1)

*Participants could provide multiple answers.
PT, personal training.

ees (b = –1.50, SE = 0.56, z = –2.68, and $P = 0.007$).

Next, a *post hoc* examination was performed to identify the specific health behaviors that contributed to these findings. GEE analyses were performed for each of the six specific health behaviors (subscales) with the five variables in the analyses. The results showed that former/current smokers were less adherent in dietary habits (b = 0.50, SE = 0.18, z = 2.71, and $P = 0.007$) and stress management (b = 0.56, SE = 0.21, z = 2.63, and $P = 0.009$) than non-smokers. Employed participants were less adherent in dietary habits (b = 0.01, SE = 0.11, z = –3.84, and $P < 0.001$) and medication compliance and medical examinations (b = –0.30, SE = 0.12, z = –2.44, and $P = 0.015$) than unemployed participants.

DISCUSSION

To our knowledge, this study is the first to report outcomes in health behavior adherence in metabolic syndrome related to the Seoul Program during the COVID-19 pandemic. Three findings are particularly noteworthy. First, findings demonstrated the durability of the positive impact of the program. Participants reported

maintenance of significant changes in all six health behaviors targeted by the Seoul Program for an average of 2.37 years, ranging from 1.25 to 6.0 years. These data were self-reported and may have been affected by social desirability; however, the changes in clinical parameters provided objective support for the idea that persistent changes in health behaviors did take place. Systolic blood pressure, blood glucose levels, and waist circumference improved with a significant reduction in the number of risk factors for metabolic syndrome from baseline to follow-up.

Participants lowered their systolic blood pressure by a mean of 2.61 mmHg from baseline to follow-up, bringing the group mean (120.96 mmHg) close to the normal range of 120 mmHg. Research has shown that a 5 mmHg reduction of systolic blood pressure reduces the risk of major cardiovascular events by about 10%.[25] Assuming linearity, the reduction of 2.61 mmHg reduced our participants' cardiovascular risk by 5%. Mean blood glucose levels were within the normal range at both baseline and follow-up, but these decreased from 98.19 to 95.09 mg/dL. This 3.1 mg/dL reduction in blood glucose levels demonstrated desirable movement away from the pre-diabetes range of 100 to 125 mg/dL. For long-term change in waist circumference, a 3% change between 1.8 and 4.1 cm is considered a clinically relevant change.[26] Our participants nearly reached that threshold with a mean reduction of 1.48 cm in waist circumference after a minimum of 6 months participation in the Seoul Program.

Second, study findings demonstrated that these positive lifestyle changes could be maintained successfully during the COVID-19 pandemic, contrary to negative effects of the pandemic in the population at large. In South Korea, the number of patients with metabolic syndrome increased to 21% during the pandemic. Body mass index, systolic blood pressure, and lipid profiles all significantly worsened after February 2020 compared to 2018–2019.[16] Although South Korea did not impose lockdowns on communities, strict COVID-19 monitoring and contact tracing as well as social distancing requirements were established.[27] During this period, indoor physical exercise in facilities such as fitness centers was prohibited, and limitations on social gatherings were placed on restaurants and other public venues. Within this context, the increase in physical activity found in our study was particularly noteworthy given that physical activity decreased globally during the pandemic and most significantly in Asia. Comparisons of 90-day periods of step counting before and during the pandemic showed the greatest decrease in Asia (30%) compared to North America (4%), Europe (14%), and South America (29%).[28]

Third, to date no other reports have examined the influence of smoking and employment on the health behaviors of Seoul Program participants. Only two prior studies evaluated behavior change in the program; both were limited in scope and were conducted prior to the COVID-19 pandemic. Ham et al.[17] focused on diet adherence, reporting that participants improved their adherence to diet recommendations and reduced risk factors over 12 months of program participation in 2015. Choo et al.[11] found differences in risk factors among participants stratified into low-, moderate-, and high-risk groups over 12 months in 2013. Risk factors improved for the moderate- and high-risk groups but worsened for the low-risk group. Neither of these studies examined the effect of other variables on health behavior adherence. In our study, prior and current use of cigarettes and employment were found to hinder performance of recommended health behaviors over time. Non-smokers showed better adherence to program-recommended health behaviors overall, particularly in dietary habits and stress management. In South Korea, as in other parts of the world, epidemiological studies have shown that smokers' diets are less healthy than non-smokers. Korean smokers have been found to be more likely than non-smokers to have irregular meals and large dinners, eat out frequently, and have other unhealthy dietary habits.[29] Considering that smokers have greater problems with poor dietary habits in a normal, non-pandemic environment, these tendencies may have been exacerbated by the increased stress of the pandemic. The finding that stress management was also worse for smokers in our study may lend some support to this conjecture.

Because the Seoul Program was provided without charge to participants, those with financial constraints and lower socioeconomic status could participate. In fact, unemployed participants in our study adhered better to recommended health behaviors overall, particularly in terms of dietary habits and medication compliance/medical examinations. Other studies have reported the opposite, that unemployed participants tend to have a higher number of risk factors and a greater prevalence of metabolic syndrome.[30-32] However, workers in our study were predominantly service industry

workers (44.7%) and professional and office workers (21%). Service jobs commonly require shift work. Shift work, especially night shift work, can disrupt meals, sleep, and rest. Professional and office work is associated commonly with long sedentary periods as well as occupational stress. Shift work, occupational stress, and sedentary work have all been identified as primary contributors to metabolic syndrome.[33] In addition, our finding that employed participants were less adherent in dietary habits may also have been exacerbated by the pandemic. Many employees experienced disruption in normal work patterns, particularly changing to working at home. One study found the pandemic change to working at home resulted in increases in daily time worked, sedentary time, and perceived stress, all of which were associated with weight gain.[34] Our participants may have experienced similar issues due to the pandemic.

Limitations

This study has several limitations. First, the study findings cannot be generalized to the Seoul Program as a whole. Because the 25 public health centers that administer the program were closed due to the pandemic, this study used a self-selected, convenience sample. Thus, we would expect the sample to be more actively engaged and successful and not represent the population of program participants. In addition, the sample was predominantly composed of workers in the service industry (45%) and was not representative of all employment types.

Second, baseline health behavior data for this study was not collected when participants started the Seoul Program but was recalled many months later. To increase accuracy, participants reviewed their counseling notes and diagnostic test results, both of which were issued to them at the start of the Seoul Program. These notes contained information on their past health behaviors, similar to the content of the health behaviors instrument, and helped to minimize recall bias, but could not eliminate this bias entirely.

Third, for 80% of participants, the second set of metabolic syndrome test results were completed before the 25 health centers were closed for the pandemic. These test results were collected by the Seoul Program an average of 1.26 years prior to our collection of health behavior data during the pandemic. This time lapse limited our ability to examine the impact of health behavior changes on clinical parameters during the pandemic.

Finally, our study lacked a control group, and could not definitively determine whether the significant differences found between baseline and follow-up may not have been caused by participation in the Seoul Program. However, we partially addressed this question by examining the health screenings statistical yearbook published by the Korean National Health Insurance Service to determine if metabolic syndrome risk factors showed a decreasing trend in South Korea during the pandemic. The answer is no; the percentage who had metabolic syndrome increased from 19.2% in 2019 to 20.6% in 2020 and 21.3% in 2021. The percentage who had at least one risk factor also increased slightly or was stable: 68.3% in 2019, 69.8% in 2020, and 69.6% in 2021.[1] These data provide additional confidence that the findings of our study showing a reduction in metabolic syndrome clinical parameters and risk factors were due to the subjects' participation in the Seoul Program.

Conclusion

This sample of 116 participants in a comprehensive metabolic syndrome management program was found to improve their health behaviors, maintain these positive behaviors for 1 to 6 years, and sustain these behaviors even during the COVID-19 pandemic. Improvements were seen in all six health behaviors: physical activity and weight control, eating habits, alcohol consumption and smoking, stress management, sleep and rest, and medication compliance/medical examination. Health behavior changes were supported by improved clinical parameters and reduced risk factors. In this predominantly successful sample, smoking and employment were found to hinder adherence to healthy behaviors. Study findings encourage participation in the Seoul Program and other such programs to combat the increased prevalence of metabolic syndrome seen during the pandemic. The findings also point to the need to identify novel ways to better support those who smoke and work, such as enlarging the focus to include workplace interventions to promote healthy lifestyle changes and better lifelong health.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGMENTS

This study was funded by the 2021 American Association of Occupational Health Nurses Foundation Medique New Researcher Grant; the 2021 Sigma Alpha Lambda Chapter Award, Alpha Lambda Chapter of Sigma Theta Tau Honor Society of Nursing; the 2020–2021 Tom and Sherri Mendelson Student Research Award, College of Nursing, University of Illinois at Chicago (UIC); the Award for Graduate Research from UIC Graduate College; and the 2020 Global Korean Nursing Foundation USA scholarship award. In addition, the authors appreciate all participants in the study.

AUTHOR CONTRIBUTIONS

Study concept and design: SP, LQ, CGP, EC, OSH, and CEF; acquisition of data: SP; drafting of the manuscript: SP and CEF; critical revision of the manuscript: LQ, CGP, EC, and OSH; statistical analysis: SP, CGP, and CEF; obtained funding: SP; administrative, technical, or material support: SP; and study supervision: LQ, CGP, EC, OSH, and CEF.

REFERENCES

1. Korean National Health Insurance Service. Health screenings statistical yearbook in 2021 [Internet]. National Health Insurance Service; 2022 [cited 2024 Jan 23]. Available from: https://www.nhis.or.kr/nhis/together/wbhaec07000m01.do?mode=view&articleNo=10831133&article.offset=0&articleLimit=10
2. Moore JX, Chaudhary N, Akinyemiju T. Metabolic syndrome prevalence by race/ethnicity and sex in the United States, National Health and Nutrition Examination Survey, 1988-2012. Prev Chronic Dis 2017;14:E24.
3. Saklayen MG. The global epidemic of the metabolic syndrome. Curr Hypertens Rep 2018;20:12.
4. Marhl M, Grubelnik V, Magdič M, Markovič R. Diabetes and metabolic syndrome as risk factors for COVID-19. Diabetes Metab Syndr 2020;14:671-7.
5. van Namen M, Prendergast L, Peiris C. Supervised lifestyle intervention for people with metabolic syndrome improves outcomes and reduces individual risk factors of metabolic syndrome: a systematic review and meta-analysis. Metabolism 2019;101:153988.
6. Park S, Jang MK, Park CG, Hong OS. Predictors of health promotion behaviors among working adults at risk for metabolic syndrome. Nurs Res 2022;71:275-84.
7. Johnson P, Turner L, Carter M, Kelly R, Ewell PJ. Metabolic syndrome prevalence and correlates in a worksite wellness program. Workplace Health Saf 2015;63:245-52.
8. Lee JA, Cha YH, Kim SH, Park HS. Impact of combined lifestyle factors on metabolic syndrome in Korean men. J Public Health (Oxf) 2017;39:82-9.
9. Liu Y, Ozodiegwu ID, Yu Y, Hess R, Bie R. An association of health behaviors with depression and metabolic risks: data from 2007 to 2014 U.S. National Health and Nutrition Examination Survey. J Affect Disord 2017;217:190-6.
10. Yang X, Di W, Zeng Y, Liu D, Han M, Qie R, et al. Association between shift work and risk of metabolic syndrome: a systematic review and meta-analysis. Nutr Metab Cardiovasc Dis 2021;31:2792-9.
11. Choo J, Yoon SJ, Ryu H, Park MS, Lee HS, Park YM, et al. The Seoul metropolitan lifestyle intervention program and metabolic syndrome risk: a retrospective database study. Int J Environ Res Public Health 2016;13:667.
12. Centers for Disease Control and Prevention. About the national DPP [Internet]. CDC; 2022 [cited 2024 Jan 23]. Available from: https://www.cdc.gov/diabetes/prevention/about.htm
13. Diabetes Prevention Program (DPP) Research Group. The Diabetes Prevention Program (DPP): description of lifestyle intervention. Diabetes Care 2002;25:2165-71.
14. Auriemma RS, Pirchio R, Liccardi A, Scairati R, Del Vecchio G, Pivonello R, et al. Metabolic syndrome in the era of COVID-19 outbreak: impact of lockdown on cardiometabolic health. J Endocrinol Invest 2021;44:2845-7.
15. Ryder M, Guerin S, Forde R, Lowe G, Jaarsma T, O'Neill M, et al. The perceived effects of COVID-19 while living with a chronic illness. J Nurs Scholarsh 2023;55:154-62.
16. Sohn M, Koo BK, Yoon HI, Song KH, Kim ES, Kim HB, et al. Impact of COVID-19 and associated preventive measures

on cardiometabolic risk factors in South Korea. J Obes Metab Syndr 2021;30:248-60.
17. Ham D, Cho Y, Park MS, Park YS, Kim SY, Seol HM, et al. Inverse association of improved adherence to dietary guidelines with metabolic syndrome: the Seoul Metabolic Syndrome Management program. Nutr Res Pract 2020;14:621-36.
18. Seoul Metropolitan Government. See Seoul citizen' metabolic syndrome at a glance. Seoul Metropolitan Government; 2019.
19. Fisher WA, Fisher JD, Harman J. The information-motivation-behavioral skills model: a general social psychological approach to understanding and promoting health behavior. In: Suls J, Wallston KA, editors. Social psychological foundations of health and illness. Blackwell Publishing; 2003. p. 82-106.
20. Park SS, Oh SW. Strategy for the management of metabolic syndrome of Seoul citizen. Food Ind Nutr 2010;15:10-6.
21. Park MS, Park YS, Kim SY, Park S, Seol HM, Woo S, et al. Introduction and effectiveness of the Seoul metabolic syndrome management. Public Health Aff 2017;1:25-39.
22. Seoul Metropolitan Government. A 2018 management plan of metabolic syndrome of the Seoul Metropolitan Government. Report No. Health and Medical Policy Division-9761. Seoul Metropolitan Government; 2018.
23. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive summary of the third report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA 2001;285:2486-97.
24. Kang SW. The validity and reliability of a lifestyle evaluation tool for patients with metabolic syndrome. J Korean Acad Fundam Nurs 2010;17:487-97.
25. Blood Pressure Lowering Treatment Trialists' Collaboration. Pharmacological blood pressure lowering for primary and secondary prevention of cardiovascular disease across different levels of blood pressure: an individual participant-level data meta-analysis. Lancet 2021;397:1625-36.
26. Verweij LM, Terwee CB, Proper KI, Hulshof CT, van Mechelen W. Measurement error of waist circumference: gaps in knowledge. Public Health Nutr 2013;16:281-8.
27. Center Disaster and Safety Countermeasure Headquarters. Basic guidelines for distancing in daily life [Internet]. Korean Ministry of Health and Welfare; 2020 [cited 2024 Jan 23]. Available from: https://ncov.kdca.go.kr/socdisBoardList.do
28. Tison GH, Barrios J, Avram R, Kuhar P, Bostjancic B, Marcus GM, et al. Worldwide physical activity trends since COVID-19 onset. Lancet Glob Health 2022;10:e1381-2.
29. Kim YO. Dietary habits of smokers and non-smokers in the Korean Health and Nutrition Survey. Prev Nutr Food Sci 2002;7:442-6.
30. Mirmiran P, Aghayan M, Bakhshi B, Hosseinpour-Niazi S, Azizi F. Socioeconomic status and lifestyle factors modifies the association between snack foods intake and incidence of metabolic syndrome. Nutr J 2021;20:70.
31. Cho HH, Lee DW, Hahm MI. Association between nutrition labelling awareness and the metabolic syndrome: results from the Korean National Health and Nutrition Examination Survey (KNHANES) 2016-2018. Br J Nutr 2021;126:685-94.
32. Ying X, Yang S, Li S, Su M, Wang N, Chen Y, et al. Prevalences of metabolic syndrome and its sex-specific association with socioeconomic status in rural China: a cross-sectional study. BMC Public Health 2021;21:2033.
33. Santana AI, Merces MC, Magalhães LB, Costa AL, D'Oliveira A. Association between metabolic syndrome and work: an integrative review of the literature. Rev Bras Med Trab 2020;18:185-93.
34. Coşkun MG, Öztürk Rİ, Tak AY, Sanlier N. Working from home during the COVID-19 pandemic and its effects on diet, sedentary lifestyle, and stress. Nutrients 2022;14:4006.