

## Effectiveness of Internet-based Interventions on HbA1c Levels in Adult Patients with Diabetes: A Meta-Analysis of Randomized Controlled Trials

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**Objectives:** This study aimed to verify the effectiveness of Internet-based intervention programs for adults with diabetes by conducting a meta-analysis of studies conducted since 2000. **Methods:** We conducted a systematic review of research papers published in domestic and overseas journals from January 2000 to December 2015, and selected 9 papers that met the analysis criteria. Data analysis was performed using the open source statistical software R 3.5.0, to analyze the effectiveness of Internet-based interventions on experimental and control groups. **Results:** The analysis showed that intervention programs for controlling HbA1c levels in adult patients with diabetes most commonly comprised 7 sessions on Internet-based management (77.8%), and the most common frequency of application of intervention programs was 4 session in 6 months (33.4%). The present meta-analysis revealed statistically significant effects of Internet-based intervention activities (SMD = 0.92, 95% CI 0.45-1.40). The analysis of the effect size according to the intervention period showed that the 3-month, 6-month, and 12-month interventions reported in eight studies (89%) had a high effect on the Internet-based intervention group. **Conclusions:** The results of this study confirm the effectiveness of Internet-based intervention programs for adult patients with diabetes. The need for research on the utilization of Internet-based intervention programs for the steady management of diabetes, a chronic disease; for the development of specific guidelines for intervention activities; and for establishing appropriate protocols are acknowledged.

**Key words:** Diabetes mellitus, Internet, Intervention, Meta-analysis

### INTRODUCTION

According to the National Statistical Office, the proportion of the elderly population in Korea had reached 7.1% in 2000 [1], and according to the resident population statistics released by the Ministry of Public Administration and Security [2], it was 14.02% in 2017 [2]. According to the statistics released by the National Statistical Office in December 2016, Korea is expected to enter the early ages in 2026 [1]. Along with aging, the prevalence of chronic diseases is also increasing steadily, and mortality and disease structures are changing toward chronic diseases [3]. Further, 81% of all deaths can be attributed to chronic diseases and 7 of the top 10 deaths were due to chronic diseases, especially deaths from diabetes and cerebrovascular disease were higher than the OECD average [3].

In particular, the prevalence rate of diabetes mellitus increased from 9.5% in 2015 to 11.3% in 2016 [4]. According to the Korean Diabetes Association, 63% of patients with diabetes are managed very poorly [5]. This increase in chronic complications results in an increase in medical costs for disease management as well as disease burden and disability, and the need for continuous blood glucose control, and prevention and management of complications is increasing. Since 2002, the government has established a Comprehensive National Health Promotion Plan to promote a chronic disease management project centered on public health centers. However, it is difficult to manage the health care of chronic illnesses effectively due to regional constraints of services and difficulties in connection with medical institutions [6]. To improve the quality of life of people in the modern society, it is necessary to provide

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Received: September 12, 2018 Revised: November 8, 2018 Accepted: November 17, 2018

No potential conflict of interest relevant to this article was reported.

**How to cite this article:**

Jung CS, Noh HJ, Gu MJ, Kim YY, Lee SY. Effectiveness of internet-based interventions on HbA1c levels in adult patients with diabetes: a meta-analysis of randomized controlled trials. J Health Info Stat 2018;43(4):307-317. Doi: <https://doi.org/10.21032/jhis.2018.43.4.307>

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services related to lifestyle-related healthcare management and individual healthcare, and to offer appropriate services [6]. Recently, programs and research combining healthcare, biotechnology, and information technology (IT) have been developed. Among them, the Internet or telephone is attracting attention as diabetes education method because it can easily receive economical diabetes education at home without patients wanting to hospital. With the development of new technology, records measurement, monitoring, management and medical service are available. The ability to remotely provide health information between patients and healthcare providers not only improves their control and comprehension of their illnesses, but also enables them to monitor themselves at home, reducing the burden of disease [7]. However, despite the highest proportion of households with Internet access and computer use among the 35 OECD member countries, there has been little research on the application of Internet-based intervention programs for the development of these technologies and chronic disease management [8]. However, few studies have conducted an effect analysis. The purpose of the present study was to review the effects of Internet-based intervention programs on patients with diabetes mellitus in Korea and abroad. Korea's Internet penetration rate has grown since the commencement of commercial internet services in 1994 and the commercialization of high-speed internet services in 1998. However, with the activation of mobile Internet in 2013, the penetration rate of household Internet has started to decrease. Therefore, this study selected the period from 2000 to 2015 as a reference point for selecting studies on Internet-based interventions for the management of diabetes in adult patients. In addition, a meta-analysis can provide a rational and valid basis for clinical decision-making, avoiding unnecessary repetitive research, and identifying comprehensive results that can be generalized by systematically analyzing and integrating individual research results quantitatively.

Therefore, in this study, the effect of Internet-based interventions on controlling blood glucose levels in adult patients with diabetes was examined, to help avoid errors that other researchers can make I will be able to give. This study also aims to identify ways to solve the problems experienced by previous researchers. Accordingly, this study aimed to compare and analyze the total effect size of HbA1c control in domestic and foreign studies conducted from 2000 to 2015, which examined an internet-based intervention program for adults with diabetes. Additionally, it aimed to investigate specific characteristics such as intervention period and type of intervention. Based on these findings, it aimed to

provide guidelines for future studies on Internet-based blood glucose control interventions and to provide basic academic data for developing appropriate programs.

The purpose of this study was to conduct a meta-analysis of studies conducted in Korea and abroad after 2000, to verify the effectiveness of internet-based intervention programs for adults with diabetes, and to confirm the validity of these interventions. First, the total effect size of internet-based interventions for blood glucose control in adult patients with diabetes was calculated and the statistical significance was verified. Second, after verifying the heterogeneity of Internet-based interventions for blood glucose control in adult patients with diabetes, control effect analyses (meta-ANOVA and meta-regression analysis) were conducted to explain the heterogeneity. Third, an error analysis was conducted to verify the validity of the study results.

## METHODS

### Study design

This study aimed to examine the effect of internet-based intervention programs on HbA1c levels of adult patients with diabetes, which is a major outcome variable for such patients, in order to systematically and synthetically analyze the effects of such interventions.

### Criteria for selecting research subjects

First, research papers were searched according to the population, intervention, comparison, and outcome (PICO) criteria to systematically select the meta-analysis literature from the large amount of literature and contradictory research results. Among the studies conducted between January 2000 and December 2005, the subjects (P) of the present study were limited to adults with diabetes, that is, patients aged over 18 years. The intervention method (I) was internet-based intervention programs for controlling HbA1c levels. The comparative group (C) comprised those who did not receive the internet-based intervention, while and outcome (O) or dependent variable was HbA1c level, which is the main outcome variable for adults with diabetes. The study design was limited to RCTs. In other words, studies that did not meet this research criterion, such as qualitative studies, reviews, and single-group pre- and post-experimental studies were excluded. Further, to enable effect size conversion, only studies that reported data such as mean, standard deviation, and 95% confidence interval were selected. Therefore, we excluded

non-weighted studies, studies that did not calculate the effect size, and monographs and conference materials that were presented only as abstracts or posters.

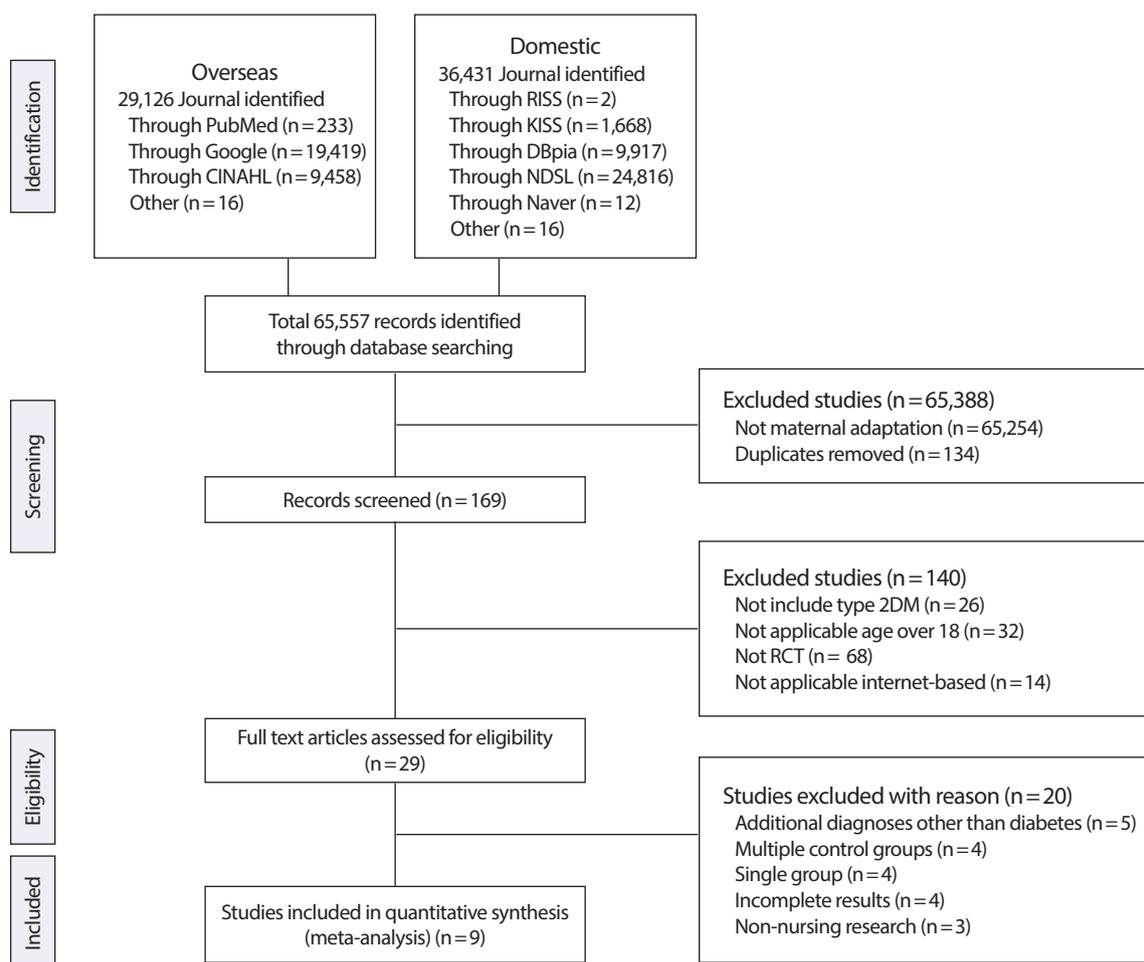
### Search and selection of data

This study collected the articles providing an internet-based intervention to control the HbA1c levels of adult patients with diabetes by searching domestic academic databases online and by manually searching the reference lists of the identified documents. The literature selection process was conducted in four stages, and each stage is shown in Figure 1. Specifically, 26 papers that did not include patients with type 2 diabetes, 32 papers that included participants younger than 18 years, and non-RCT papers (qualitative, mixed, and questionnaire studies) were excluded. At this stage, 5 studies with additional diagnoses other than diabetes, 4 studies with multiple control group, 4 studies with single group,

3 non-nursing studies were excluded. In case of disagreement between the researchers in this process, the decision was made based on mutual discussions. In case of further disagreement, the principle of third-party intervention was set up, but the researchers proceeded without any special disagreements.

### Evaluation of the quality of the articles to be analyzed

The quality of the final 9 papers was evaluated using the controlled trial (RCT, NRCT) evaluation method developed by the Scottish Intercollegiate Guidelines Network (SIGN) in 2015 [9]. After five independent researchers conducted the quality evaluation, we reached the conclusion through the process of reviewing and discussing the discrepancies. In the evaluation, the following 10 items are used to confirm the internal validity of the individual evaluation: research topic and concept definition, random assignment, concealment, double blinding, baseline homo-



**Figure 1.** The PRISMA flow chart. NDSL, national digital science library; CINAHL, cumulative index to nursing and allied health literature; RCT, randomized controlled trials; DM, diabetes mellitus.

geneity evaluation, execution error, dropout rate, analysis performed as assigned, and homogeneity of each test site. Items 1-7 were evaluated as “yes”, “no”, or “unknown”, and item 9 and 10 were evaluated as “yes”, “no”, “do not know”, and “not applicable”. The overall assessment of the quality of the study was evaluated as “++”, “+”, “-”, and “0” depending on how well each study minimized errors.

### Data analysis

The characteristics of the study were coded according to the criterion of coding based on author (year), research design, age of subjects, number of samples, intervention subject, intervention technique, and intervention period. To evaluate the effectiveness of the intervention studies, statistical values of the pre- and post-test means, the standard deviation, and the sample size of the experimental and control groups were collected. The analytical program for examining the effectiveness of the web-based intervention according their impact on the experimental and control groups was analyzed using the open-source statistical software R 3.5.0 [10]. Hedges’g (standardized mean difference, SMD) and 95% confidence intervals (95% CI), which are corrected standardized mean dif-

ferences, were calculated for each study sample size. The mean effect size was analyzed by applying a random-effects model with different sample sizes. Additionally, we examined the forest plot for conducting a visual assessment of the heterogeneity of effect sizes. For specific heterogeneity confirmation, the  $I^2$  value, which is the ratio of actual dispersion to total dispersion, was calculated. The funnel plot was used to examine publication errors, and Egger’s regression test [11] was used to examine the detailed publication errors.

## RESULTS

### Selection process of research

The selection process of articles was based on the method recommended by PRISMA, which comprises the following four steps (Figure 1). In the first stage, 65,557 journals from domestic and foreign journals were searched using various databases. In the second stage, the titles of the articles retrieved were reviewed to exclude 65,254 articles that did not deal with adult diabetes related variables. The five researchers compared the literature with title, year, and author, the number of papers re-

**Table 1.** General characteristics of the studies included in the meta-analysis

No	Study author	Country	Study design	Subjects			Setting	Intervention			Quality assessment <sup>1</sup>	
				Age (y)	Exp (n)	Cont (n)		Exp group type	Cont group type	Duration		
1	Lorig et al. (2010)	USA	RCT	≥ 18	60	50	Type 2 DM patient diagnosis	IBM	IDSMP	UC	6 months	+
2	Avdal et al. (2011)	Turkey	RCT	≥ 18	61	61	Type 2 DM patient diagnosis	IBE	Web-based diabetes training	Face-to-face education	6 months	++
3	Tang et al. (2013)	USA	RCT	≥ 18	193	189	Type 2 DM patient diagnosis	IBM	EMPOWER-D	UC	6 months	++
4	Moattari et al. (2013)	Iran	RCT	≥ 18	24	24	Type 1 and 2 DM patient diagnosis	IBE	Electronic education intervention	Face-to-face education	3 months	++
5	James et al. (2003)	USA	RCT	≥ 18	307	291	Type 2 DM patient diagnosis	IBM	DMA	Don't use internet	12 months	++
6	Kim et al. (2003)	Korea	RCT	≥ 30	55	55	Type 2 DM patient diagnosis s	IBM	IBGMS	UC	3 months	++
7	Bond et al. (2007)	USA	RCT	≥ 60	31	31	Type 1 and 2 DM patient diagnosis	IBM	Diabetes-take charge website	UC	6 months	++
8	Hugh et al. (2011)	Canada	RCT	≥ 18	23	23	Type 2 DM patient diagnosis s	IBM	IBGMS	UC	12 months	++
9	Graham et al. (2005)	USA	RCT	≥ 18	52	52	Type 2 DM patient diagnosis	IBM	My Care Team website	UC	12 months	++

RCT, randomized controlled trials; Exp, experimental; Cont, control; DM, diabetes mellitus; IBM, internet-based management; IBE, internet-based education; IDSMP, internet-based diabetes self-management program; EMPOWER-D, engaging and motivating patients online with enhanced resources-diabetes; DMA, diabetes disease management application; IBGMS, internet-based glucose monitoring system; UC, Usual Care.

<sup>1</sup>++: High quality (all or most of the criteria were met, little or no risk of bias, conclusions unlikely to be changed by further studies).

+: Acceptable (some of the criteria were met, some fault in the study with an associated risk of bias, and result may change in the light of further research).

maining after excluding 134 duplicate papers in the database and journals was 169. In the third step, the 5 researchers applied the preset exclusion criteria on research subjects and research design by reviewing the abstracts of the selected articles, with blind extraction before comparison. In the fourth step, the 5 researcher's finally selected 9 research papers that met the criterion pertaining to the intervention implemented.

### Characteristics of thesis subjects

Table 1 shows the results of analyzing the characteristics of the 9 research papers selected for this study. The contents comprise authors, year of publication, country, type of research design, age of subjects, number of subjects and samples, program type, and period of intervention. Among the 9 papers analyzed, 2 each were published in 2003 and 2013 (22.2% each), and 1 each were published in 2005, 2007, and 2010 (11.1% each). With reference to the country in which the study was conducted, the United States had the largest number, with 5 studies, followed by 1 each in Iran, Korea, Turkey, and Canada. All the 9 studies were RCTs. Seven studies (77.8%) comprised patients with Type 2 diabetes, aged 18 years or older, while 2 studies included patients with Type 1 and Type 2 diabetes (22.2%). Of these, only 1 article pertained to subjects over 30 years old and those over 60 years. The number of subjects ranged from 23 to 307 in the experimental group, and 23 to 291 in the control group. The total sample included 1 subject, 50 to 60, and 290-310 subjects. Internet-based management was the most common type of intervention, with 7 studies employing the same (77.8%), followed by Internet-based education (22.2%). Internet-based management (IBM) was the most common type of intervention (77.8%) and internet-based education (IBE) was two (22.2%). The IBM intervention program includes two new studies using the internet-based glucose monitoring system (IBGMS), an internet-based diabetes self-management program (IDSMP), an online disease management system (Diabetes-takecharge web site/MyCareTeam web site), two diabetes-take-a-care applications (diabetes disease management application). The IBE intervention program consisted of one web-based diabetes training and one electronic education intervention program. The control group for all experimental groups was non-Internet based, and the usual management or face-to-face training was conducted. In terms of the duration of the program, 4 studies (33.4%) implemented the intervention for 6 months, followed by 3 (33.3%) for 12 months, and 2 (12.5%) for 3 months.

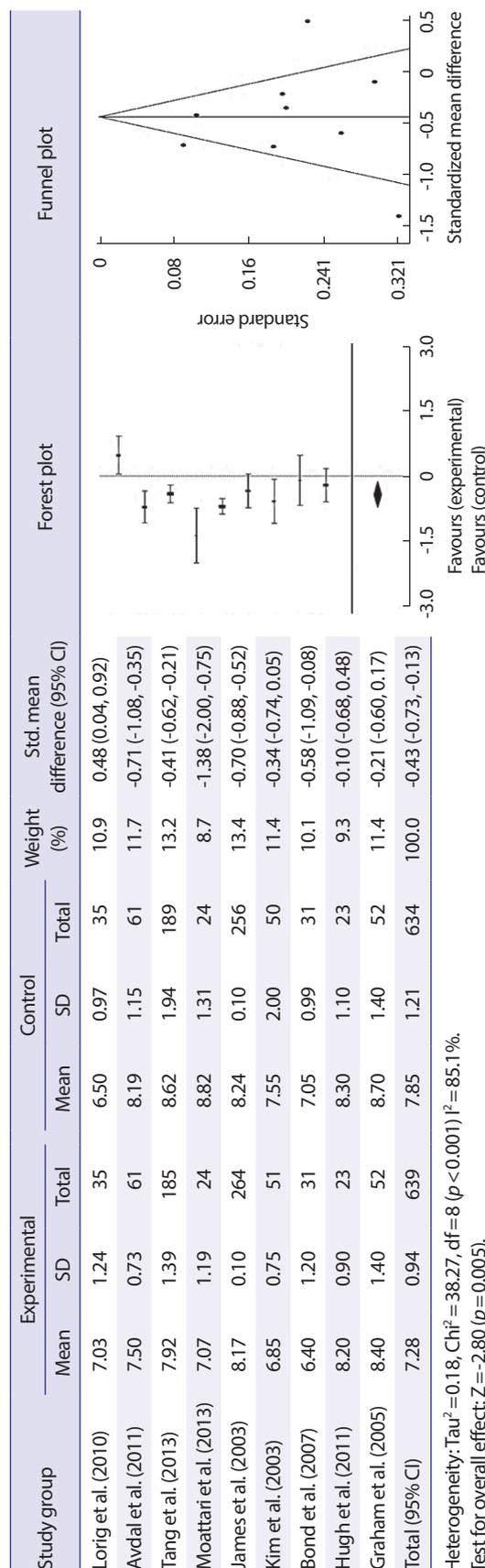


Figure 2. Internet-based HbA1c management effects in adult patients with diabetes mellitus by studies. SD, standard deviation; Std., standard; CI, confidence interval.

### Quality assurance of research articles

Table 1 shows the results of the evaluation of the 9 selected quality evaluations using the evaluation list developed by SIGN [9]. All studies were RCTs that used random assignment of participants to the two groups, in which all research articles and concept definitions were clearly described. Five studies indicated that they used random numbers, coin throwing, and computer programs for randomization, but none of the 4 studies stated that concealment is a fact. However, it was concluded that the differentiation between internet-based intervention and non-internet-based intervention could be sufficiently concealed between the subjects. In addition, in 1 study each, statistical analysts and study assistants were blinded to the group assignment, respectively, but most of the studies did not disclose double blindness. Even with double-blind assignment, researchers and researchers may find that internet-based intervention is aimed at better quality of life. This needs to be explored in future research. In 8 articles, the homogeneity test was described on the baseline or presented in the results table. Although most of the explanations for the reliability and validity of the measurement tools were lacking in all studies, HbA1c level was judged to be a sufficiently reliable physiological measurement method. Most studies presented flow charts and a results table. Therefore, the dropout rate could be confirmed. Most of the studies mentioned the place where the study was conducted. If the required items for the quality evaluation of the paper were performed optimally, they were labelled “++” (I am sure that the conclusions will not change due to some uncompleted parts) and “+” (Conclusions are unlikely to change due to improper or unmet criteria). If most items were

unmet, “-” was assigned (the conclusion of the study is highly likely to change). Eight papers were labelled as “++” and 1 was labelled “+”. Therefore, the overall quality of the selected papers was deemed to indicate that the conclusion of the study would not change (Appendix 1).

### Effectiveness and heterogeneity of internet-based intervention

The effectiveness of the 9 selected studies was calculated and visualized using SMDs to obtain a Forest plot. Figure 2 shows the detailed effectiveness of the experimental and control groups. Table 2 shows the detailed effectiveness of the experimental group and the control group SMD = 0.92 (95% CI: 0.45, 1.40), and the postoperative efficacy of the control group was SMD = 0.04 (95% CI: 0.40, 0.49). The heterogeneity of the overall effectiveness of the experimental group was  $I^2 = 93.5%$  ( $p < 0.001$ ), and the heterogeneity of the total effect of the control group was  $I^2 = 93.6%$  ( $p < 0.001$ ) [12].

### Analysis of publication errors

To verify the validity of the results of the selected studies, a publication bias analysis was conducted through funnel plot analysis. Figure 2 shows a symmetrical view of the center line. For an objective error analysis, Egger's regression test was performed on the relationship between the effect size and standard error of each study. As a result, the experimental group was  $z = -0.068$ ,  $p < 0.531$ , and the control group was  $z = 1.336$ ,  $p < 0.182$ , indicating no publication errors.

**Table 2.** Meta-analysis of internet-based HbA1c management effects in adults with diabetes mellitus by studies

No	Study	Experimental group				Std. mean difference (95% CI)	Control group				Std. mean difference (95% CI)
		Pre		Post			Pre		Post		
		n	Mean (SD)	n	Mean (SD)		n	Mean (SD)	n	Mean (SD)	
1	Lorig et al. (2010)	60	7.12 (1.59)	35	7.03(1.24)	0.06 (-0.36, 0.48)	50	6.71 (1.25)	35	6.50 (0.97)	0.19 (-0.21, 0.58)
2	Avdal et al. (2011)	61	8.01 (0.97)	61	7.50 (0.73)	0.59 (0.23, 0.95)	61	8.14 (0.99)	61	8.19 (1.15)	-0.05 (-0.40, 0.31)
3	Tang et al. (2013)	202	9.24 (1.59)	185	7.92 (1.39)	0.88 (0.67, 1.09)	189	9.28 (1.74)	189	8.62 (1.94)	0.36 (0.16, 0.56)
4	Moattari et al. (2013)	24	9.10 (1.29)	24	7.07 (1.19)	1.61 (0.96, 2.26)	24	9.42 (1.78)	24	8.82 (1.31)	0.38 (-0.19, 0.95)
5	James et al. (2003)	264	8.40 (0.10)	264	8.17 (0.10)	2.30 (2.08, 2.52)	291	8.10 (0.10)	256	8.24 (0.10)	-1.40 (-1.59, -1.20)
6	Kim et al. (2003)	51	7.20 (0.85)	51	6.85 (0.75)	0.41 (0.02, 0.80)	55	7.25 (0.80)	50	7.55 (2.00)	-0.24 (-0.63, 0.16)
7	Bond et al. (2007)	31	7.00 (1.10)	31	6.40 (1.20)	0.51 (0.01, 1.02)	31	7.11 (0.91)	31	7.05 (0.99)	0.06 (-0.44, 0.56)
8	Hugh et al. (2011)	23	8.80 (1.30)	23	8.20 (0.90)	0.53 (-0.06, 1.12)	23	8.50 (1.20)	23	8.30 (1.10)	0.17 (-0.41, 0.75)
9	Graham et al. (2005)	52	10.0 (0.80)	52	8.40 (1.40)	1.39 (0.96, 1.82)	52	9.90 (0.80)	52	8.70 (1.40)	1.04 (0.63, 1.45)
Summary		693	8.01 (1.07)	651	7.28 (0.94)	0.92 (0.45, 1.40)	701	8.00 (1.08)	646	7.85 (1.21)	0.04 (-0.40, 0.49)
Random effects model		Heterogeneity: $I^2 = 93.6%$ $\tau^2 = 0.478$ , $p < 0.001$					Heterogeneity: $I^2 = 93.6%$ $\tau^2 = 0.426$ , $p < 0.001$				

Std., standard; SD, standard deviation; CI, confidence interval.

## DISCUSSION

In this study, we calculated the effect size of the impact of Internet-based intervention programs for adults with diabetes mellitus on their HbA1c level, through a meta-analysis of studies conducted from 2000 to 2015, to derive basic data for the development of appropriate internet-based intervention programs in future. A total of 65,557 papers were searched, among which, 9 papers were selected according to the preset selection criteria. The papers were distributed evenly from the early 2000s to 2015. Specifically, 2 papers each were conducted in 2003, 2011, and 2013, and 1 each were conducted in 2005, 2007, and 2010. In this study, we selected studies conducted during this period because it is representative of the growth of information technology in Korea, because the high-speed commercial internet services were launched in 1998, since the introduction of the internet in 1994. The internet penetration rate was only 49.8% in 2001, but it had increased by 13.4% from the previous year, to 85.7% as of 2016. However, 8 among the 9 studies that examined the effect of an internet-based intervention program on HbA1c control in adult patients with diabetes had been conducted outside Korea. The countries in which these 9 studies were conducted do not have such high penetration rates, namely the United States, Canada, Turkey, and Iran. Despite the high penetration rate of the Internet, it is unexpected that research on intervention programs for the regulation of internet-based HbA1c in Korea is rare. Indeed, the internet and infrastructure facilities are expanding in Korea as compared to the US and Canada. However, compared to these countries, the national land area of Korea is relatively small, and medical facilities are located in a closed geographical area and the total population is small. Since it can be effective even if the face-to-face activities are mainly performed as mediation activities for the control of HbA1c in adult diabetic patients, it is considered that research on the necessity of mediation activities based on the Internet is rare.

The intervention used in this study was internet-based management (77.8%) and internet-based education (22.2%). First, in the internet-based management program, a new study using the internet-based glucose monitoring system (IBGMS) was conducted. The internet-based diabetes self-management program (IDSMP) Disease Management System Patient Online Involvement and Motivation Program EMPOWER-D (Diabetes Disease Management Application), diabetes-take charge Web site/My Care Team Web site). The internet-based education program

consisted of one web-based diabetes training program and one electronic education intervention program. The control group for all experimental groups was non-internet-based and consisted of general management or face-to-face training that was usually conducted. In terms of the duration of the program, 4 studies (33.4%) implemented the intervention for 6 months, followed by 3 (33.3%) for 12 months, and 2 (12.5%) for 3 months. The present study was similar to that conducted by Toma [13], which is a meta-analysis of intervention activities for adult patients with diabetes. Both studies aimed to compare the content and composition of detailed interventions. The weighted mean difference (WMD) = -0.20%, 95% CI: -0.43, 0.03,  $p = 0.090$  on HbA1c regulation in mobile-only intervention was not statistically significant in the study by Toma [13]. However, that when combining internet-based interventions was significant (WMD = -0.54%, 95% CI: -0.72, -0.37,  $p < 0.001$ ).

The intervention period had a significant effect on the effectiveness of internet-based intervention activities. In the meta-analysis of this study, two out of nine papers were interventions for three months, four were interventions for six months, and three were interventions for 12 months. In terms of the size of the effect according to the intervention period, about 8 studies (89%) showed high effect in the experimental group when 3, 6, and 12 months intervention activities were carried out based on the internet. When only one study (11%) had a 6-month intervention period, the effect size of the control group was lower than that of the experimental group. Further, the effect size of the control group was lower than that of the experimental group when only about 11% of the subjects had received the 6-month intervention. The results of the preliminary systematic review and meta-analysis showed that the intervention effect tended to decrease with the duration of the intervention [13,14]. There are several possible reasons for this. First, the reduction in effectiveness can be motivated by the patients' reduced enthusiasm or motivation, especially because most of the studies included in this meta-analysis involved regular measurement of HbA1c levels. Second, the lack of ease of use can weaken the effect. Considering that most of the subjects in the study were over 18 years of age and in 2 studies they were over 30 years old and over 60 years old, respectively, this population may not be familiar with new types of technology. These results, however, do not encourage us to shorten the intervention period. Rather, they point to the need to employ relative measures to increase patient compliance and motivation. To prevent the mediation effect from deteriorating the effectiveness of the program over time, appropriate interventions should

be developed.

Here, the quality of the selected studies was evaluated individually and overall. In the individual evaluation results, all 9 studies were found to have employed research methods for improving the internal validity of the study. Thus, the risk of errors was low and there was no problem in synthesizing the results and drawing conclusions. However, considering that all the papers were RCTs, 89% of them were “++”; they satisfied most of the criteria and there was almost no risk of errors. Thus, their results are not likely to change. However, 11% of studies “partially satisfied” the criteria, and there were some deficiencies related to the risk of errors. This means that the results of the overall quality evaluation may change the conclusions of the papers selected in this study. However, Herbison et al. [15] tested 43 different quality assessment tools, and they pointed out that none of the quality assessment tools can reliably distinguish the quality of the research. Juniet et al. [16]. The present individual quality evaluation results suggest that the internal validity of the selected studies was optimal, such that the results are unlikely to change.

The results of a comparative analysis of the effect sizes of internet-based intervention activities for controlling HbA1c levels in adult patients with diabetes are based on a preliminary follow-up of the intervention group. The effect was statistically significant with  $SMD = 0.92$  (95% CI: 0.45, 1.40), and the postoperative effectiveness of the control group was  $SMD = 0.04$  (95% CI: -0.40, 0.49). The heterogeneity of the overall efficacy of the experimental group was  $I^2 = 93.5\%$  ( $p < 0.001$ ) and that of the total effect of the control group was  $I^2 = 93.6\%$  ( $p < 0.001$ ). These results are consistent with the results of Shen [17], in the WMD of HbA1c is consistent with the fact that the SMD of HbA1c levels between the experimental and control groups were 0.4%, thus favoring internet-based intervention. A previous study also supports the finding that a 1% decrease in HbA1c would reduce all risks associated with diabetes by 21%, including death, myocardial infarction, and microvascular complications [18]. Therefore, in order to manage diabetes in adult patients steadily, internet-based intervention activities should be utilized as much as possible.

## CONCLUSION

We conducted a meta-analysis on nine studies of interventional activities for regulating HbA1c in adult diabetics during the period from 2000 to 2015. As a result of the research, it was found that the intervention ac-

tivity based on the internet showed a higher effect than the control group. This is a result of demonstrating that internet-based intervention is effective as a mediator for blood glucose control through long-term and steady HbA1c management in a typical adult chronic disease. Since those with chronic diseases need to maintain their health through self-management of regular lifestyle habits, and through education, monitoring, and management by medical institutions, it is important to implement periodic centralized interventions for the management of patients' lives. Therefore, the need for an Internet-based blood glucose control intervention program for adults with diabetes is acknowledged. In addition, the present study suggests that interventions for HbA1c regulation in adult patients with diabetes can be performed on a long-term, patient-centered basis by controlling the blood glucose level using internet-based interventions. Although the results of the analysis of publication errors in the present study were not statistically significant, it was confirmed that there were no publishing errors. However, most of the RCT studies included in the study were conducted outside Korea. Therefore, the present findings cannot be generalized to domestic research. Further, owing to the lack of specific conclusions such as concealment or double-blindness, the comparison of specific intervention activities for blood glucose control used in the present analysis was not presented. Therefore, it is necessary to pay attention to the generalization of the effect of internet-based intervention activities for controlling blood glucose in adult patients with diabetes. Future studies will also need to focus on improving evidence-based practice through meta-analyses of RCT studies, and to develop standard guidelines for internet-based intervention programs for blood glucose control in adult patients with diabetes. The internet penetration rate in Korea is the highest in the world, and public big data such as medical information and checkup data of the whole people are integrated, and it is leading the world competitive advantage in the latest information and communication equipment. It is in urgent need of countermeasures because it is lagging behind utilization in such advanced countries. The results of this study are as follows. First, the effectiveness of internet-based intervention for the health care of chronic patients including diabetes was verified. As a result, intervention activities were effective. Based on the results of this research, it is necessary to identify the necessity of mobile healthcare service as well as internet-based intervention activities in future researches, and to grasp the possibilities, limitations, and effective ways to utilize them. Finally, this study proposes the following recommendations for future research. First, a

comparative study of various concurrent intervention methods and single intervention methods is needed as well as a comparative study of internet-based intervention programs for the control of blood sugar in adult diabetic and pediatric diabetic patients. Second, to increase the capacity of healthcare providers and users to utilize internet-based intervention activities for the management of chronic diseases, it is necessary to increase the reliability of the health information available on the internet and to establish concrete programs. Third, we need to identify ways to implement remote patient monitoring services to popularize internet-based health care of patients with chronic diseases.

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## 국문초록

인터넷 기반 중재프로그램을 통한 성인 당뇨 환자의 HbA1c 중재효과: 메타분석

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**목적:** 본 연구의 목적은 메타분석을 이용하여 2000년 이후 국내외 당뇨병을 가진 성인을 대상으로 수행된 인터넷 기반 중재 프로그램의 효과를 검증하고 실무 적용의 타당성을 확인하기 위함이다.

**방법:** 2000년 1월부터 2015년 12월까지 시행된 연구 중 국내외 학술지에 게재된 연구 논문을 대상으로 체계적 검토를 시행하였으며, 이 중 분석 대상 기준에 적합한 최종 9편의 논문을 선정하였다. 자료 분석은 Internet-based Intervention의 실험군과 대조군에 따른 효과성을 파악하기 위하여 오픈 소스 통계 소프트웨어인 R 3.5.0을 사용하여 분석하였다.

**결과:** 분석 결과 성인 당뇨 환자의 HbA1c 조절을 위한 인터넷 기반 중재 프로그램의 효과 크기에 관한 연구는 국외 8편, 국내 1편이었다. 연구에 사용된 중재는 Internet-based Management가 7편(77.8%)으로 가장 많았고, Internet-based Education이 2편(22.2%)이었으며, 중재 프로그램 적용기간은 6개월이 4편(33.4%)으로 가장 많았다. 선행연구와의 중재 효과 비교에서는 모바일 전용 중재에서의 HbA1c 조절에 대한 가중평균 차이(WMD -0.20%, 95% CI: -0.43-0.03;  $p=0.09$ )의 효과는 통계적으로 유의하지 않았으며, 모바일과 인터넷을 기반으로 한 중재를 통합했을 경우 가중평균 차이(WMD 0.54%, 95% CI: 0.72-0.37;  $p<0.001$ )의 효과를 나타냈다. 본 연구의 메타분석 결과에서도 인터넷을 기반으로 한 중재활동에서 통계적으로 유의한 효과를 보였다. 중재기간에 따른 효과 크기 분석 결과에서는 약 89%인 8편에서 3개월, 6개월, 12개월 모두 인터넷을 기반으로 한 중재활동 시행 시, 실험군에서 높은 효과를 보였으나, 중재 지속 기간의 증가에 따라 중재 효과는 감소하는 경향을 나타내었다.

**결론:** 본 연구의 결과에서는 인터넷 기반 중재 프로그램의 효과를 확인할 수 있었으며, 이는 인터넷을 기반으로 한 중재활동이 성인의 대표적 만성질환인 당뇨관리를 위한 HbA1c 및 혈당조절에 효과적임을 의미한다. 이와 함께 만성질환인 당뇨의 꾸준한 관리를 위한 인터넷 중재 프로그램의 활용 방안에 대한 연구와 중재활동의 구체적인 지침, 프로토콜 수립의 필요성이 제기된다.

**주제어:** 당뇨병, 인터넷, 중재, 메타분석

**Appendix 1.** Studies included in meta-analysis

- a1. Lorig K, Ritter PL, Laurent DD, Plant K, Green M, Jernigan VB, et al. Online diabetes self-management program: a randomized study. *Diabetes Care* 2010;33(6):1275-1281.
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**Appendix 2.** Quality assessment of studies included in the meta-analysis

Item study ID	1	2	3	4	5	6	7	8	9
An appropriate and clearly focused question	Y	Y	Y	Y	Y	Y	Y	Y	Y
Treatment group is randomized	Y	Y	Y	Y	Y	Y	Y	Y	Y
An adequate concealment method is used	Y	Y	C/S	Y	Y	C/S	C/S	Y	Y
Double blind about treatment allocation	C/S	C/S	Y	C/S	C/S	C/S	C/S	C/S	C/S
Baseline homogeneity	C/S	Y	Y	C/S	C/S	Y	Y	Y	Y
The only difference between groups is the treatment	Y	Y	Y	Y	Y	Y	Y	Y	Y
Use valid and reliable measurement methods	Y	Y	Y	Y	Y	Y	Y	Y	Y
Dropout rate	41	0	8	0	0	0	0	0	0
Perform analysis as assigned	Y	Y	Y	Y	Y	Y	Y	Y	Y
Homogeneity of each experimental site	Y	Y	Y	Y	Y	Y	Y	Y	Y
Total quality assessment	+	++	++	++	++	++	++	++	++

Y, yes; N, no; C/S, can't say; NA, not applied; ++, high quality (all or most of the criteria were met, little or no risk of bias, conclusions unlikely to be changed by further studies); +, acceptable (some of the criteria were met, some fault in the study with an associated risk of bias, and result may change in the light of further research).