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RESEARCH ARTICLE

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Smartphone-based home workout program for shift-work nurses working during the COVID-19 pandemic

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Abstract

This study aimed to develop a smartphone-based home workout program for shift-work nurses to increase their levels of exercise and examine its effects on health (sleep disturbance, fatigue, musculoskeletal problems, and resilience) and nursing performance. For this quasiexperimental study with a nonequivalent control group, 54 shift-work nurses were recruited from two general wards at a hospital in Korea and assigned to the intervention and control groups. Nurses in the intervention group were encouraged to exercise regularly using the home workout application for 18 weeks. For the first 12 weeks, text-message counseling and environmental improvement were carried out; only environmental improvement was implemented in the remaining 12–18 weeks. The control group did not receive any intervention. After excluding dropouts, the data of the final 25 participants in the intervention group and 24 participants in the control group were analyzed. Compared with the control group, the intervention group showed statistically significant improvements in physical and psychological health. Hospital organizations could adopt a smartphone-based home workout program to overcome obstacles to exercise, which could lead to positive health outcomes for shift-work nurses.

KEYWORDS
exercise, health, health app, Korea, nurses, smartphone

Key points

- A smartphone-based home workout program could improve shift-work nurses' health.
- A smartphone-based home workout program could be useful under the restrictive conditions of the recent COVID-19 pandemic.
- The transtheoretical model-based guidelines could encourage nurses to maintain workout routines.

1 | INTRODUCTION

Due to the recent COVID-19 pandemic, social distancing has become the norm, and levels of physical activity are rapidly decreasing worldwide (Tison et al., 2020). Because these changes can lead to various physical and psychological health problems, health authorities around the world are establishing guidelines for physical activity that is possible even under restricted conditions (NHS Inform, 2021; WHO Europe, 2021).

Low levels of physical activity among nurses could affect their physical and psychological health, which could hinder the quality of nursing care and negatively affect patient safety (Ryu & Choi-

Kwon, 2020). Nurses should achieve an appropriate level of physical activity to maintain their physical and psychological well-being and nursing performance.

2 | BACKGROUND

The proportion of shift-work nurses with an appropriate level of physical activity is less than 50% of the general adult population in Korea (Lee & Chung, 2017). Medical personnel who worked in the recent COVID-19 pandemic have reported that they rarely engage in appropriate levels of physical activity during their nonwork hours (Diomidous, 2020). A low level of physical activity has been linked to poor sleep and a high level of fatigue, often accompanied by physical symptoms, such as musculoskeletal disorders (Jo et al., 2018; Kim & Yeo, 2017). A lack of physical activity makes it difficult to have positive emotions and lowers resilience (Carriedo et al., 2020). As nurses' health problems can directly affect patient safety (Ryu & Choi-Kwon, 2020), nurses should maintain appropriate levels of physical activity for physical and psychological well-being.

The low levels of physical activity among nurses can be attributed to nonstandard work schedules (e.g., rotating schedules including night shifts) and limited accessibility to regular exercise programs (Lee & Chung, 2017). Time constraint is the greatest obstacle to regular and consistent exercise (Suh, 2006). Therefore, when developing interventions to increase nurses' levels of physical activity, time flexibility is an important consideration. Smartphone-based home workout programs are designed to encourage exercise at home (or indoors) and have been applied in health management (Korean Consumer Agency, 2019). Although smartphone-based home workout programs could facilitate physical activity free of time and place constraints (Lee & Woo, 2019), there is a lack of research on shift-work nurses whose social activity is restricted due to the COVID-19 pandemic.

To motivate program users to continuously manage their health and provide bilateral feedback, strategies to attract users to use the programs must be implemented (Zhang et al., 2017). The transtheoretical model (TTM) may be useful in this case. The TTM is a comprehensive and integrated theory that explains individual health behaviors (Prochaska & DiClemente, 1983). It proposes five stages of change as follows: (1) precontemplation, (2) contemplation, (3) preparation, (4) action, and (5) maintenance. The TTM promotes the implementation of these stages by applying the appropriate processes of change (Prochaska & DiClemente, 1983). The stages of change are enhanced by emphasizing the benefits of physical activity and by using the processes of change (i.e., experimental and behavioral processes) (Romain et al., 2018). In recent studies, the TTM has been reported to induce meaningful changes in physical activity (Chen et al., 2020; Shaver et al., 2019). By supplementing the one-way interaction nature of application-based exercise programs, appropriate guidelines for each stage of the TTM could increase the motivation of participants. However, limited studies have included the TTM-based guidelines for smartphone-based home workout programs. Furthermore, exercise continuity following the termination of the researchers' intervention should be further investigated.

In our study, we developed a TTM-based home workout program to increase the level of physical activity of shift-work nurses and examined its effects on physical (sleep disturbance, fatigue, and musculoskeletal problems) and psychological (resilience) health indicators, along with nursing work performance as a work outcome. For an extended follow-up, we assessed these outcomes for 18 weeks.

3 | MATERIALS AND METHODS

3.1 | Study design

This was a quasiexperimental study with a nonequivalent control group and a pre- and posttest design.

3.2 | Participants and setting

This study was conducted in two general wards with 836 beds at a teaching hospital in a metropolitan city in South Korea from May to November 2020. To avoid any spillover effect from the intervention, we assigned each general ward to the intervention or control group. To minimize differences between the two groups, we selected two similar target wards (in terms of the specialty, team nursing system, and number of beds). The required number of participants was estimated using the G*Power statistical analysis software with $\alpha = 0.05$, $\beta = 0.20$, and effect size $= 0.80$; this indicated that a sample size of 21 per group was required. Considering that 30% of participants might drop out, we recruited 27 nurses per group (Figure 1). The inclusion criteria were nurses who had at least 3 months of experience as a registered nurse and were involved in 8-h rotating work schedules, including night shifts. Nurses who were pregnant were excluded. Of 54 participants, two nurses in the intervention group dropped out due to personal reasons and unit transfer, and three nurses in the control group dropped out due to unit transfer and resignation. After excluding the dropouts, the data of the final 25 participants in the intervention group and 24 participants in the control group were analyzed.

3.3 | Interventions

3.3.1 | Exercise using a smartphone-based home workout application

Initially, we reviewed the available smartphone applications for exercise to determine whether they met the guidelines for physical activity published by the US Department of Health and Human Services (2018), which include the following criteria: (1) users can choose physical activities that match their fitness level and/or health-related goals; (2) inexperienced users can start with a low-intensity exercise and

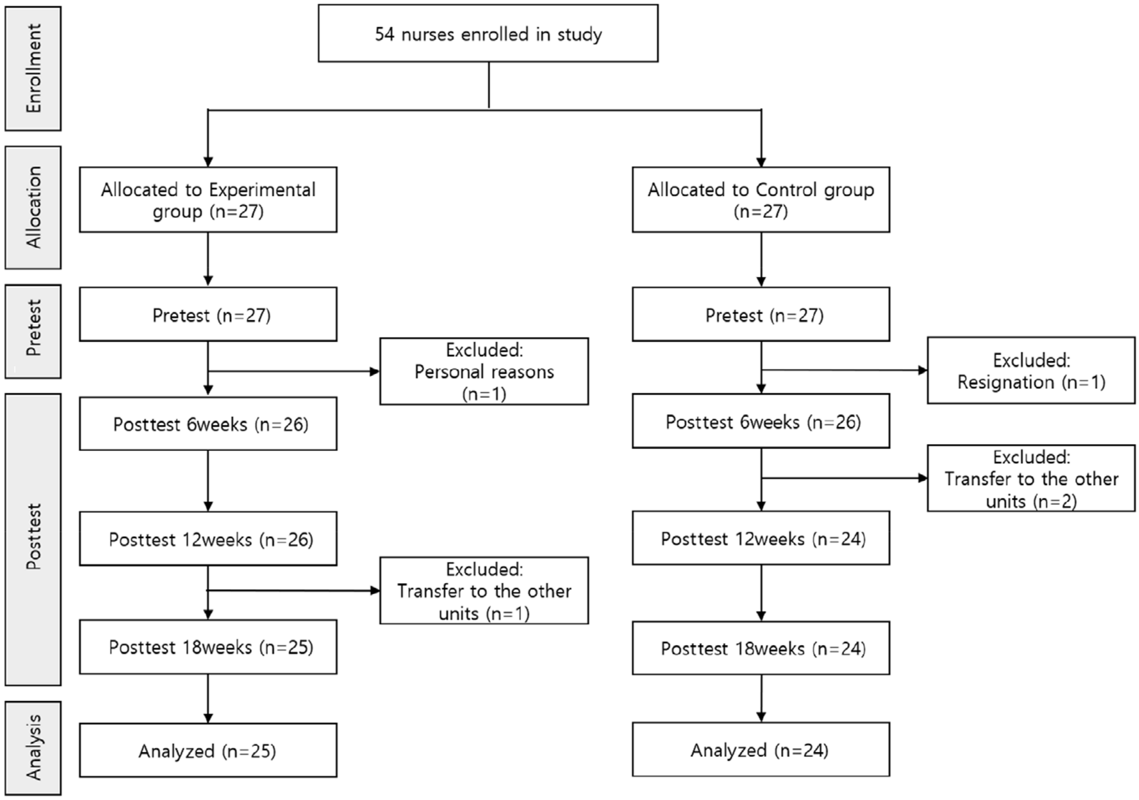

FIGURE 1 Flow diagram of the study

gradually increase the amount of physical activity; (3) users can do warmup and cooldown exercises; and (4) users can include strength training to stimulate all major parts of the body evenly. Because the temporal burden of exercise has been reported to be a significant obstacle to exercise and maintaining physical activity levels (Hardcastle et al., 2018), we selected applications with exercise modules of short duration so that users can easily adjust the duration of exercise. Finally, we selected an application that runs on Android and iOS devices and provides programs for strength/aerobic exercise (7 modules) and stretching (19 modules). The exercise modules were based on the 7-min workout method developed by the American College of Sports Medicine (ACSM; 2018), which includes full-body muscle exercise consisting of 12 major movements performed quickly and continuously, with repeating 30 s of high-intensity exercise and 10 s of rest. Its effectiveness has been verified worldwide (Mattar et al., 2017). The ACSM guidelines indicate that healthy adults should exercise 3–5 days per week. As a guideline, our program suggested that exercise using the home workout application should consist of (at least) one or two workouts per day for 3–5 days per week.

3.3.2 | Text-message counseling

Based on the TTM, those in the precontemplation stage were assumed to have no intention to exercise and participate in this study. We divided our participants into two groups of stages: (1) the contemplation and preparation stages for those who had not exercised but planned to exercise in this study or who exercised irregularly around one or two times a week (n = 22, 88% of the intervention group; n = 22, 92% of the control group), and (2) the action and maintenance stages for those who performed exercise regularly for 3 days or more a week (n = 3, 12% of the intervention group; n = 2, 8% of the control group).

We developed counseling guidelines for participants in the contemplation and preparation stages so that they could move on to the next positive change stage and for those in the action and maintenance stages to continue to exercise consistently (Table S1) (Stonerock & Blumenthal, 2017). Counseling guidelines for those in the contemplation and preparation stages involved cognitive experimental processes, such as consciousness raising (increasing interest in home workout by providing guidance on the exercise programs, methods, and effects), self reevaluation (helping to realize the relationship between one's behaviors and values and the intrinsic motivation for exercise), environmental reevaluation (informing that nurses who did not perform regular exercise could be an inappropriate role model for their patients), and social liberation coping strategies (helping to recognize that the home workout application is an appropriate alternative in social situations where various restrictions due to COVID-19 are imposed on exercising outdoors or in facilities).

For those in the action and maintenance stages, guidelines were developed concerning relationships (suggesting and encouraging exercise with closely associated people), reinforcement management (supporting the benefits of exercise, when recognized), counterconditioning (helping to relieve symptoms through stretching rather than lying down when feeling tired or experiencing musculoskeletal pain), and self-liberation as a coping strategy (helping users to commit to exercising and develop a belief that they can continue exercising).

3.3.3 | Environmental improvement

In line with TTM recommendations, we displayed a poster in the nurses' office to encourage exercise and remind nurses of the benefits of exercise as a stimulus control and coping strategy. We changed the poster's content every 2 weeks. In addition, we supplied exercise equipment every 4 weeks.

3.4 | Procedures

The experimental group used the home workout application for 18 weeks. Based on the previously developed TTM-based guidelines, text-message counseling and environmental improvement were carried out for 12 weeks by the research team to facilitate a positive stage of change and encourage home workouts. After 12 weeks, text-message counseling was discontinued; only environmental improvement (displaying posters to encourage exercise and supplying exercise equipment) was implemented until week 18 to confirm whether those in the experimental group maintained their level of physical activity without counseling intervention. The experimental group received text-message counseling once per week; during the counseling phase, each participant's exercise progress was examined, and regular workouts were encouraged. The control group did not receive any intervention related to home workout; control group participants were asked to maintain their usual lifestyles.

3.5 | Instruments

Before the intervention commenced, we assessed the participants' general characteristics and levels of sleep disturbance, fatigue, musculoskeletal problems, resilience, and nursing performance. In addition, at 6, 12, and 18 weeks, sleep disturbance, fatigue, subjective symptoms of musculoskeletal problems, resilience, and nursing performance were evaluated. For the intervention group, exercise adherence (whether or not exercise was performed, frequency of exercise, or when exercise was stopped) was assessed at 18 weeks. Permission has been received from the copyright holders to use and translate copyrighted instruments employed in the research.

Sleep disturbance was measured using the Insomnia Severity Index (Cho et al., 2014; Morin, 1993), which measures the degree of insomnia and the quality of sleep for the last 2 weeks. The index consists of seven 5-point Likert-type items (range 0–4) concerning the severity of insomnia symptoms, satisfaction with sleep, the degree to which sleep disturbance interferes with activity, and perception of sleep disturbance. The index is calculated as the sum of the item scores (range 0–28). Higher scores indicate more severely disturbed sleep.

The Korean version of the Multidimensional Fatigue Scale (Chang, 2000) was used to measure *fatigue* levels. It consists of 19 items, including general fatigue (8 items), daily life dysfunction (6 items), and situational fatigue (6 items). Each item is scored on a 7-point Likert-type scale (1 = strongly disagree; 7 = strongly agree). The scale score is the sum of item scores. A higher score indicates a higher level of fatigue.

Musculoskeletal problems were assessed by inquiring about symptoms in any part of the body (e.g., hand/finger/wrist, arm/elbow, shoulder, waist, leg/foot) in the past 4 weeks (Cohen, 1997). We asked whether pain or discomfort (aching, stiffness, burning, numbness, or tingling) had been felt in any part of the body in the past 4 weeks. If so, the duration, severity, and frequency of pain over the past 4 weeks were assessed. Musculoskeletal disorder cases were defined as having moderate to severe pain at least once during the past 4 weeks (Choi, 2005).

The Connor-Davidson Resilience Scale (Baek et al., 2010; Connor & Davidson, 2003) was used to measure the *resilience* of the participants. This scale has 25 5-point Likert-type items (0 = not at all; 4 = almost always) and is calculated as the sum of item scores (range, 0–100). A higher score indicates greater resilience.

Nursing performance was measured using the Performance Measurement Scale for Hospital Nurses (Ko et al., 2007), which adopts the items of the Your Own Performance Scale of Van de Ven and Ferry's (1980), an organizational evaluation tool for measuring clinical nurses' performance. This instrument, which is widely used in Korea (Han et al., 2020), has 17 items with options ranging from 1 (strongly disagree) to 7 (strongly agree). The scale score is calculated as the sum of the scores for each item (range, 17–68). A higher score indicates better nursing performance.

At 18 weeks, we distributed a structured questionnaire to the intervention group and asked them about their home workout experience using the smartphone application. Questions included whether exercise was maintained and the average frequency of workouts per week for the past 6 weeks. If exercise was not maintained, the time at which the exercise was stopped was determined.

3.6 | Statistical analysis

Data analysis was performed using SPSS version 26.0 (IBM, Armonk, NY, USA). Descriptive analyses of general characteristics and dependent variables were conducted using the frequency and percentage or mean and SD. Homogeneity between the two groups at baseline was examined using chi-square test with Fisher's exact test and an independent *t*-test. Changes in sleep disturbance, fatigue, musculoskeletal problems, resilience, and nursing performance were analyzed using a mixed model. Mixed model analysis is a comprehensive statistical technique that can account for correlations among data. This approach has the advantage of being able to handle dropout or missing values; thus, it is preferred to traditional approaches (e.g., repeated measures analysis of variance) in healthcare studies (Chakraborty & Gu, 2019). The maintenance of physical activity in the intervention group is expressed as the frequency and percentage. We conducted independent *t*-test and chi-square test with Fisher's exact test to examine differences in physical and psychological health and nursing performance at 18 weeks according to the frequency of exercise, including whether exercise was continued until the end of the program.

3.7 | Ethical considerations

The approval for this study was obtained from the Institutional Review Board of Hallym University Medical Center (IRB protocol number: HALLYM 2020-03-004-001). During the study, we strictly adhered to the research ethics guidelines. The purpose and procedure of the study were fully disclosed to the participants before study initiation. Written consent was obtained from the participants. This study was conducted in accordance with the principles of the Declaration of Helsinki. All participants gave informed consent for the research, and their anonymity was preserved.

4 | RESULTS

4.1 | Baseline characteristics of the participants

All participants were females. The mean age in the intervention group was 26 years, and the mean age in the control group was 29 years ($t = -1.71$, $p = 0.10$) (Table 1). Those with less than 5 years of registered nurse experience comprised 76% of the intervention group and 50% of the control group ($\chi^2 = 3.56$, $p = 0.08$). The number of night shifts worked was 5 per month in both groups ($t = -0.12$, $p = 0.90$). The proportion of nurses who engaged in regular physical activity for >3 days

TABLE 1 Baseline characteristics of the participants

	Intervention ($n = 25$) *n* (%) or *M* ± *SD*	Control ($n = 24$) *n* (%) or *M* ± *SD*	*t* or χ^2	*p*
Age (year)	26.2 ± 5.7	28.8 ± 5.0	$t = -1.71$	0.10
Gender				
Female	25 (100.0)	24 (100.0)		
Marital status				
Single	25 (100.0)	22 (91.7)	$\chi^2 = 2.17$	0.24
Married	0 (0.0)	2 (8.3)		
Educational attainment				
Associate	6 (24.0)	9 (37.5)	$\chi^2 = 1.08$	0.67
Bachelor of science in nursing	18 (72.0)	14 (58.3)		
Graduate	1 (4.0)	1 (4.2)		
Daily work hour	8.3 ± 0.4	8.4 ± 0.6	$t = -1.27$	0.21
Number of night shifts per month	5.3 ± 1.5	5.4 ± 1.6	$t = -0.12$	0.90
Position				
Staff nurse	24 (96.0)	24 (95.8)	$\chi^2 < 0.01$	>0.99
Charge nurse	1 (4.0)	1 (4.2)		
Years of registered nurse experience				
<5 years	19 (76.0)	12 (50.0)	$\chi^2 = 3.56$	0.08
≥5 years	6 (24.0)	12 (50.0)		
Height (cm)	161.7 ± 4.5	161.5 ± 4.1	$t = 0.18$	0.86
Body weight (kg)	57.0 ± 7.1	55.6 ± 7.4	$t = 0.70$	0.49
Participating in physical activity				
<3 days per week	22 (88.0)	22 (91.7)	$\chi^2 = 0.18$	>0.99
≥3 days per week	3 (12.0)	2 (8.3)		
Sleep disturbance	11.5 ± 7.0	11.8 ± 6.8	$t = -0.18$	0.86
Fatigue	92.0 ± 15.9	95.0 ± 14.8	$t = -0.68$	0.50
Musculoskeletal cases	14 (56.0)	14 (58.3)	$\chi^2 = 0.03$	>0.99
Resilience	58.8 ± 10.9	55.5 ± 11.6	$t = 1.03$	0.31
Nursing performance	50.0 ± 3.1	50.8 ± 4.5	$t = -0.72$	0.47

TABLE 2 Changes in physical and psychological health and work outcomes over time

	Baseline M ± SD or n (%)	6 weeks M ± SD or n (%)	12 weeks M ± SD or n (%)	18 weeks M ± SD or n (%)	F	p
Sleep disturbance						
Intervention	11.5 ± 7.0	7.9 ± 5.8	6.1 ± 4.5	7.1 ± 5.0	Group = 5.32	0.03
Control	11.8 ± 6.8	12.0 ± 6.6	11.5 ± 7.1	11.7 ± 6.4	Time = 6.71	<0.01
					Group × time = 5.41	<0.01
Fatigue						
Intervention	92.0 ± 15.9	86.1 ± 19.3	83.8 ± 17.4	81.8 ± 16.5	Group = 5.98	0.02
Control	95.0 ± 14.8	96.2 ± 16.4	94.8 ± 15.0	97.7 ± 16.2	Time = 1.96	0.10
					Group × time = 3.90	0.01
Musculoskeletal cases						
Intervention	14 (56.0)	9 (36.0)	8 (32.0)	3 (12.0)	Group = 0.12	0.73
Control	14 (58.3)	13 (54.2)	10 (41.7)	13 (54.2)	Time = 4.13	0.01
					Group × time = 2.77	0.04
Resilience						
Intervention	58.8 ± 10.9	61.3 ± 11.0	63.9 ± 12.7	67.0 ± 14.2	Group = 3.81	0.08
Control	55.5 ± 11.6	57.9 ± 13.6	57.0 ± 15.7	56.3 ± 15.6	Time = 4.36	0.01
					Group × time = 3.67	0.01
Nursing performance						
Intervention	50.0 ± 3.1	52.0 ± 3.7	53.1 ± 4.3	54.0 ± 5.2	Group = 0.83	0.37
Control	50.8 ± 4.5	51.1 ± 6.4	51.8 ± 3.7	51.7 ± 4.4	time = 5.61	<0.01
					Group × time = 2.08	0.11

per week was 12% ($n = 3$) in the intervention group and 8% ($n = 2$) in the control group ($\chi^2 = 0.18$, $p > 0.99$). There were no statistically significant differences in general characteristics between the two groups.

There were no differences in physical health between the groups at baseline ($t = -0.18$, $p = 0.86$ for sleep disturbance; $t = -0.68$, $p = 0.50$ for fatigue; $\chi^2 = 0.03$, $p > 0.99$ for proportion of participants with musculoskeletal problems).

4.2 | Changes in health and work outcomes in the intervention and control groups

The levels of sleep disturbance and fatigue were significantly lower in the intervention group than in the control group (group: $F = 5.32$, $p = 0.03$ for sleep disturbance; $F = 5.98$, $p = 0.02$ for fatigue) (Table 2). The interaction terms of group × time were statistically significant, indicating that sleep disturbance and fatigue were significantly different between the two groups. Decreases in sleep disturbance and fatigue were observed only in the intervention group; however, there were no changes in the control group over time (group × time: $F = 5.41$, $p < 0.01$ for sleep disturbance; $F = 3.90$, $p = 0.01$ for fatigue). Similarly, a significant group-by-time interaction was observed for musculoskeletal problems (group × time: $F = 2.77$, $p = 0.04$); a decrease was observed in the intervention group, whereas no change was observed in the control group. As a psychological health indicator, resilience showed a significant group-by-time difference (group × time: $F = 3.67$, $p = 0.01$), which was increased in the intervention group and remained the same in the control group. However, nursing performance (work outcome) did not differ (group: $F = 0.83$, $p = 0.37$); the pattern of change was similar between the two groups (group × time: $F = 2.08$, $p = 0.11$).

4.3 | Maintenance of physical activity in the intervention group

In the intervention group, 84% ($n = 21$) of the participants continued to exercise until the end of the program (Table 3). No participant reported exercising more than 6 days per week; 60% ($n = 15$) and 24% ($n = 6$) of these participants reported exercising 3–5 days per week and 1–2 days per week, respectively. Among those who did not complete the 18-week program (16%, $n = 4$), half of them stopped exercising 1 week before the end of the program, and half of them stopped exercising 2 weeks before the end of the program.

There was no significant difference in health status at 18 weeks between participants who continued to exercise until the end of the program ($n = 21$) and those who stopped exercising during the study period ($n = 4$). Among those who continued to exercise until the end of the program ($n = 21$), health status did not differ significantly according to the frequency of physical activity (i.e., those who exercised 1–2 days per week [$n = 6$] vs. those who exercised 3–5 days per week [$n = 15$]).

TABLE 3 Differences in physical and psychological health and nursing performance at 18 weeks by (1) whether or not participants completed the program, and (2) the frequency of exercise among the intervention group

	Those who continued to exercise until the end of program ($n = 21$) M ± SD or n (%)	Those who stopped exercise during the program ($n = 4$) M ± SD or n (%)	t or χ^2	p	Those who exercise 1–2 days a week ($n = 6$) M ± SD or n (%)	Those who exercise 3–5 days a week ($n = 15$) M ± SD or n (%)	t or χ^2	p
Sleep disturbance	7.1 ± 4.9	6.8 ± 6.2	$t = 0.14$	0.41	7.3 ± 5.1	7.1 ± 5.0	$t = 0.11$	0.91
Fatigue	79.8 ± 16.6	92.0 ± 13.2	$t = -1.38$	0.11	77.5 ± 14.7	80.7 ± 17.7	$t = -0.40$	0.70
Musculoskeletal cases	3 (14.3)	0 (0.0)	$\chi^2 = 0.65$	>0.99	1 (16.7)	2 (13.3)	$\chi^2 = 0.04$	>0.99
Resilience	66.0 ± 14.6	72.0 ± 12.1	$t = -0.77$	0.50	65.3 ± 15.6	66.3 ± 14.7	$t = -0.13$	0.90
Nursing performance	53.8 ± 5.4	55.0 ± 4.6	$t = -0.43$	0.88	54.0 ± 6.7	53.7 ± 5.1	$t = -0.12$	0.90

5 | DISCUSSION

In contrast to the findings of a previous study showing that approximately 20% of shift-work nurses regularly exercise at least 3 days per week (Lee & Chung, 2017), at baseline, only 10% of the participants in our study exercised at that level (12% in the intervention group and 8% in the control group). This level of physical activity is particularly low compared with that of the general adult population (50%) during the COVID-19 pandemic (López-Bueno et al., 2020). Physical activity has declined sharply around the world because of social distancing guidelines due to COVID-19 (Tison et al., 2020). In the face of the pandemic, healthcare workers have been reported as not engaging in adequate levels of physical activity in their spare time (Diomidous, 2020). In our study, the proportion of those exercising 3 or more days per week in the intervention group was increased five times at 18 weeks (60%, $n = 15$) compared with the baseline (12%, $n = 3$). Smartphone applications have the advantage of overcoming the barriers of place and time (Lee & Woo, 2019); they are easy to use due to fewer constraints from shift-work schedules. Our program included text-message counseling and environmental improvement to encourage the participants to maintain their workout routines at home, which led to improvements in the nurses' physical and psychological health.

Increased physical activity can promote psychological and emotional stability, which in turn improves sleep quality (Song et al., 2018; Susanti et al., 2022). Increased blood circulation and metabolism can effectively reduce fatigue-inducing factors (Yun, 2019). While participating in our home workout program, the proportion of nurses with musculoskeletal symptoms in the intervention group showed a steady decrease from 56% at baseline to 12% at 18 weeks. This might be attributed to aerobic exercises that could strengthen the muscles, as well as stretching that could reduce muscle tension (Umehara et al., 2018). A previous study has reported the beneficial effects of 4-week exercise programs for nurses (Ryu & Choi-Kwon, 2020). Our study provides evidence for the benefit of longer interventions and the maintenance of physical activity.

While working out at home using the smartphone application, social relationships may be strengthened by maintaining supportive relationships with peer nurses. As physical activity levels increase, negative emotions (e.g., stress) may decrease, and constructive and positive thinking may increase (Carriedo et al., 2020). Such changes may bring about increased resilience—a psychological strength that can support one's growth and ability to overcome difficulties. Resilience is a quality that has attracted attention as a psychological factor related to coping with the circumstances of the COVID-19 pandemic (Barzilay et al., 2020). Our study demonstrated an effective intervention that could increase the resilience of nurses in limited social situations and further improve their health.

After 12 weeks of intervention, text-message counseling was discontinued, and only environmental improvement was implemented to determine whether the participants maintained their workout routines voluntarily during the final 6 weeks. Our findings revealed that workout routines were maintained for a certain period among those who stopped exercising in the intervention group ($n = 4$). Health status was similar at 18 weeks between those who stopped exercising and those who completed the program, as exercise cessation happened only 1–2 weeks before the end of the study. Furthermore, health status was similar irrespective of the frequency of exercise. A 7-min exercise can produce beneficial effects even if it is performed only once per week (Mattar et al., 2017). As most of the strength and aerobic exercises in the application were introduced as 7-min modules (as recommended by the ACSM), the degree of improvement was similar between those who exercised only 1–2 days per week and those who exercised 3–5 days per week.

No significant interaction of time and group was observed for nursing performance, thus suggesting that our intervention did not lead to a positive work outcome. Especially during the COVID-19 pandemic where nurses experience a substantial increase in patient care demands, our program would not be sufficient to have a considerable beneficial effect on work performance. However, both the intervention and control groups showed a similar pattern of increasing nursing performance over time. The increase in nursing performance in both groups may be explained by the accumulation of clinical experience over time (Kim & Park, 2019). Although the difference in nursing performance in relation to increasing physical activity was insignificant, the nursing performance of the intervention group showed a tendency to increase more steeply than that of the control group during the 18-week study period. It is necessary to further investigate the effect of increased physical activity on nursing performance through longer interventions and follow-up assessments.

Our study findings should be interpreted with caution considering the limitations of the study. First, as this study recruited nurses from a single teaching hospital, the study findings might not be generalizable. Second, the participants were not randomly assigned to the intervention and control groups, which threatens the study's internal validity. Although homogeneity between the groups was observed in terms of participant characteristics at baseline, the possibility that unmeasured factors may affect the results could not be excluded. Finally, data were self-reported and thus might be susceptible to response bias, such as recall, denial, and social desirability. Future studies should include larger sample sizes recruited from multiple organizations and randomly assigned to the intervention and control groups. Objective outcome measures, for example, the use of a device to measure sleep quality, and a longer follow-up should be considered.

6 | CONCLUSION

Our findings provide important evidence regarding the positive effects of a smartphone-based home workout program for shift-work nurses. In a situation where social activity is restricted due to the COVID-19 pandemic, our home workout program, available as a smartphone application, could effectively overcome obstacles to physical activity that are faced by shift-work nurses. Although smartphone applications for physical exercise have been reported to lack motivational features to encourage their continuous use, the TTM-based guidelines can compensate for this inherent shortcoming and promote exercise and health. Hospital organizations could adopt a smartphone-based workout program to promote positive changes, both physically and mentally, for shift-work nurses.

7 | RELEVANCE TO CLINICAL PRACTICE

In a situation where social activity is restricted due to the COVID-19 pandemic, our home workout program, available as a smartphone application, could effectively overcome obstacles to physical activity that are faced by shift-work nurses. Hospital organizations could adopt a smartphone-based workout program to promote positive changes, both physically and mentally, for shift-work nurses. Although smartphone applications for physical exercise have been reported to lack motivational features to encourage their continuous use, the TTM-based guidelines can compensate for this inherent shortcoming and promote exercise and health.

AUTHOR CONTRIBUTIONS

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DATA AVAILABILITY STATEMENT

Data available on request due to privacy/ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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