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Relationship between Diabetes Self-Management and the Use of Health Care Apps: A Cross-Sectional Study

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Abstract

Background People with diabetes are increasingly using smartphone health care applications (apps) to manage their health. However, few studies have examined the percentage of people with diabetes using health care apps and their relationship to self-care.

Objective The purpose of this study is to determine the prevalence of health care apps among people with diabetes and the relationship between app use and self-management.

Methods A cross-sectional study was conducted using an online survey among people with type 2 diabetes. Multiple linear regression analysis was conducted using the scores of the Japanese version of Summary of Diabetes Self-Care Activities and exercise and general diet subscales as the objective variables.

Results Of 253 participants included in this study, 61 (24.1%) used health care apps. Approximately 20% of those aged ≥ 60 also used health care apps. Use of health care apps was a significant predictor of physical activity frequency along with autonomous motivation ($p < 0.001$). Participants who used health care apps showed a 0.91 point higher physical activity score than those who did not. Regarding the general diet score, the use of health care apps was not significantly associated with dietary habits ($p = 0.29$).

Conclusion Among people with type 2 diabetes, 24.1% used health care apps, and self-management scores of exercise were significantly higher in people with diabetes who used health care apps than in those who did not.

Keywords

- patient self-care
- home care and e-health
- telemedicine and telehealth
- consumer health informatics
- diabetes mellitus
- chronic disease

Background and Significance

Up to 2019, the number of people with diabetes mellitus among adults was approximately 463 million (9.3% of the total population) worldwide.[1] People with diabetes are at a high risk of developing long-term vascular complications, causing considerable mortality.[2] Therefore, it is important to maintain good glycemic control through health care behaviors, such as healthy diets, exercises, and appropriate medications.

To maintain good blood glucose control and prevent diabetes and its complications, various Diabetes Self-Management Support (DSMS) programs have been developed.[3,4] DSMS helps people implement and maintain coping strategies and behaviors necessary for diabetes self-management.[5] Participation in DSMS programs improves and strengthens diabetes knowledge, self-management skills (e.g., meal planning and physical activity), and health status.[6,7] DSMS is typically performed in community-based settings, such as

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clinics or community organizations; however, methods employing smartphone health care applications (apps) are also gaining attention.[8–10]

Generally, health care apps are intended to provide health benefits to users, such as encouraging health management habits and disseminating health knowledge.[11–13] Several types of health care apps have been developed, and currently, there are more than 500,000 health care apps available in various online stores,[14] such as the Mac App Store and Google Play Store. Moreover, numerous health care apps have been developed to support self-management behaviors among people with diabetes.[15] Several studies have reported changes in diabetes self-management behaviors after using these apps for several months.[16–19] Although individual apps have been reported to be beneficial for people with diabetes, due to language and usability barriers,[20,21] people with diabetes do not always have access to validated apps. In other words, it is assumed that some patients are using apps that have not been validated for their usefulness to people with diabetes. Therefore, to determine whether the use of health care apps is associated with self-care, we surveyed people with diabetes regarding their use of health care apps and their self-care status. Few studies have examined the percentage of people with diabetes using health care apps and their relationship to self-care in this way. It is important to conduct this basic study because determining the prevalence of health care apps and their relationship to self-care could provide evidence for clinicians to use such apps to promote DSMS. Health care apps generally introduced to people with diabetes are of the type that support self-management by recording exercise and diet and monitoring/reporting blood glucose levels and medication status.[22] However, since the majority of people with diabetes in Japan, approximately 80%, do not manage their blood glucose levels,[23,24] we conducted this survey focusing on self-care, particularly exercise and dietary lifestyle.

Objective

The purpose of this study is to investigate the use of health care apps by people with type 2 diabetes and to describe the relationship between diabetes self-management behaviors and the use of health care apps.

Methods

Study Design

An Internet-based survey of individuals who had preregistered with a research firm was used to conduct this cross-sectional study. Data were collected in June 2021.

Participants

The participants were recruited from a panel of people with type 2 diabetes who were registered with a research firm. The selection criteria were as follows: people with type 2 diabetes, aged $\geq$ 18 years, ability to read and write Japanese language, and ability to provide informed consent. No exclusion criteria were set.

All sampling/recruitment and the survey were conducted within the Web page of the research firm. A two-stage sampling method was employed. In the first stage, people with type 2 diabetes who had preregistered with a research firm were asked to complete a screening survey. In the screening survey, they were inquired regarding the reasons for their medical visits or hospitalizations in the past 5 years, and those who stated the reason as type 2 diabetes were selected. In the second stage of sampling, a research cooperation request form was provided and participants were asked whether they agreed to participate in the study; those who agreed were designated as research participants.

G*Power 3.1 was used to estimate the minimum sample size. To separately analyze participants with high and low Summary of Diabetes Self-Care Activities (SDSCA) scores (SDSCA score difference, 3.0; standard deviation, 6.0; significance level, 0.05; power, 0.95), the required minimum sample size was 210.

Possible Biases

It is crucial that people with diabetes be sampled without age or gender bias. Therefore, a research firm was selected based on its track record of academic research with people with diabetes. Over 15,000 individuals with diabetes have participated in previous surveys. The average age of respondents to previous survey was close to the average age of people with diabetes in Japan reported in 2019. Because of concerns about the low number of female respondents in past surveys, a lower limit was set in advance for the number of male and female respondents.

Second, a selection bias was considered, in which responses are concentrated among respondents who are digitally literate. Since this bias could not be completely avoided, we decided to establish a "do not have a smartphone" question to see if the responses were not excessively biased toward smartphone owners.

Ethical Approval and Consent to Participate

All participants provided written informed consent before the initiation of the study. The study protocol was reviewed and approved by the Institutional Review Board of Kobe City College of Nursing (20122-05).

Questionnaire Development and Variables

This cross-sectional survey was conducted using an Internet-based questionnaire. The entire survey was conducted on the research firm's Web page. Respondents logged into the Web page to complete the survey. As it is an Internet-based survey, the questionnaire was developed and designed by referring to the "Checklist for Reporting Results of Internet E-Surveys."[25]

Health Care App Use

The participants were asked regarding the use of health care- and fitness-related apps on their smartphones. The following answer choices were available: "currently using," "have used in the past," "have never used," and "do not have a smartphone." Additionally, the respondents were asked to provide the characteristics of the apps they use. The following options

were provided for app characteristics: "general condition (body temperature/sleep/general condition)," "weight management," "physical activity (pedometer/activity meter)," "dietary management," and "other type." In this study, participants who answered "currently using" were defined as people with diabetes using health care apps.

Self-Management Measurement

The SDSCA-Revised is a scale that includes commonly recommended measures of diabetes self-management behaviors.[26] Japanese version of the SDSCA (J-SDSCA) questionnaire was applied,[27] and among various items in this questionnaire, "general diet" and "exercise" were used in this study. Higher scores on these items indicated better self-management behavior.

Other Independent Variables

Data on sociodemographic variables (e.g., age, sex, and family size) that influence diabetes self-management behaviors were collected.[28,29] Moreover, motivational questions regarding treatment behaviors were included in the survey. Autonomous motivation is an important concept as it is associated with achieving and maintaining diabetes-related self-care goals.[30–34] The Treatment Self-Regulation Questionnaire (Controlled and Autonomous motivation) was used to measure motivation.[35]

Statistical Analysis

Data obtained from the entire questionnaire were coded and entered using Microsoft Excel. The data were then analyzed using SPSS version 26. Frequency and cross-tabulations were used to describe the data. To analyze the association between health care app use and diabetes self-management behaviors, multiple regression analysis was conducted using the J-SDSCA and subscales of general diet and exercise as objective variables. In this study, age, sex, and family size were set as covariates, and the health care app use and motivation scale were considered independent predictors. The unstandardized and standardized partial regression coefficients and 95% confidence intervals are presented. The Durbin–Watson (DW) test was used to confirm that the model was independent of multicollinearity and to demonstrate its adequacy, with a DW value of 1.5 to 2.5 as the preferred range.[36] Statistical significance was set at a p-value of < 0.05.

Results

Participant Characteristics and Health Care App Use on Smartphones

Overall, 466 people with diabetes participated in the screening survey, and 253 participants completed the survey. ►Table 1 shows the demographic characteristics of the 253 participants. There were no incomplete data, and all

Table 1 Summary of the sociodemographic statistics of the survey population ($N = 253$)

Demographic details	Frequency (%)	Mean ± SD
Sex		
Female	103 (40.7)	
Male	150 (59.3)	
Age (y)		63.7 ± 10.1
< 60	86 (34.0)	
60–69	83 (32.8)	
> 70	84 (33.2)	
Family member		
Living alone	45 (17.8)	
Living with family members	208 (82.2)	
Use of health care apps on smartphone		
Currently using	61 (24.1)	
Have used in the past	18 (7.1)	
Have never used	129 (51)	
Do not have a smartphone	45 (17.8)	
Type of health care apps participants have used		
General condition apps (body temperature, sleep monitor)	26 (10.3)	
Weight management apps	31 (12.3)	
Physical activity apps (pedometer, activity monitor)	67 (26.5)	
Diet management apps	16 (6.3)	
Other apps	8 (3.2)	

Abbreviation: SD, standard deviation.

Table 2 Multiple regression of factors contributing to physical activity habits[a]

Variables	Unstandardized Beta	SE	Standardized Beta	Significance	95% CI	
(Constant)	−3.92	0.96		0.00	−5.81	−2.03
Age	0.03	0.01	0.12	0.05	0.00	0.05
Sex (dummy[b])	0.48	0.27	0.10	0.08	−0.05	1.00
Living alone (dummy[c])	0.16	0.34	0.03	0.65	−0.52	0.83
Autonomous motivation	0.58	0.11	0.34	0.00	0.36	0.80
Controlled motivation	0.17	0.12	0.09	0.15	−0.06	0.40
Current use of apps <any health care apps>	0.91	0.32	0.17	0.00	0.29	1.53

Abbreviations: CI, confidence interval; J-SDSCA, the Japanese version of the Summary of Diabetes Self-Care Activities; SE, standard error.
[a]The dependent variable is exercise score on J-SDSCA.
[b]Sex is a dummy variable (female = 1, male = 2).
[c]Living alone is a dummy variable (living alone = 0, with family members = 1).

data were eligible for the final analysis. Thus, there was no handling of missing data.

Of the 253 participants, 24.1% (61/253) reported that they were using health care apps at the time. Moreover, 31.6% (25/79) of those aged < 60 years, 20.5% (17/83) of those aged 60 to 69 years, and 19.0% (16/84) of those aged > 70 years used health care apps. A physical activity app was the most used type of app, which was used by 26.5% (67/253) of the respondents.

Determinants of Physical Activity Habits

Multiple linear regression analysis was conducted to predict the frequency of individuals' physical activity based on their use of health care apps. A significant regression equation was obtained (F (6,246) = 14.30; $p < 0.001$), with an R^2 value of 0.24. The independent predictors that were significantly associated with this model were autonomous motivation and health care app use. Participants who used health care apps showed a higher physical activity score by 0.91 points than those who did not (see ►Table 2 for all regression values). The DW statistic value in this model was 2.07.

Determinants of Dietary Habits

Multiple linear regression analysis was conducted to predict the general diet score on the use of health care apps. A significant regression equation was obtained (F (6,246) = 9.82; $p < 0.001$), with an R^2 value of 0.17. The use of health care apps was not shown to be significantly associated with dietary habits in this model. Autonomous motivation was the only independent predictor that was significantly associated with this model (see ►Table 3 for all regression values). The DW statistic value in this model was 1.92.

Discussion

Health Care App Use by People with Type 2 Diabetes

Of the total participants in this study, 24.1% used health care apps. In the 2018 survey, 33.3% of people with type 2 diabetes

Table 3 Multiple regression of factors contributing to dietary habits[a]

Variables	Unstandardized Beta	SE	Standardized Beta	Significance	95% CI	
(Constant)	−0.39	1.16		0.74	−2.69	1.90
Age	0.00	0.02	−0.01	0.89	−0.03	0.03
Sex (dummy[b])	−0.14	0.32	−0.02	0.67	−0.78	0.50
Living alone (dummy[c])	0.37	0.42	0.05	0.38	−0.46	1.19
Autonomous motivation	0.77	0.14	0.39	0.00	0.50	1.03
Controlled motivation	0.09	0.14	0.04	0.55	−0.20	0.37
Current use of apps <any health care apps>	0.40	0.38	0.06	0.29	−0.35	1.16

Abbreviations: CI, confidence interval; J-SDSCA, the Japanese version of the Summary of Diabetes Self-Care Activities; SE, standard error.
[a]The dependent variable is general diet score on J-SDSCA.
[b]Sex is dummy variable (female = 1, male = 2).
[c]Living alone is dummy variable (living alone = 0, with family members = 1).

used health care apps for diabetes management compared with past surveys.[37] The mean age of participants in this study was 63.7 ± 10.1 years, which was more than that in previous studies; this could have influenced the slightly lower rate of app use. Several previous studies have noted design and usability issues specific to older adults and various psychological barriers.[38] However, this survey found that approximately 20% of respondents over the age of 60 years reported using health care apps to manage their health, indicating that even among the elderly, about one-fifth of the elderly use health care apps on a daily basis. This may be due to the widespread use of smartphones, which reduces barriers to health care management among older adults using health care apps. In fact, based on the penetration rates alone, smartphone use for health care purposes in people with diabetes was more prevalent in the present study than in a 2014 Latino survey in which only 3.3% of people with diabetes used health care apps.[39]

Second, in terms of the type of app, the most common type of app used was associated with exercise management. However, previous studies have described effective and frequently used features of health care apps, such as food intake recording,[37] medication management,[40] and blood glucose management.[41] According to a series of studies on the relationship between health care app and diabetes management, regardless of what is managed on their smartphone, there would be a factor that promote diabetes self-care in use of smartphones for health.

Third, 7% of individuals indicated that they have used health-related apps in the past. Issues related to usability were noted as a reason for lack of continued use.[20,21,42] In addition, a previous survey in Australia reported that over 40% of respondents believed that smartphone-based management would not help them.[43] A past study had shown that although people with type 2 diabetes favored the features of health care apps and expressed interest in mobile health, their use of the apps was less than 10%.[44] These suggest that user engagement needs to be strengthened. To address these issues, a regular survey of easy-to-use yet effective diabetes support apps that clinicians can refer to may be effective. The Association of Diabetes Care & Education Specialists in the United States recommends diabetes support apps and regularly reviews the accuracy and relevance of the information,[45] and it may be helpful to refer to these activities in each language area.

Relationship between Health Care App Use and Exercise Habits

The participants who used health care apps showed a higher physical activity score by 0.91 points than those who did not. Thus, a difference of approximately 1 day in physical activity frequency was noted between the two groups, indicating a clear relationship between health care app use and physical activity frequency. This result is consistent with those of previous studies, suggesting that health care app use stimulates diabetes self-management behaviors along with individual self-efficacy and autonomous motivation.[32]

Other studies have reported that only 9% of people with diabetes habitually engage in effective exercise.[46] A sedentary lifestyle, such as lack of exercise habits, has been an independent risk factor for mortality[47,48]; therefore, approaches to encourage physical activity are of growing interest among clinicians involved in diabetes management.[49] The results of this study indicate that health care apps can potentially be used to help people with type 2 diabetes acquire or maintain exercise habits.

Relationship between Health Care App Use and Healthy Eating Habits

Several studies have reported the association between dietary habits and health care app use[37,50]; however, the results of this study showed no association between them. Multiple regression analysis revealed that the only independent predictor affecting dietary self-management was autonomous motivation. Another previous study reported that autonomous motivation was the only variable that improved dietary activity. Further, it reported that controlling motivation, self-efficacy, social support, and health literacy were not associated with dietary activity.[33] As a healthy diet requires several steps, such as acquiring the right knowledge, shifting the diet, and introducing a new food culture,[34,51,52] using a health care app alone may not lead to the development of healthy eating habits. The result of lack of significant differences in the dietary scores using health care apps is consistent with those of previous intervention studies in which no change was reported in the dietary scores,[16,53] thus reaffirming the difficulty in improving dietary behavior. The results of this study suggest that autonomous motivation plays a role in their eating habits, it is therefore important to help people with diabetes find meaning for themselves in healthy eating by encouraging reflection.[54] It can be stated that autonomous motivation requires several months of continuous positive coaching by the clinician.[55] In the future, it is necessary to confirm whether the use of smartphone interventions facilitates ongoing coaching and test whether they contribute to changes in dietary behavior.

Limitations

This study has several limitations. The survey was conducted among people with diabetes from a research firm through the Internet, which could have resulted in selection bias. However, the age range, sex ratio,[23] smartphone ownership,[56] and health care app use[37] of the respondents in this study approximated the data reported in other studies. These results suggest that the demographics of the respondents adequately reflect the population of people with type 2 diabetes in Japan. However, the potential lack of generalizability is a concern because the target population of this study included preregistered survey participants from a research firm.[57]

Another important limitation is that although we examined app use, we did not assess the technique of using the apps and the duration for which participants used the apps (frequency and intensity). Furthermore, we cannot rule out the possibility that factors related to the socioeconomic status, such as education and economic status, may influence self-management. A resurvey using these parameters might be useful for refining and clarifying the factors that contribute to the variations in the diabetes self-management status.

Future studies are needed to determine whether the effects of using health care apps are sustainable and effective in preventing diabetes complications. Medical outcomes, such as hemoglobin A1c level, may be used in such studies to demonstrate the effects of health care apps in further detail.

Conclusion

This study reported an association between self-management behaviors and health care app use in people with diabetes. Approximately 25% of people with diabetes used health care apps, and those who used health care apps showed significantly higher exercise self-management scores than those who did not.

Clinical Relevance Statement

Exercise self-management scores were significantly higher among those using health care apps than those not using such apps. Therefore, including recommendations for using health care apps in the DSMS may be effective in acquiring exercise habits. The fact that one in four people with diabetes used the app in this study could be encouraging for potential health care app users.

Protection of Human and Animal Subjects

This study was conducted in compliance with the World Medical Association Declaration of Helsinki on ethical principles for medical research involving human subjects, and it was reviewed by the Institutional Review Board of Kobe City College of Nursing.

Ethical Approval

All participants provided written informed consent before initiation of the study. The study protocol was reviewed and approved by the Institutional Review Board of Kobe City College of Nursing (20122-05).

Data Sharing Policy

Data are available upon reasonable request. The data that support the findings of this study are available from the corresponding author upon reasonable request. The approval of the Institutional Review Board of Kobe City College of Nursing may be required to determine whether the data acquisition is reasonable.

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Conflict of Interest

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