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The Effectiveness of a mHealth Program Using Wearable Devices and Health Coaching among Bus Drivers for Promoting Physical Activity

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Purpose: Bus drivers are at high risk of chronic diseases due to risk factors associated with poor diet, physical inactivity, high levels of sedentary behaviors, and unfavorable working environments. This study developed a mHealth program for bus drivers, and examined the effectiveness of a mHealth program for promoting physical activity among bus drivers using wearable devices and health coaching. **Methods:** Forty-seven workers from two bus companies were allocated to the experimental group and the control group. Participants were asked to wear a wearable device (Fitbit Charge HR) during waking hours for a day. Participants in the experimental group were provided with a Fitbit, weekly face-to-face health coaching, a mHealth workbook, and text and photo messaging for 12 weeks. The control group only received a Fitbit. **Results:** By week 12, there were significant differences between the experimental and control groups in exercise self-efficacy ($p<.015$) and daily walking steps ($p<.001$). **Conclusion:** The findings have demonstrated that the mHealth program using wearable devices and health coaching is effective for bus drivers for promoting physical activity. Based on our findings, it is recommended to encourage the mHealth program using wearable devices and health coaching for bus drivers' wellness.

Key Words: Exercise; Mentoring; Telemedicine; Wearable electronic devices

INTRODUCTION

Bus drivers are predisposed to work-related musculoskeletal disorders as they have to maintain the same driving posture continuously and sit for a long time at work during workdays [1]. Moreover, they are at high risk group for cardiovascular disease (CVD) due to long work hours of 52 or more hours per week and irregular shifts [2]. In particular, bus drivers are exposed to poor working environments, including insufficient breaks due to short bus dispatch intervals, irregular mealtimes, and exposure to noise and whole-body vibration while driving [1-3]. Work schedules of Korean bus drivers is 12-hour shifts or 8-hour shifts, and their dispatch times and break times vary from workplace [4]. A systematic review of health and wellness among long-haul truck and bus drivers in the US and Canada revealed vulnerability to risk factors, such as lack of physical activity, which may cause CVD and diabetes [5].

Because lack of physical activity is a significant factor in increasing health risks, such as coronary artery disease and CVD [6], it is essential to increase physical activity to prevent chronic diseases and promote wellness. According to the Korea National Health and Nutrition Examination Survey (KNAHES), the proportion of adults aged 19~64 who walked for at least 150 minutes over the previous week showed a decreasing trend from 58.3% in 2014 to 47.8% in 2019 [7]. Among men, in particular, the proportion decreased with age, with 68.4% of men between 19 and 29 indicating walking compared to 40.9% among men between 50 and 59, and the downward trend was clearer in men than in women of the same age ranges [7]. As a large number of bus drivers are middle-aged or older men who sit on the job for prolonged periods of driving and non-driving time [2], a program for bus drivers to increase

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physical activities should be developed.

As wearable tracking devices have been developed, which can influence health behaviors such as increasing physical activity with rapid advancements in information communication technology, research on mobile Health (mHealth) to promote physical activity is actively conducted [8]. Wearable tracking devices have been demonstrated to help study participants change health behaviors by providing daily steps and pulse rate data, thereby allowing people to self-monitor their health behavior [9]. However, a systematic review on the effectiveness of mHealth reported that positive effects of mHealth were not consistently observed, as it would be difficult to continue improving physical activity by using a wearable tracking device alone due to limitations of self-motivation [10]. Therefore, the mHealth program to improve physical activity for bus drivers should be considered by incorporating effective motivational strategies, such as text messages, photo messages, apps, and personal coaching [10-12]. Text messaging on phones is currently under investigation as a form of mHealth service owing to its ability to continuously motivate users by sending motivational messages in real-time without temporal or spatial restrictions [11]. Moreover, the effectiveness can be maximized by reinforcing individualized goal-setting and customized health coaching to promote physical activity custom fit each user's characteristics [12].

Specifically, bus drivers are considered a vulnerable population for participating in health promotion or wellness programs by institutions and public health centers due to unfavorable working environments with irregular shifts and long working hours [13]. Given that this population is more likely to develop various chronic diseases, customized interventions are required to promote physical activity provided at their workplaces or everyday lives. The mHealth program using mobile health technology might effectively engage the bus drivers in wellness programs [14]. To date, however, studies on mHealth programs for promoting physical activity among bus drivers are lacking, even though a large number of studies have examined the effectiveness of mHealth programs targeting adult men and women of various ages. Therefore, this study aimed to develop a mHealth program to promote physical activity using a wearable devices (Fitbit Charge HR, FB405, San Francisco, US) and health coaching, and then examine the effectiveness of the program on daily steps, exercise self-efficacy, autonomous motivation to exercise, and physiological indices, such as blood pressure and blood glucose level.

METHODS

1. Participants

Study participants were bus drivers working at two bus companies, C and S, including approximately 100 employees respectively. Both companies provided bus transportation services, were of similar size and had similar characteristics of workers. The companies were a 20-minute drive by car from each other, which restricted daily interactions between workers. The experimental group was conveniently sampled from workers of C company, while the control group was recruited from workers at S company. Announcements with inclusion and exclusion criteria were posted in front of the company cafeterias and on company message boards to recruit participants. The inclusion criteria of participants were age between 19 and 65 years, having a smartphone, and receiving text messages and photo messages. Exclusion criteria were contraindications for exercise, such as chest pain, CVD, and musculoskeletal disorders.

The sample size was calculated using the G*power software program with version 3.1.9.2. The criteria for independent t-test were as follows: statistical power ($1-\beta$) of .80, significance level (α) .05, effect size (d) 0.50. It was indicated that we needed a total of 54 participants (27 people per group). Due to the difficulty in recruiting participants, we recruited 54 participants, with 27 in the experimental group and 27 in the control group for the study. After excluding seven data due to withdrawal from the mHealth program, a total of 47 data were analyzed.

2. Procedure

1) Development of the mHealth program for promoting physical activity using Fitbit and health coaching

A 12-week mHealth program for promoting physical activity was designed, where Fitbits, weekly personal coaching, workbooks, and daily text messages and weekly photo messages were provided to participants in the experimental group. The Fitbit provided real-time information regarding physical activity, thereby allowing bus drivers to self-monitor their activities. The participants in the experimental group were given mHealth workbooks that included long-term and short-term goals for physical activity, recommended daily steps, good nutrition, and prevention of chronic diseases. Based on each participant's physical activity level and daily steps identified through the mHealth portal, weekly face-to-face health coaching was provided. The text messages sent to the participants included motivational text, such as "It is Monday, the day you set your goal for daily steps! The target steps of this week for [participant's name] is [the number of daily steps set as the goal for the participant] steps. Let us be active and walk vigorously today" health information text, such as "From the moment you exercise slightly out of breath for 20 minutes or more, your health indicators will improve," and supportive and encouraging text, such as "It is not easy to exercise in hot weather, right? How about exercising indoors to achieve your goal?" On Mondays, motivational texts were sent to remind the workers of their health goals and help them plan and set their weekly targets. In addition, photo messages were sent every Sunday, which contained graphs showing the extent of physical activity over the last seven days to help the participants visually monitor their physical activity levels.

2) Administration of a mHealth program

The mHealth program for promoting physical activity using Fitbit and health coaching was administered for 12 weeks. The experimental group was provided with Fitbit devices, mHealth workbooks, weekly face-to-face health coaching by the research team, and text and photo messages. The workers in the experimental group attended a program orientation and signed a written consent declaring active participation in the program and goal achievement. After the orientation, the participants were instructed regarding Fitbit operation and checking health information and physical activity. The participants were informed that the research team could monitor their health behavior information through the mHealth portal system linked to workers' Fitbit. The control group was provided with only Fitbits to monitor their health behavior. For ethical considerations, the control group was provided with the mHealth workbook and health coaching after completing the program in the experimental group.

In Week 1 of the mHealth program, the objective was for the participants to recognize their physical activity level by assessing current physical activity level. Education was provided about the importance of daily physical activity. During personal coaching, the participants were encouraged to set long-term goals through the 12-week mHealth program and short-term goals of each week. Text messages were sent to help participants reach their short-term and long-term goals of physical activity. The objective of the mHealth program in Weeks 2~7 was to increase their daily steps gradually to a desirable level identified through program participation at Week 1. Education of mobile health workbook was provided; the dosage of aerobic exercise about frequency, intensity, and duration of exercise, identifying barriers of exercising, offering problem-solving strategies to improve exercise self-efficacy, and teaching ways to increase the amount of physical activity by 15~20%. Weekly individual health coaching was given, including checking whether daily steps were reached based on their short-term goals in the previous week. Based on the personal health coaching and daily step account through Fitbit, personalized motivational text messages and photo messages were sent on a weekly basis. In Weeks 8~12, the objective was to maintain increased physical activity and exercise intensity at 50~60% of the target heart rate. Education was given about checking the target heart rate on Fitbit, the meaning of 50~60% of the target heart rate, and ways to perform activities to reach the level. Weekly health coaching included monitoring of workers' target heart rate and checking short-term goals in each previous week. Like Weeks 2~7, text and photo messages to help bus drivers promote physical activity were sent (Table 1).

3. Measurements

Daily steps. Daily steps mean the average value of the number of using a wearable device (Fitbit Charge HR, FB 405, San Francisco, US). Fitbit contains a three-axis accelerometer which tracks motion patterns, an altimeter, which tracks altitude changes, and an optical heart rate tracker, which continuously monitors heart beats [15-17]. Fitbit is the most commonly used brand regarding movement sensors, which has proven to be a useful and reliable activity tracker in medical research [15-17]. The daily step-count was collected from Fitbit. Workers wore the Fitbit Charger HR on their wrists during waking hours for an entire day, and the number of steps measured with the Fitbit was uploaded to the worker's personal smartphone and the manager's website in real time every minute. For check the result of the step data, the worker could check the number of steps in a graph or number on a minute, daily, or weekly basis through a smartphone. The research team was able to check the number of steps in real time through the mobile health portal linked to the worker's Fitbit.

Exercise self-efficacy. The exercise self-efficacy assesses confidence in the ability to exercising in high-risk situations [18]. The scale consists of 8-item, and higher scores represent higher self-efficacy for exercise. The responses ranged from 1 (not at all sure) to 5 (absolutely sure). The total scores ranged from 8 to 40; higher scores indicate greater exercise self-efficacy. The Cronbach's α for this study was .95 for the perceived competence.

Autonomous motivation to exercise. Autonomous motivation to exercise was evaluated by the Treatment Self-

Table 1. Contents of a mHealth Program using Wearable Devices and Health Coaching for Promoting Physical Activity

Week	Contents
Orientation	Introduction to mHealth program
	Fitbit provision and installation of the Fitbit app
1st week	Objective: Recognize one's physical activity level by assessing current physical activity level
	1. Fitbit self-monitoring
	2. Education of mobile health workbook: Importance of daily physical activity
	3. Weekly health coaching: Set long-term goals through the 12~week mHealth program and short-term goals of each week
	4. Customized daily text messaging based on health coaching contents
2nd~7th week	Objective: Increase one's daily steps gradually to a desirable level identified through program participation at week 1
	1. Fitbit self-monitoring
	2. Education of mobile health workbook: The dosage of exercise about frequency, intensity, and duration of exercise, identifying barriers of exercising, offering problem-solving strategies to improve exercise self-efficacy, and teaching ways to increase the amount of physical activity by 15~20%
	3. Weekly health coaching: Checking whether daily steps were reached based on their short-term goals in the previous week and establishing an activity plan
	4. Customized daily text messaging based on health coaching contents
8th~12th week	Objective: Maintain increased physical activity and exercise intensity at 50~60% of the target heart rate on Fitbit
	1. Fitbit self-monitoring
	2. Education of mobile health workbook How to calculate target heart rate, checking the target heart rate, the meaning of 50~60% of the target heart rate, and ways to perform activities to reach the level.
	3. Weekly health coaching: Monitoring their target heart rate, checking whether daily steps were reached based on their short-term goals in the previous week, and establishing an activity plan
	4. Customized daily text messaging based on health coaching contents

Regulation Questionnaire-exercise (TSRQ-exercise) [19]. The TSRQ-exercise consisted of three subscales, including amotivation (3 items), controlled motivation (6 items), and autonomous motivation (6 items). The scale is a 6-item questionnaire to assess autonomous motivation for exercise in this study. Responses are given a 7-point Likert scale ranging from 1 (not at all true) to 7 (very true). Participants responded to: ‘The reason I would exercise regularly is…'. Higher scores indicate a greater level of autonomous motivation. The Cronbach's α for this study was .89 for the autonomous motivation to exercise.

Physiological indices: Blood pressure and blood glucose level. Blood pressure was measured using an electronic sphygmomanometer (HEM-7122, Omron, Japan). After the participants was allowed to sit on a chair and rested for at least 10 minutes, they were not allowed to move or speak during the measurement. For blood glucose level, participants kept fasting for more than 10 hours, and measured using a simple blood glucose meter (Accu-Chek Active, ROCHE, Germany).

4. Data Collection

After receiving the approval of an institutional review board (IRB No. A17-Y-0019), the researcher visited the two bus companies to obtain permission for conducting research from the management at each company. After permission was obtained, pre- and post-survey, blood pressure, and blood glucose level tests were administered to bus drivers at the workplace. A nurse with two years or more of clinical experience was hired as a researcher conducting data collection. The study investigator was blinded to group allocation, informed of the study purposes and procedure, and trained regarding the surveys, blood pressure measurement, and blood testing methods.

5. Data Analysis

The collected data were analyzed using the SPSS/WIN 25.0 program. First, the general characteristics of the participants were analyzed using the average standard deviation of the frequency percentage. Second, a homogeneity test was conducted using a x^2 and independent t-test. Third, the effectiveness of the intervention on daily steps, exercise self-efficacy, autonomous motivation to exercise and physiological indices using paired t-test, independent t-test

RESULTS

1. Homogeneity of General Characteristics in Participants

There were no significant differences in general characteristics and variables between the two groups (Table 2). There were 24 participants in the experimental group and 23 participants in the control group. Their average age was 53.33~54.43 and their average working experience was 13.09 (experimental group) and 11.52 (control group), respectively.

2. Effectiveness of a Mhealth Program for Promoting Physical Activity Using Fitbit and Health Coaching

There were statistically significant differences between the two groups in daily steps (t=3.89, $p<.001$) and exercise self-efficacy (t=2.54, $p=.015$). However, there was no significant difference between the two groups in autonomous motivation to exercise (t=1.43, $p=.161$), systolic BP (t=-0.48, $p=.630$), diastolic BP (t=0.04, $p=.971$), and blood glucose level (t=-0.16, $p=.671$) as indicated in Table 3.

DISCUSSION

The mean age of the participants was 53.8, which aged drivers are required to accurately recognize their health status and establish health promoting behavior for the rest of their healthier working life [20]. Literature reviews on workers in transportation companies have demonstrated that drivers are a highly vulnerable working population with limited opportunities to access resources to improve their health and wellness due to poor working conditions [5,20-21]. Therefore, as it is necessary to develop a wellness program for bus drivers, the mHealth program using Fitbit and health coaching for promoting physical activity is developed to improve drivers' wellness.

Our findings indicated that daily steps in the experimental group significantly increased by over 3,000 steps after participation in the mHealth program, whereas daily steps in the control group did not change, with a significant between-group difference. These results were in line with those of previous studies using a smartphone app-based walking program and an exercise program using a pedometer among taxi drivers, which found that the daily

Table 2. Homogeneity Test of Characteristics of the Participants (*N*=47)

Characteristics	Categories	Exp. (n=24)	Cont. (n=23)	x^2 or t (p)
		n (%) or M±SD	n (%) or M±SD	
Age (year)		53.33±6.50	54.43±5.49	-0.63 (.534)
Gender (Male)		24 (100.0)	23 (100.0)	-
Marital status	Married	20 (83.3)	20 (87.0)	0.12 (.727)
	Single	4 (16.7)	3 (13.0)	
Educational level	High school	20 (83.3)	16 (69.6)	1.21 (.265)
	≥College	4 (16.7)	7 (30.4)	
Working experience (year)		13.09±10.16	11.52±6.76	0.61 (.548)
Comorbidities of chronic diseases	Yes	12 (50.0)	13 (56.5)	0.20 (.654)
	No	12 (50.0)	10 (40.5)	
Daily steps (steps/day)		9,817.92±2,325.31	10,458.39±2,270.90	-0.96 (.345)
Exercise self-efficacy		2.96±1.04	3.08±0.75	-0.44 (.660)
Autonomous motivation to exercise		4.28±1.34	4.23±1.47	0.11 (.912)
Systolic blood pressure		132.08±9.37	131.91±12.09	0.05 (.957)
Diastolic blood pressure		88.25±9.45	85.57±8.39	1.03 (.309)
Blood glucose level		144.17±69.84	145.65±46.07	-0.09 (.932)

Cont.=control group; Exp.=experimental group.

Table 3. Effectiveness of the mHealth Program (*N*=47)

Variables	Group	Pretest	Posttest	Effect by point	Intergroup effect
		M±SD	M±SD	t (*p*)	t (*p*)
Daily steps	Exp.	9,817.92±2,325.13	13,615.83±3,755.13	6.95 (<.001)	3.89 (<.001)
	Cont.	10458.39±2270.90	11,196.00±3,167.79	1.30 (.207)	
Exercise self-efficacy	Exp.	2.96±1.04	3.51±0.81	4.18 (<.001)	2.54 (.015)
	Cont.	3.07±0.75	3.14±0.89	0.45 (.655)	
Autonomous motivation to exercise	Exp.	4.28±1.34	5.17±1.16	3.52 (.002)	1.43 (.161)
	Cont.	4.24±1.47	4.54±1.36	0.95 (.354)	
Objective health status					
Systolic BP	Exp.	132.08±9.37	125.08±10.79	-2.45 (.004)	-0.48 (.630)
	Cont.	131.91±12.10	126.52±11.38	-2.17 (.041)	
Diastolic BP	Exp.	88.25±9.45	81.58±9.25	-2.72 (.012)	0.04 (.971)
	Cont.	85.57±8.39	78.74±17.33	-1.89 (.073)	
Blood glucose level	Exp.	144.17±69.84	135.58±38.38	-0.49 (.625)	-0.16 (.871)
	Cont.	145.65±46.09	140.35±33.10	-0.55 (.587)	

BP=blood pressure; Cont.=control group; Exp.=experimental group.

steps increased by 600~2,000 steps in the experimental group, with significant differences between experimental and control group [22]. The reason for a significant increase of daily steps of drivers in the experimental group is due to the continuous motivation provided by the weekly face-to-face health coaching to monitor the seven-day physical activity level and check achievement of long-term and short-term goals on a weekly basis. In addition, motivational text messages and customized photo messages visualizing daily steps over the last seven days would influence the participants in achieving their short-term goals on daily steps.

Exercise self-efficacy in the experimental group greatly improved after the mHealth program, while the control group showed little change, with a statistically significant difference between the two groups. This finding was consistent with previous studies, which reported significant increases in exercise self-efficacy after participation in interventions using Fitbit or smartphone apps [22-24]. Exercise self-efficacy refers to confidence regarding one's own ability to continue performing exercise under any circumstances and is an important factor in self-initiating and maintaining exercise [25]. Bandura [26] argued that self-efficacy stems from the experience of mastering health behavior, verbal persuasion, vicarious experience, and physiological feedback. Exercise self-efficacy in the present study probably increased, as the mHealth program helped the participants gain the experience of goal achievement through setting short-term and long-term goals for daily walking steps and supporting them during individual health coaching. Moreover, it is possible that exercise self-efficacy probably increased due to vicarious experience, as the researcher made weekly visits to the transportation company to meet bus drivers and provided opportunities to seeing other similar drivers performing an exercise successfully.

Systolic and diastolic blood pressure significantly decreased in the experimental and control groups; however, the between-group difference was not statistically significant. As blood pressure decreased even in the control group, which received only Fitbits, the significant decrease in systolic and diastolic blood pressure in the experimental group cannot be considered an effect of the mHealth program. According to the systematic review on the relationships between blood pressure and cardiovascular disease, the risk for major CVD significantly decreases by reducing systolic and diastolic blood pressure by 10 mmHg [27]. The participants in this study were men in their 50s, and decreased risk for major CVD due to a reduction of blood pressure by 5~8mmHg in the experimental and control groups is of significance from the perspective of health promotion and disease prevention among middle-aged men.

This study was the first to examine the effectiveness of the mHealth program for wellness that could be applied at the workplace in transportation service companies by using Fitbit and health coaching to promote physical activity among bus drivers. In addition, the bus drivers' physical activity was objectively assessed using Fitbit to count the number of steps. However, this study had some limitations. First, as participants were conveniently sampled from workers in city bus transportation companies in a single small-to-medium city, the results may not be generalizable. A follow-up study should be conducted with workers across several companies providing various transportation services, considering city size and company characteristics. Second, participants were not randomly assigned to either the experimental or control group based on the bus company they worked for; therefore, intervention outcomes may have been influenced by exogenous variables. In the future, the effects of the mHealth program should be tested in a randomized control group study. Third, it is necessary to conduct a follow-up study with a larger number of participants to increase the effect on the research findings since statistical analysis was performed with a smaller number of data. Finally, this program can be performed only for those who can use wearable devices and smartphone.

CONCLUSION

This study aimed to develop a mHealth program for bus drivers using Fitbit and health coaching to improve physical activity and examine the effectiveness of the mHealth program on the daily steps, exercise self-efficacy, autonomous motivation to exercise, and physiological indices including blood pressure and blood glucose level. The findings demonstrated that the mHealth program was effectively increased the number of steps and exercise self-efficacy, including among male workers in their 50s who were not physically active and were difficult to visit public health centers due to their shiftwork. The mHealth program is expected to create healthy and happy workplaces if established as a workplace wellness program in the transportation companies.

These results suggest several implications. First, while the mHealth program was effective in increasing the number of steps and exercise self-efficacy in bus drivers, autonomous exercise motivation did not significantly improve. Autonomous motivation to exercise refers to a psychological need to self-initiate and maintain exercise [19]. Individuals with stronger autonomous motivation actively perform exercises based on personal beliefs and value systems rather than external pressure; therefore, autonomous motivation is critical in performing exercise persistently [28]. The effect of the mHealth program on autonomous motivation to exercise should be re-evaluated after the program is modified by adding a suitable strategy to reinforce it. Second, the mHealth program to improve bus drivers' wellness did not include a nutrition component. The mHealth program consisting of physical activity and other components, such as nutrition and stress management, could be added. Recently, Korean public health centers have provided various mobile health programs including physical activities and good nutrition for community residents with health risk factors. Such mobile health program by public health centers should be targeted vulnerable populations including bus drivers, homeless, etc.

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