



Effects of a Program Applying the Transtheoretical Model on Diet and Exercise Behaviors among Hospital Personnel with Metabolic Syndrome

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Abstract

Background: Metabolic syndrome is a major public health concern associated with increased risks of type 2 diabetes mellitus and cardiovascular disease. Hospital personnel may be particularly vulnerable due to occupational demands, shift work, and limited opportunities for self-care.

Objective: To evaluate the effects of a stage-tailored intervention based on the Transtheoretical Model on awareness of metabolic syndrome prevention, dietary behavior, physical activity, body weight, and waist circumference among hospital personnel with metabolic syndrome. **Methods:** A

quasi-experimental two-group pretest–posttest design with cluster allocation was conducted among 64 hospital personnel in a private hospital in Thailand. Four departmental clusters were first identified, and cluster-level simple random allocation was used to assign two clusters to the intervention group and two clusters to the comparison group. Simple random sampling was then used to select participants until the required sample size of 32 participants per group was achieved. The intervention group received a five-week stage-tailored intervention followed by a three-week follow-up period, while the comparison group received routine health information. Data were analyzed using repeated measures ANOVA, paired t-tests, and independent t-tests ($p < .05$). **Results:** The intervention group demonstrated significant improvements in awareness of metabolic syndrome prevention and physical activity over time ($p < .05$). Waist circumference also showed a significant within-group reduction in the intervention group. However, no significant group-by-time interaction effects were observed for

behavioral or anthropometric outcomes, and no significant between-group differences were found in body weight or waist circumference. **Conclusion:** A stage-tailored intervention based on the Transtheoretical Model resulted in partial improvements in awareness and selected health outcomes, particularly physical activity and waist circumference within the intervention group. These findings suggest potential benefits of readiness-based behavioral strategies in workplace health promotion; however, stronger evidence from larger and longer-term studies is needed to confirm between-group effectiveness.

Keywords: Transtheoretical model, Metabolic syndrome, Physical activity, Dietary behavior.

What was Known

- Metabolic syndrome increases cardiometabolic risk among healthcare workers.
- Stage-based behavior change programs may improve dietary and physical activity behaviors.

What's New and Next

- A stage-tailored workplace intervention was associated with increased awareness and physical activity over time.
- Multi-site studies with larger sample sizes are needed to confirm long-term clinical effects.

Introduction

Metabolic syndrome is a cluster of metabolic abnormalities characterized by insulin resistance, hyperglycemia, hypertension, central obesity, and dyslipidemia, all of which are associated with increased risks of type 2 diabetes mellitus and cardiovascular disease^(1,2,3). Individuals with metabolic syndrome have approximately a fivefold greater risk of developing type 2 diabetes mellitus and a 2.4-fold higher risk of cardiovascular mortality compared with those without the condition^(1,2). The condition is commonly identified using the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) criteria, which have been widely applied in clinical practice and epidemiological research⁽³⁾. Recent evidence also indicates that metabolic syndrome contributes substantially to healthcare burden, reduced quality of life, and premature mortality worldwide^(1,2,3).

Recent global reports indicate that noncommunicable diseases and metabolic-related conditions continue to increase worldwide, particularly among working-age populations and healthcare workers^(1,2,4,5). Metabolic syndrome has become a major global public health concern

because it contributes substantially to cardiovascular disease, type 2 diabetes mellitus, reduced quality of life, and premature mortality^(1,2,3). Approximately one fourth of the global adult population is affected by metabolic syndrome⁽¹⁾. In Thailand, the prevalence among adults aged 15 years and older was 25.1%, with a higher prevalence in women (27.7%) than men (22.5%)⁽⁶⁾. Data from the Thai National Health Examination Survey have also demonstrated a substantial burden of metabolic syndrome and related metabolic risk factors among Thai adults and working-age populations⁽⁶⁾. Similar high prevalence rates of metabolic syndrome have been reported in many countries, particularly among Asian adult populations^(3,7).

Unhealthy lifestyle behaviors are major contributing factors to metabolic syndrome, particularly excessive caloric intake, high consumption of sugar-sweetened beverages and high-fat foods, physical inactivity, sedentary behavior, and prolonged sitting time^(8,9,10). These behaviors contribute to insulin resistance, abdominal obesity, dyslipidemia, and impaired glucose metabolism. Similar patterns have also been observed among Thai working populations, particularly in relation to unhealthy dietary intake, insufficient physical activity, and obesity-related risk behaviors⁽⁶⁾. Recent systematic reviews and meta-analyses have reported that lifestyle modification interventions, including dietary improvement and regular physical activity, are associated with significant reductions in body weight, waist circumference, and metabolic risk factors among individuals with metabolic syndrome^(11,12).

Hospital personnel are at increased risk of metabolic syndrome due to occupational and environmental factors, including shift work, heavy workload, psychological stress, fatigue, and limited opportunities for self-care^(13–15). Consistent with this concern, a recent systematic review and meta-analysis reported that shift work significantly increases the risk of metabolic syndrome among healthcare workers⁽¹⁴⁾. Annual health examination records from the study hospital indicated an increasing prevalence of metabolic risk factors among personnel between 2022 and 2023. The proportion of personnel with BMI $\geq 23 \text{ kg/m}^2$ increased from 54.27% to 58.04%, while hyperglycemia increased from 20.49% to 31.36%, and dyslipidemia increased from 45.09% to 48.27%.

A preliminary assessment among hospital personnel with metabolic syndrome revealed unhealthy dietary and physical activity behaviors. Most participants frequently consumed meals from restaurants or food delivery services, convenience foods, and fried or high-fat foods (80.0%). In addition, 73.33% reported late evening meals, 60.0% regularly consumed sugar-sweetened

beverages, and 46.66% reported frequent snacking. Regarding physical activity, 86.66% reported insufficient exercise and reliance on elevators instead of stairs. Participants also reported low motivation and unclear health goals. These behaviors may contribute to increased cardiometabolic risk and negatively affect the overall health and well-being of hospital personnel^(8–10).

Although hospital personnel generally possess adequate health knowledge, many are unable to maintain healthy behaviors due to workload demands, shift work, fatigue, and limited organizational support. In the study setting, existing workplace health promotion activities primarily consisted of general health education without structured, theory-based behavioral interventions tailored to individuals' readiness for change. Recent evidence from workplace-based intervention studies has shown that structured and theory-driven lifestyle programs are more effective than general health education in improving dietary behaviors, physical activity, and metabolic risk profiles among working populations^(11,12).

The Transtheoretical Model (TTM) is a widely used behavioral change framework that conceptualizes behavior change as a dynamic and progressive process occurring through identifiable stages of readiness to change^(16–19). The model incorporates key constructs including stages of change, processes of change, decisional balance, and self-efficacy^(16–19).

The application of TTM may be particularly suitable for hospital personnel because many healthcare workers possess adequate health knowledge but experience difficulty translating awareness into consistent behavioral practice. Therefore, the TTM was selected as the conceptual framework for this study.

Previous studies have demonstrated that TTM-based interventions can facilitate improvements in dietary behaviors, physical activity, and other health-related behaviors across various adult populations^(17,18,20,21). However, limited studies have specifically examined TTM-based interventions among hospital personnel with metabolic syndrome. Therefore, this study aimed to examine the effects of a stage-tailored health behavior modification program based on the Transtheoretical Model on awareness, dietary behavior, physical activity, and waist circumference among hospital personnel with metabolic syndrome.

The conceptual framework of this study was based on the TTM, incorporating stages of change, processes of change, decisional balance, and self-efficacy to influence behavioral and clinical outcomes (Figure 1).

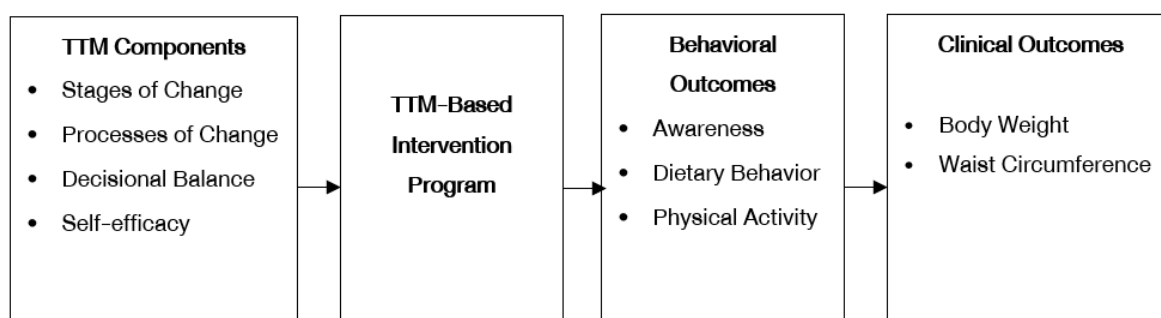


Figure 1 Conceptual Framework of the TTM-Based Intervention

Materials and Methods

Study Design and Setting

This study employed a quasi-experimental two-group pretest–posttest design with cluster allocation. The study was conducted among personnel working in a tertiary-care private hospital in Bangkok, Thailand. Participants were allocated to either the intervention group or the comparison group according to departmental clustering in order to minimize contamination between groups. Data were collected at three time points: baseline, post-intervention at Week 5, and follow-up at Week 8. The study was conducted between October and December 2025.

Participants and Eligibility Criteria

The reference population comprised hospital personnel who participated in annual health examinations during the 2024 fiscal year. Participants were aged 25–60 years and diagnosed with metabolic syndrome according to the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III, 2005) criteria.

Metabolic syndrome was defined as the presence of at least three of the following five abnormalities: central obesity (waist circumference ≥ 90 cm in men or ≥ 80 cm in women), elevated fasting plasma glucose (≥ 100 mg/dL or use of glucose-lowering medication), elevated blood pressure ($\geq 130/85$ mmHg or antihypertensive medication), hypertriglyceridemia (≥ 150 mg/dL), and low HDL cholesterol (< 40 mg/dL in men or < 50 mg/dL in women, or lipid-lowering medication).

Inclusion criteria were as follows: (1) having complete annual health examination records; (2) being classified in the precontemplation or contemplation stage for dietary and/or physical activity

behavior based on the Stage of Change assessment questionnaire; (3) being able to communicate via telephone and the LINE application; and (4) providing written informed consent prior to participation.

Exclusion criteria included individuals with medical contraindications to physical activity, those participating in other structured weight reduction programs, or those using weight-loss medications during the study period. Participants were withdrawn if they requested discontinuation or experienced illness or injury that prevented continued participation.

Sample Size Calculation

The sample size was calculated using a priori power analysis for comparing means between two independent groups (two-tailed), with a significance level (α) of 0.05 and a statistical power of 0.80. The effect size was estimated based on findings from a previous related study by Phosri²¹. Using G*Power version 3.1.9.2, the minimum required sample size was determined to be 52 participants (26 participants per group).

To compensate for potential attrition or incomplete data, the sample size was increased by 20%, resulting in a total of 64 participants, with 32 participants assigned to the intervention group and 32 participants assigned to the comparison group. No participants withdrew during the study period.

Sampling Procedure and Group Allocation

A cluster randomization design was employed at the departmental level to minimize contamination between the intervention and comparison groups. Hospital personnel were first identified and categorized into four departmental clusters, including the outpatient department, inpatient department, medical support services, and administrative services. Two clusters were randomly allocated to the intervention group, while the remaining two clusters were allocated to the comparison group using cluster-level simple random allocation.

All eligible personnel within each selected cluster were identified according to the predefined inclusion and exclusion criteria. Simple random sampling was then used to select participants until the required sample size of 32 participants per group was achieved.

To minimize contamination, intervention and comparison activities were conducted in separate buildings and on different days, and participants were instructed not to share program-related information or educational materials with individuals outside their assigned group.

Baseline characteristics, including demographic and health-related variables, were assessed to evaluate baseline comparability between groups prior to the intervention.

The intervention protocol was strictly standardized across all participants in the intervention group in terms of duration, frequency, content, and delivery format of both educational sessions and LINE-based communications, ensuring consistency of exposure throughout the study period.

Intervention Program

The health behavior modification program was developed based on the Transtheoretical Model (TTM), incorporating its core constructs—stages of change, processes of change, decisional balance, and self-efficacy—to improve dietary behavior and physical activity among hospital personnel with metabolic syndrome.

The intervention was conducted over 8 weeks, consisting of a 5-week active intervention phase followed by a 3-week follow-up phase.

Intervention Activities

Week 1: Awareness Enhancement Session

This session aimed to increase participants' awareness of metabolic syndrome, its related health risks, and unhealthy lifestyle behaviors.

Participants attended a structured group session (≤ 60 minutes) consisting of:

- Interactive lecture on metabolic syndrome and lifestyle-related risks
- Self-assessment of dietary and physical activity behaviors
- Individual feedback based on baseline health screening data
- Distribution of a health handbook and self-monitoring diary

This session emphasized consciousness raising and self-reevaluation processes, corresponding to the precontemplation and contemplation stages of TTM.

Week 3: Skill Development and Behavioral Practice Session

This session focused on enhancing behavioral skills, self-efficacy, and problem-solving abilities related to healthy eating and physical activity.

Participants attended a 60-minute interactive group session, including:

- Nutrition education for real-life food selection
- Demonstration of home-based and workplace-friendly exercises
- Group discussion and experience sharing
- Problem-solving training to address barriers to behavior change

This session targeted helping relationships, self-liberation, and counterconditioning processes, aligned with the preparation stage.

Week 5: Maintenance and Reinforcement Session

This session aimed to strengthen behavioral maintenance and long-term adherence.

Activities ($\leq$ 60 minutes) included:

- Goal setting for dietary and physical activity behaviors
- Self-monitoring and progress review
- Positive reinforcement and feedback
- Peer support and group encouragement

This phase emphasized reinforcement management and stimulus control processes, corresponding to the action and maintenance stages.

Continuous Digital Support (8 Weeks)

Throughout the intervention period, participants received structured digital support via the LINE application. Messages were delivered 3–4 times per week using standardized content developed by the research team, including:

- Educational messages on metabolic syndrome
- Healthy dietary recommendations
- Physical activity guidance
- Motivational prompts to enhance adherence

All messages were standardized to ensure consistent delivery and to support behavior reinforcement in daily life.

Stage-Matched Behavioral Support

Participants' stage of change was assessed at Weeks 2, 4, and 6 using a validated 2-item Stage of Change questionnaire covering dietary behavior and physical activity. Classification was based on the dominant stage response.

Participants who showed delayed progression or regression received tailored support according to their readiness for change as follows:

Week 2: Early-stage Support

Participants remaining in or regressing to the precontemplation or contemplation stage received:

- Peer support using a buddy system
- Group encouragement and motivational reinforcement

Week 4: Preparation-stage Support

Participants who did not progress to the preparation stage received:

- Individual counseling by the researcher
- Brief motivational interviewing to enhance readiness for change

Week 6: Action-stage Support and Reinforcement

Participants who had not reached the action stage received:

- Individual telephone counseling (20–30 minutes per session) conducted by a multidisciplinary team, including a nutritionist or dietitian
- Focus on barrier identification, problem-solving, and adherence enhancement

In addition, a step-count competition (pedometer-based intervention) was implemented for 2 consecutive weeks to enhance physical activity through behavioral reinforcement and social motivation.

Control Group Intervention

Participants in the comparison group received:

- Standardized health education materials
- General health counseling equivalent in duration to the intervention group sessions

However, the comparison group did not receive:

- Stage-matched intervention tailoring
- Individualized behavioral counseling based on TTM stage
- Behavioral reinforcement strategies

Step-count competition or structured behavioral monitoring

6. Outcome Measures

Research instruments included screening tools, questionnaires, and anthropometric measurements. The questionnaires were developed and adapted from previously validated instruments and relevant literature on metabolic syndrome-related behavioral assessment. Metabolic syndrome was assessed according to the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III, Ref) criteria.

The questionnaires consisted of four parts:

(1) General Information Questionnaire

This section contained 10 items assessing demographic and work-related characteristics. Example items included sex, age, body mass index, waist circumference, educational level, blood pressure, and family history of chronic diseases.

(2) Stage of Change Assessment Questionnaire

This consisted of 2 items assessing readiness for dietary and physical activity behavior change. Each item included five response options corresponding to the stages of precontemplation, contemplation, preparation, action, and maintenance. Example questions assessed participants' readiness to control high-fat food and sugary beverage consumption and to engage in regular aerobic exercise for at least 20–30 minutes, 3–5 days per week.

Participants selecting response option 1 were classified in the precontemplation stage, whereas those selecting response option 2 were classified in the contemplation stage. When dietary behavior and physical activity stages differed, classification was based on the lower stage of readiness.

(3) Awareness of Metabolic Syndrome Prevention Questionnaire

This contained 10 items rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Higher scores indicated greater awareness of metabolic syndrome prevention. Example items included awareness regarding abdominal obesity as a risk factor for metabolic

syndrome and recognition that excessive waist circumference may increase the risk of chronic diseases such as diabetes, hypertension, and cardiovascular disease.

(4) Dietary Behavior and Physical Activity Questionnaires

The dietary behavior questionnaire included 30 items, while the physical activity questionnaire included 26 items. Both used a 5-point Likert scale, with higher scores reflecting healthier behaviors. Example dietary behavior items assessed the frequency of consuming sugary beverages, sweet desserts, high-fat foods, vegetables, and fiber-rich foods. Example physical activity items assessed exercise frequency, duration of physical activity, and participation in aerobic exercise such as brisk walking, running, swimming, and cycling.

Interpretation of all questionnaire scores was based on mean values, where higher scores indicated greater awareness and healthier behaviors. Mean score interpretation was classified into three levels as follows: low (1.00–2.33), moderate (2.34–3.67), and high (3.68–5.00). Content validity was evaluated by five experts, yielding a content validity index (CVI) of 1.00. The reliability of all questionnaires, assessed using Cronbach's alpha, ranged from 0.86 to 0.93

Anthropometric measurements included body weight, measured using a calibrated digital weighing scale, and waist circumference, measured using a standard anthropometric tape following standardized procedures. Blood pressure was measured using an automated sphygmomanometer after participants had rested for at least 5 minutes, and the average of two measurements was recorded for analysis.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 30 under the Mahidol University license. Statistical significance was set at $p < .05$.

Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to summarize participant characteristics.

Normality assumptions were evaluated using skewness and kurtosis values. Although minor deviations from normality were observed in some variables, parametric statistics were applied based on the Central Limit Theorem because each group contained more than 30 participants.

Repeated measures ANOVA was used to examine group effects, time effects, and group-by-time interaction effects. Bonferroni adjustment was applied for pairwise comparisons.

Paired t-tests were used to compare within-group changes, whereas independent t-tests were used to compare differences between groups for body weight and waist circumference outcomes.

Results

1. *Baseline Characteristics of Participants*

Baseline characteristics are presented in Table 1. The two groups were comparable in age, body mass index (BMI), waist circumference, blood pressure, sex distribution, and shift work status (all $p > .05$).

Participants were predominantly female (65.6%), with a mean age of approximately 46 years. The mean BMI was $31.31 \pm 5.16 \text{ kg/m}^2$ in the Intervention group and $31.00 \pm 5.35 \text{ kg/m}^2$ in the comparison group.

A statistically significant difference was observed only in job category ($p < .001$), consistent with the cluster-based allocation design.

2. *Effects of the TTM-Based Intervention*

As shown in Table 2, mean scores for awareness, dietary behavior, and physical activity at baseline, post-intervention, and follow-up are presented for both groups.

Mauchly's test indicated that the assumption of sphericity was not violated ($p = .350$); therefore, sphericity-assumed results were reported. Repeated measures ANOVA (Table 3) showed significant main effects of group, $F(1, 62) = 4.14$, $p = .048$, and time, $F(2, 124) = 3.12$, $p = .048$, for awareness. The group $\times$ time interaction was not statistically significant, $F(2, 124) = 2.51$, $p = .086$.

For dietary behavior, no significant group effect, $F(1, 62) = 0.25$, $p = .620$; time effect, $F(2, 124) = 1.87$, $p = .160$; or interaction effect, $F(2, 124) = 0.42$, $p = .660$, was observed.

For physical activity, significant main effects were found for group, $F(1, 62) = 6.31$, $p = .020$, and time, $F(2, 124) = 3.87$, $p = .020$. The interaction effect was not statistically significant, $F(2, 124) = 2.14$, $p = .120$.

Table 1 Baseline characteristics of participants

Variables	Experimental (n=32) n (%)	Comparison (n=32) n (%)	p-value
Age (years)	46.69 (7.88)	45.50 (9.88)	0.693 ^a
BMI (kg/m ²)	31.31 (5.16)	31.00 (5.35)	0.852 ^a
Waist circumference (cm)	100.63 (9.69)	97.77 (12.63)	0.295 ^a
Systolic BP (mmHg)	138.13 (8.65)	138.47 (12.66)	0.900 ^a
Diastolic BP (mmHg)	85.09 (7.91)	88.81 (9.34)	0.091 ^a
Female	21 (65.6)	21 (65.6)	1.000 ^b
Shift work	22 (68.8)	20 (62.5)	0.599 ^b
Job category			< .001 ^c
Clinical	12 (37.5)	16 (50.0)	
Support	20 (62.5)	0 (0.0)	
Administrative	0 (0.0)	16 (50.0)	

^a Independent samples t-test.^b Chi-square test.^c Fisher–Freeman–Halton exact test.**Table 2** Mean and standard deviation of study outcomes at each time point

Outcome Variables	Group	Pre-test Mean (SD)	Post-test Mean (SD)	Follow-up Mean (SD)
Awareness	Experimental	4.03 (0.43)	4.30 (0.44)	4.36 (0.41)
	Comparison	4.36 (0.35)	4.27 (0.57)	4.43 (0.46)
Dietary behavior	Experimental	3.47 (0.25)	3.49 (0.26)	3.61 (0.31)
	Comparison	3.49 (0.29)	3.48 (0.28)	3.54 (0.36)
Physical activity	Experimental	3.20 (0.48)	3.52 (0.50)	3.59 (0.49)
	Comparison	3.23 (0.49)	3.17 (0.47)	3.35 (0.67)

SD = standard deviation.

3. Effects of the Intervention on Clinical Outcomes

Body Weight

No significant differences in body weight were observed between groups at baseline ($p = .888$) or at follow-up ($p = .606$). Within-group analysis showed no significant change in the Intervention group ($p = .809$), whereas a significant increase was observed in the comparison group ($p < .001$). (Table 4)

Waist Circumference

No significant between-group differences were found at baseline ($p = .314$) or follow-up ($p = .262$). Within-group analysis showed a significant decrease in waist circumference in the Intervention group ($p = .007$) and a significant increase in the comparison group ($p = .001$). (Table 4)

Table 3 Results of Repeated Measures ANOVA for Study Outcomes

Outcome	Source	SS	df	MS	F	p-value
Awareness	Group	0.71	1	0.71	4.14	0.048
	Error	10.69	62	0.17		
	Time	1.32	2	0.66	3.12	0.048
	Time × Group	1.07	2	0.53	2.51	0.086
	Error (Time)	26.33	124	0.21		
Dietary behavior	Group	0.02	1	0.02	0.25	0.620
	Error	4.58	62	0.07		

Outcome	Source	SS	df	MS	F	p-value
Physical activity	Time	0.35	2	0.17	1.87	0.160
	Time × Group	0.08	2	0.04	0.42	0.660
	Error (Time)	11.55	124	0.09		
	Group	1.62	1	1.62	6.31	0.020*
	Error	15.94	62	0.26		
	Time	2.15	2	1.07	3.87	0.020*
	Time × Group	1.19	2	0.59	2.14	0.120
	Error (Time)	34.43	124	0.28		

* $p < 0.05$.

Table 4 Effects of the Intervention on Clinical Outcomes

Outcome	Group	Pre-test	Follow-up	Within-group	Between-group
		Mean (SD)	Mean (SD)	p-value ^a	p-value ^b
Body weight (kg)	Experimental	81.73 (14.66)	81.44 (13.26)	0.809	0.606
	Comparison	81.19 (16.20)	83.40 (16.76)	< 0.001	
Waist circumference (cm)	Experimental	100.63 (9.69)	96.66 (8.89)	0.007	0.262
	Comparison	97.77 (12.63)	99.56 (11.47)	0.001	

^a Paired t-test.

^b Independent samples t-test.

4. Stages of Change

For dietary behavior, no significant differences between groups were observed at baseline, post-intervention, or follow-up (all $p > .05$). In the intervention group, a greater proportion of participants were classified in the action and maintenance stages at follow-up compared with baseline.

For physical activity behavior, no significant between-group differences were found at any time point (all $p > .05$). In the intervention group, a higher proportion of participants were in the action and maintenance stages at follow-up compared with baseline.

Discussion

1. Interpretation of Findings Based on the Transtheoretical Model

The findings can be interpreted within the theoretical framework of the Transtheoretical Model (TTM), which proposes that behavior change occurs progressively through identifiable stages and requires stage-appropriate processes to facilitate advancement^(16–19). Core constructs of the model, including stages of change, processes of change, decisional balance, and self-efficacy, were integrated into the intervention activities. The observed improvements in dietary behaviors and physical activity among participants in the intervention group suggest that the program may have facilitated progression toward healthier behaviors. Statistically significant effects were more evident for awareness and physical activity outcomes, while dietary behavior changes showed positive trends without statistically significant interaction effects. The improvement in dietary and physical activity behaviors observed in this study is consistent with previous studies using TTM-based interventions and lifestyle modification programs among individuals with metabolic syndrome^(20,21). The findings also support previous evidence indicating that stage-matched interventions can effectively enhance motivation, increase readiness to change, and promote sustainable health behavior modification^(16–19). The positive changes in decisional balance and self-efficacy observed among participants may be explained by the intervention strategies designed to strengthen perceived benefits, reduce perceived barriers, and enhance confidence in performing healthy behaviors. These findings are consistent with the theoretical assumptions of TTM and previous studies demonstrating that self-efficacy is a key predictor of successful behavioral change and maintenance^(16–19). Furthermore, the gradual progression of participants through the stages of change may reflect the effectiveness of the weekly activities, which were specifically tailored to participants' readiness to change. The intervention incorporated educational sessions, self-monitoring, goal setting, group discussion,

motivational support, and reinforcement strategies, all of which may have contributed to sustained behavioral engagement and improved health-related outcomes.

These findings support previous Thai literature describing the applicability of the Transtheoretical Model in adults with metabolic syndrome⁽²⁰⁾.

Overall, the findings suggest that a TTM-based health behavior modification program may contribute to improvements in health behaviors and psychological determinants related to behavioral change among hospital personnel at risk of metabolic syndrome.

2. Contextual Factors Related to the Hospital Work Environment

The findings of this study are also relevant to the occupational context of hospital personnel. Although healthcare workers generally possess adequate health-related knowledge, they may encounter substantial barriers to maintaining healthy behaviors due to occupational demands such as shift work, high workload, fatigue, and time constraints^(10–13).

In addition to individual-level barriers, organizational and environmental factors also appear to play important roles. Hospital work environments are commonly characterized by high task intensity, prioritization of patient care, limited break time, and irregular work schedules, all of which may reduce opportunities for self-care and engagement in healthy lifestyle practices. Workplace culture among healthcare professionals may contribute to irregular eating behaviors, prolonged sedentary time, meal skipping, and insufficient physical activity during work shifts^(10–13).

These findings are consistent with recent evidence demonstrating that healthcare workers exposed to shift work and prolonged sedentary behavior are at increased risk for metabolic syndrome and unhealthy lifestyle behaviors^(10–12). Previous studies among healthcare personnel have also reported that workload demands and limited rest periods significantly hinder participation in regular physical activity and healthy dietary practices despite adequate knowledge regarding disease prevention^(10–12).

These contextual and organizational barriers may help explain why increased awareness may not always translate into substantial or sustained behavioral change.

3. Interpretation of Clinical and Behavioral Outcomes

In terms of clinical outcomes, although statistically significant differences between groups were not observed, the reduction in waist circumference within the intervention group and the increase observed in the comparison group may indicate a potential trend toward favorable clinical

improvement. Waist circumference is considered an important indicator of central obesity and cardiometabolic risk and is strongly associated with metabolic syndrome, type 2 diabetes mellitus, and cardiovascular disease outcomes^(1–3,6).

Even modest reductions in waist circumference may contribute to clinically meaningful long-term risk reduction if sustained over time^(14,15).

The absence of statistically significant interaction effects may be explained by several methodological and contextual factors. First, the relatively small sample size may have limited statistical power to detect between-group differences. Second, the duration of the intervention and follow-up period may not have been sufficient to capture sustained behavioral and metabolic changes. Third, the workplace setting may have introduced potential contamination between groups because participants worked within the same organizational environment.

Overall, the findings suggest that readiness-based interventions grounded in the Transtheoretical Model may facilitate gradual cognitive and behavioral improvements among hospital personnel with metabolic syndrome.

4. Strengths of the Study

This study has several notable strengths. First, the intervention was firmly grounded in the Transtheoretical Model, enabling systematic tailoring of strategies according to participants' readiness to change, thereby strengthening the theoretical rigor of the intervention design.

Second, the use of a cluster allocation design strengthened internal validity by minimizing contamination between groups in a real-world hospital environment.

Third, the study incorporated multiple measurement time points, allowing for more comprehensive evaluation of both short-term behavioral changes and temporal trends in clinical outcomes.

Finally, conducting the study in a naturalistic workplace setting enhances ecological validity and increases the applicability of findings to real-world health promotion programs in healthcare organizations.

5. Limitations of the Study

Several limitations should be considered when interpreting the findings. First, the study was conducted in a single private hospital, which may limit generalizability to other settings.

Second, the relatively small sample size may have reduced statistical power to detect significant between-group differences.

Third, the quasi-experimental cluster design may introduce potential baseline differences despite allocation procedures, which could influence outcomes. In addition, a statistically significant baseline difference in job category distribution between groups was observed, which may have influenced behavioral outcomes and limited comparability between groups.

Fourth, behavioral outcomes were self-reported and may be subject to recall bias and social desirability bias.

Finally, the relatively short follow-up period may not be sufficient to capture long-term behavioral maintenance and clinical changes.

Future multi-site studies with larger sample sizes and longer follow-up periods are recommended to confirm effectiveness and sustainability of the intervention.

Ethical Approval Statement

This research was approved by the Research Ethics Committee for Human Research, Faculty of Public Health, Mahidol University, on October 24, 2024, under project code MUPH 2024-113

Author Contributions

The first author contributed to study conception and design, data collection, statistical analysis, and manuscript drafting. The co-authors provided academic supervision, contributed to refinement of the study design, and critically revised the manuscript for important intellectual content. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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Conflicts of Interest

The authors declare no conflict of interest.

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