Effectiveness of Mobile Web Application Promoting Healthy Behaviors among Adults with Prediabetes in Muang District, Phitsanulok Province, Thailand: A Randomized Controlled Trial Study

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Abstract

Background: In Thailand, the mobile web application for diabetes prevention has been limited to conduct the effects of mobile web applications on improving healthy behaviors particularly among adults with prediabetes in urban areas. However, there have been so far no such a study for collecting and analyzing data for evaluate their achievement of any application for diabetes preventive measures in Thailand.

Objective: This study aimed to examine the effects of a designed mobile web application on changes in healthy behaviors and biochemical indexes of diabetes.

Methods: From April 1 to September 30, 2021, a randomized controlled trial study was conducted in a total of 199 volunteers with prediabetes (aged 30 to 59 years) recruited from two subdistrict health-promoting hospitals in Muang District, Phitsanulok Province, Thailand. Prediabetic patients were randomly assigned to the intervention group (n=124) who received a 6-month of the DM winner application and the control group (n=75) who received the information on diabetes prevention. Both groups were assessed for health behaviors questionnaire, anthropometry, and biochemical parameters at baseline, 3 months, and 6 months and compared by a two-way repeated-measures ANOVA analysis.

Results: The results showed that there was no significant difference in physical activity between groups. However, significant differences in time effects (p=0.001) were found. The intervention group showed a significant increase in physical activity at 6 months compared to their baseline, but the control group did not. The frequent intake of high-fat food (p=0.042), fast foods (p<0.001) and soft drink (p=0.010) also significantly differed between groups. Although there were no significant differences between groups in terms of anthropometric parameters, the intervention group showed significantly reduced fasting blood sugar (FBS) (p=0.035) and significantly decreased total cholesterol and high-density lipoprotein cholesterol (HDL-C) when compared to the control group.

Conclusions: The DM winner application shows promoting healthy behaviors of adults with prediabetes in urban areas. Additionally, almost all users feel very satisfaction for applications. The DM winner application can be used as an effective tool to promote and monitor healthy behaviors in order to prevent the risk of diabetes in urban areas. Clinical Trial: Thai Clinical Trials Registry (TCTR) number TCTR20240716006; https://www.thaiclinicaltrials.org/show/TCTR20240716006.

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Trial Registration: Thai Clinical Trials Registry (TCTR) number TCTR20240716006; https://www.thaiclinicaltrials.org/show/TCTR20240716006.

Key words

Mobile web application**;** healthy behaviors; physical activity; prediabetes; type 2 diabetes mellitus

Introduction

Type 2 diabetes (T2DM) is a global issue that has experienced a rapid increase over the last three decades, particularly in the Western Pacific. The number of diabetes (DM) cases is projected to escalate from 381 million in 2013 to 591 million in 2035, indicating an estimated increasing rate of 55% [1]. The prevalence of diabetes in Thailand has steadily risen from 8.9% in 2014 to 9.5% in 2020. Similarly, prediabetes, a precursor to type 2 diabetes, has seen a slight increase in Thailand, rising from 15.4% in 2014 and 16.24% in 2016 to 10.7% in 2020 [2].

Lifestyle modifications play a crucial role in preventing the development of T2DM [3]. Despite the Thai Ministry of Public Health implementing lifestyle change intervention programs for diabetes, there is a lack of health-promoting interventions for prediabetes to support sustainable behavioral changes for diabetes prevention. Previous research suggests that technology-mediated diabetes prevention programs, such as mobile health applications (mHealth), can foster positive health behaviors among individuals with prediabetes, especially in urban settings [4-6].

Mobile applications can help to improve healthy behaviors in prediabetes such as Alive-PD application can promote changes in diet and physical activity in 6-month, mHealth application can increase autonomous motivation to prevent diabetes and a smart phone app-based achieved a greater weight loss in a multiethnic Asian population with prediabetes [5, 7-8]. Therefore, development of the effective mobile applications is necessary to provide good strategies to improve self-awareness by self-management for their health status [9]. These methods include goal setting, tracking, coaching, self-monitoring, rewarding and increasing knowledge engage healthy behaviors with people in urban communities [5,7].

However, in Thailand, the personal mobile application specifically designed for the unhealthy behavior changes for decreasing risk of T2DM has not been available yet. Few commercial mobile applications on improving healthy behaviors are urgently required particularly among people with prediabetes in the urban areas. However, this study designed “DM winner application” to conduct the feasibility to promote healthy behaviors to evaluate their achievement of any application for DM prevention in Thailand. This study aims to investigate the impact of mobile web application on changes in healthy behaviors and biochemical parameters in urban areas. The results from this study are expected to improve health promotion programs via mobile web application to change health behaviors of individual prediabetes, leading to the diabetes prevention in the urban areas of Thailand.

Materials and Methods

Study design

This was a parallel two-arm 6-month randomized controlled trial study aimed to investigate the effects of a mobile web application (DM Winner app) on changes in healthy behaviors and biochemical parameters for diabetes indices. The study was carried out from April 1 to September 30, 2021. This research was approved by the Ethics Committees of the Faculty of Tropical Medicine, Mahidol University (TMEC 20-063) and registered on the Thai Clinical Trials Registry (TCTR) number TCTR20240716006.

Sample size calculation

The sample size was estimated for comparing two independent means with an alpha level of 0.05, a power (1-β) of 0.80, the difference mean change (standard deviation) of body weight among intervention group with prediabetes (n=62) and control group (n=63) was 1.49 (2.98) and 0.46 (2.02) from six months non-randomized intervention study in Malaysia [10]. Therefore, the total sample size, with the estimated lost to follow-up rate of 30%, was determined to be 124 subjects per group and desired to be randomly assigned to receive either the intervention or control (1:1).

Participants

The participants of the study were initially identified through the Thailand Diabetes Screening Program from 2016 to 2020 in two health-promoting hospitals in Muang District, Phitsanulok Province, Thailand. Individuals indicated as prediabetics (n=1,319) were selected and further asked to voluntarily participated in the research. The inclusion criteria were adults aged 30-59 years, living in Muang district, having smartphone, can use application with access to the internet in their daily life. Exclusion criteria were participants diagnosed as DM and pregnant woman. Totally, 248 eligible voluntary participants were recruited and randomly assigned to either the intervention group (IV; n=124) or the control group (CT; n=124) in each hospital. The randomization process utilized a simple random sampling technique, employing a computer program with proportions adjusted according to the size of the prediabetes population. However, during dividing into two groups, 49 participants in the CT group requested to participate in the IV group which already reach to the sample size number; therefore, they decided refusal to participate in the study. Therefore, a total of 199 volunteers with prediabetes—comprising the intervention group (n=124) and the control group (n=75)—were included in the final analysis (Figure 1).

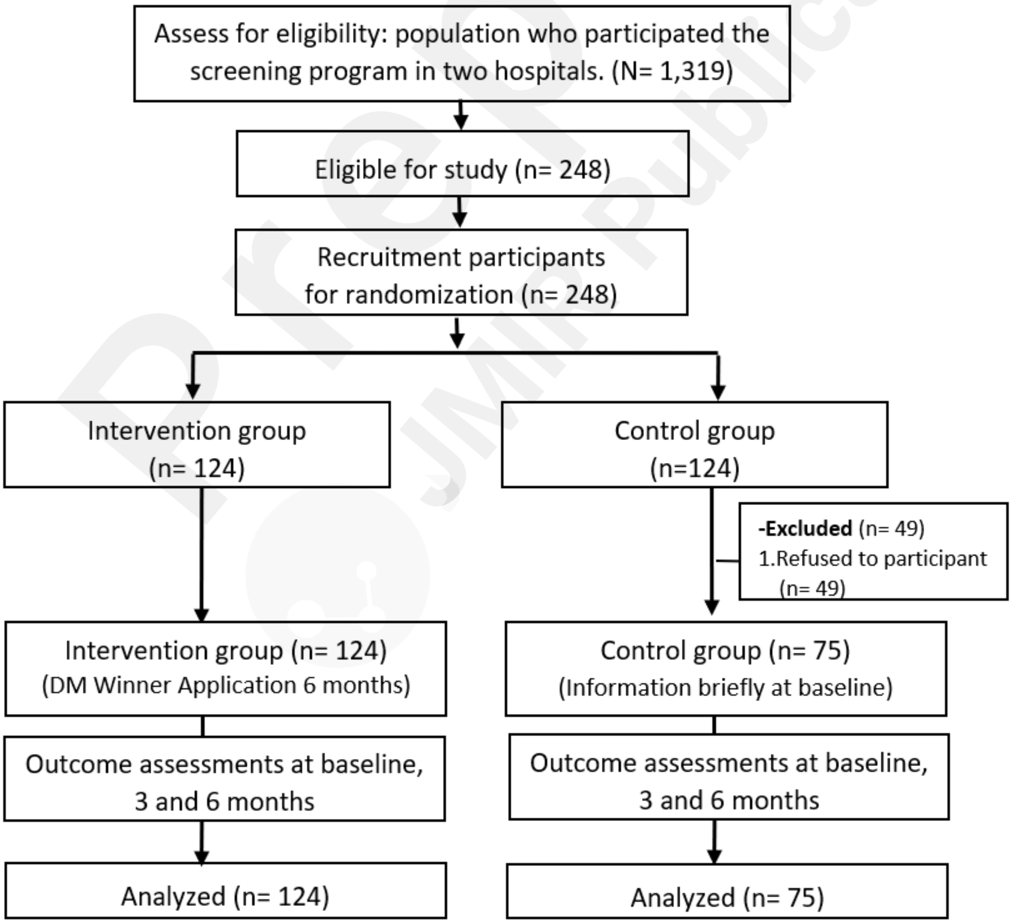


Figure 1 Consort diagram of participants screening, recruitment, and randomization.

DM Winner application

The DM Winner application on personal devices was designed to reach the ultimate goal for improving healthy behaviors of adults with prediabetes to prevent or delay type 2 DM progressing. It was provided features such as weekly goal setting, tracking, self-monitoring, coaching, and rewarding. The application includes five elements: a home screen with health information, weekly reminders, physical activity goal setting, dietary habit's goal setting, and health behavior reports.

Participants could use the application to set weekly goals for dietary habits and exercise, reporting achieved goals at the end of each week. Weekly reminders were customizable to encourage participants to improve health behaviors. The application collected data on age, weight, height, body mass index (BMI), blood pressure, waist circumference, blood glucose, exercise, dietary habits, and challenge scores.

DM Winner application development incorporated elements from various models, including social cognitive theory, self-determination theory, goal-setting theory, and positive psychology [5]. Its effectiveness was determined through a 1-month pilot study conducted between February 1 and March 3, 2021, involving 30 participants with characteristics similar to the main study to adjust functional features to align with the urban context.

Data Collection

During the first recruitment phase of the study, the staff who are health officers at hospitals explained the study details, informed consent and administered a brief self-reported questionnaire to both the IV and CT groups. The DM Winner application training was provided to the IV group at the beginning, and they utilized the application for the subsequent 6 months. On the other hand, the CT group received a brief introduction to diabetes prevention initially and were trained to use the application after the study end to improve their health behaviors as well. The data collection process involved participants being assessed through a self-report questionnaire and anthropometry measurements by trained healthcare personnel in health-promoting hospitals at baseline, 3 months, and 6 months whereas biochemical parameter measurements were taken at baseline and 3 months.

The self-reported questionnaire covered general characteristics, disease history, health risk behaviors of prediabetes, satisfaction in mobile web application and diabetic risk score [11]. Health risk behaviors included physical activity frequencies (days per week) and dietary habits frequencies (times per week) such as vegetables, fruits, grains, lean meat, snacks, alcohol, meat products, high-fat foods, fast food, soft drinks, and white rice. The reliability of physical activity and dietary habits were assessed with Cronbach's alpha equal to 0.73.

Anthropometric measurements (weight, height, waist circumference) were measured by the health officers and biochemical parameters (fasting blood sugar, serum total cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) were delivered for measurement at the Biolab Medical Technic clinic. Both parameters were collected at the baseline and after 3 months.

Statistical analysis

The descriptive data were summarized in means with standard deviation (SD) for the continuous variables and as frequency and percentage for categorical variables. General characteristics of study participants at baseline were compared using the Chi-square test, Fisher's exact test, and Independent-samples T test. To analyze differences in outcomes between the intervention and control groups at baseline, 3 months, and 6 months, a two-way repeated-measures analysis of variance (ANOVA) was performed. Furthermore, a post hoc Fisher's Least Significant Difference (LSD) adjustment was applied for pairwise comparisons. All statistical analysis was performed using the PASW Statistics for Windows, Version 18.0 (SPSS Inc., Chicago, IL, USA). A p-value of less than 0.05 was considered statistically significant.

Results

A total of 199 volunteers with prediabetes; the IV group (n=124) and CT group (n=75) were analyzed. The participants' general characteristics, family history of diseases, physical activity, dietary habits, diabetes risk score, anthropometric parameters and biochemical parameters at baseline were not significant differences (p>0.05; Table 1).

Table 1 General characteristics, health behaviors, anthropometries, biochemical parameters and diabetes risk scores of the study participants at baseline

Characteristics	Control (n=75)	Intervention (n=124)	p-value
Gender, n (%) [a]			0.565
Male	15(20.0)	20(16.13)	
Female	60(80.00)	104(83.87)	
Age (years, Mean± SD) [c]	48.07±8.39	48.55±8.40	0.695
Education, n (%) [b]			0.754
Primary school	26(34.67)	35(28.23)	
High school/Vocational certificate	27(36.00)	54(43.55)	
Diploma vocational Certificate	7(9.33)	10(8.06)	
Bachelor degrees	15(20.00)	25(20.17)	
Family history of DM, n (%) [a]	23(30.67)	43(34.68)	0.560
Exercise frequency (days per week, Mean±SD) [c]	4.56±1.76	4.52±1.39	0.899
High-fat foods frequency (Mean±SD) [c]	2.63±1.78	2.50±1.63	0.597
Fast food frequency (Mean±SD) [c]	1.91±4.05	1.23±1.34	0.088
Sweet drink frequency (Mean±SD) [c]	1.93±1.54	1.74±1.55	0.394
Body mass index; BMI (kg/m^2, Mean±SD) [c]	26.06±4.56	26.03±4.36	0.955
Waist circumference; WC (cm, Mean±SD) [c]	84.13±11.25	84.83±10.07	0.658
Biochemical parameters (Mean±SD) [c]			
FBS (mg/dl)	99.48±8.08	99.22±10.00	0.852
Total cholesterol(mg/dl)	202.28±45.24	202.94±35.62	0.910
Triglycerides(mg/dl)	155.41±108.87	140.49±64.49	0.286
HDL-C (mg/dl)	53.19±13.17	55.99±14.64	0.180
LDL-C (mg/dl)	127.13±60.49	123.40±50.39	0.644

Diabetes risk score (Mean±SD) [c]	7.03±3.06	7.38±3.94	0.498

[a] Chi square test, [b] Fisher's exact test, [c] Independent-samples T test.

Dietary habits

There were significantly changes over time for high-fat foods intake frequencies (p=0.042) (Fig 2a), fast food intake frequencies (p<0.001) (Fig 2b), and soft drink intake frequencies (p=0.010) (Figure 2c) and significant difference between groups for fast food (p=0.033) (Fig 2b).

For high-fat foods intake frequencies, there was no significant difference between groups (p=0.176) and interactions effects (group*time) (p=0.160), but was significantly difference for time effect (p=0.042). The IV group showed a significantly decrease their high-fat foods intake frequencies at 6 months when compared to those at baseline (p=0.009) and those at 3 months (p=0.010), whereas the CT group showed no change in their intake of these foods (Fig 2a).

For fast foods intake frequencies, there were significant differences between groups (p=0.033) and time effect (p<0.001). The CT group showed significantly higher fast foods intake frequencies than IV group. The fast foods intake frequencies in IV group were significantly decreased at 3 months (p<0.001) and 6 months (p<0.001), when compared to those at baseline. While the CT group showed no significant difference for fast foods intake frequencies at any times. In addition, there was no significant difference in interaction effect (p=0.735) (Fig 2b).

For soft drink consumption, there was no significant difference between group (p=0.052) and interaction effects (p=0.495). However, there was a significant difference for time effects (p=0.010). When analysis within group, the results showed that IV group showed significantly decreased of soft drink intake frequencies at 6 months compared to those at baseline (p=0.021) and at 3 months (p=0.001), but the CT group did not (Fig 2c). In addition, there were no significant differences of group, time and interactions (group*time) for intake of regular foods e.g., vegetables, fruits, grains, lean meat, meat products, and white rice (data not shown).

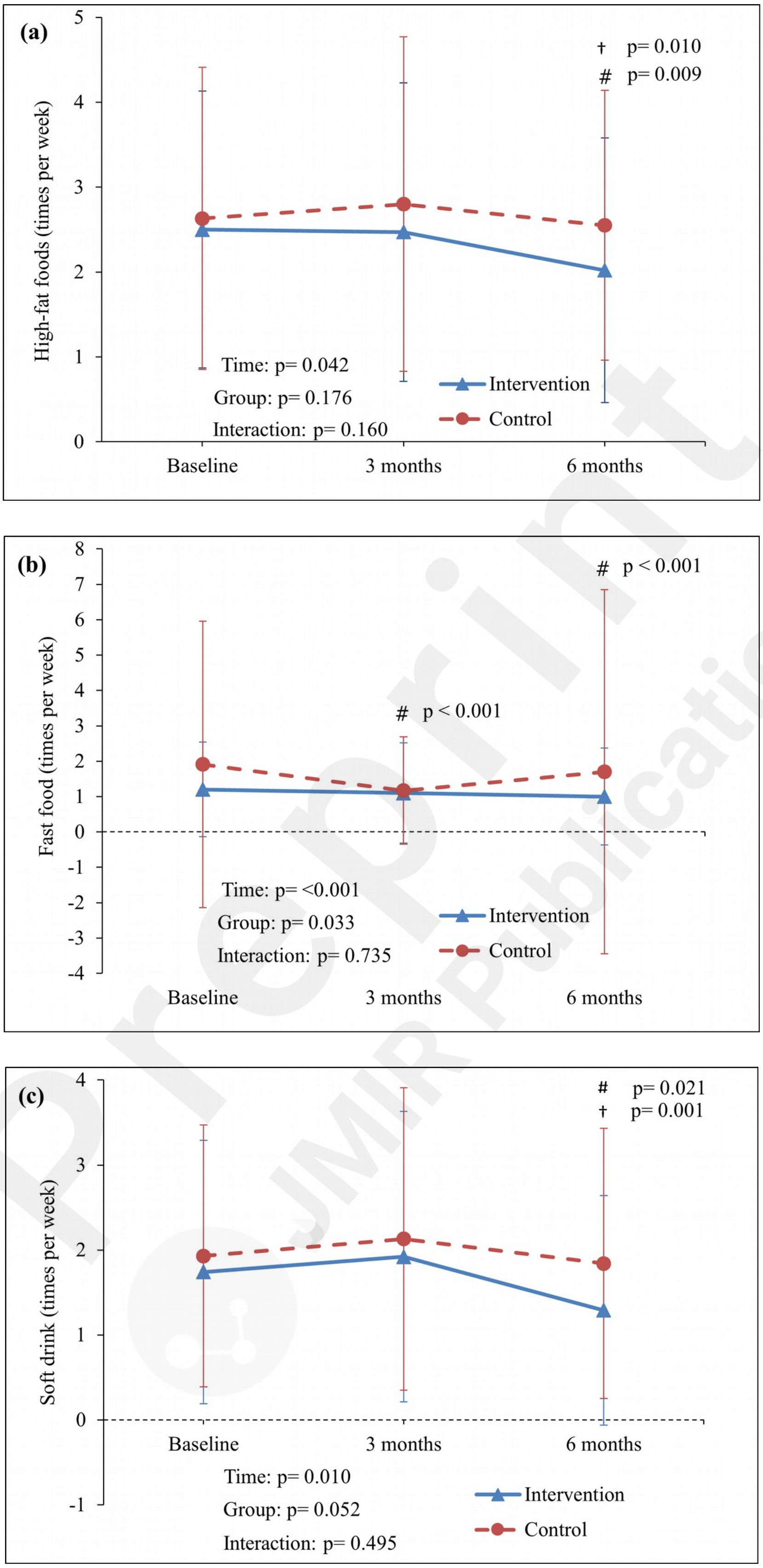


Figure 2 Frequencies of dietary habits (mean±SD) form baseline, 3 and 6 months (a= high-fat foods, b= fast food and c= soft drink). Solid line, intervention; dashed line, control. Data were analyzed

using a two-way repeated-measures ANOVA with post hoc Fisher's Least Significant Difference (LSD). # = dietary habits were significantly difference in the IV group compared to baseline. † = dietary habits were significantly difference in the IV group compared to 3 months.

Physical activities

For physical activities, there was no significant difference between groups (p=0.786). However, there was a significant difference in time effects (p=0.001) and the interactions (group*time) effects (p=0.036).

Notably, a significant time effect indicated a greater decrease in exercise frequency in the control group at 3 months (p=0.044) compared to the baseline. Exercise frequencies at 6 months significantly increased in both groups compared to 3 months (p=0.002 for IV group, p=0.003 for CT group). Furthermore, the intervention group demonstrated a substantial difference, with a greater increase at 6 months (p=0.040) compared to the baseline exercise frequency (Figure 3).

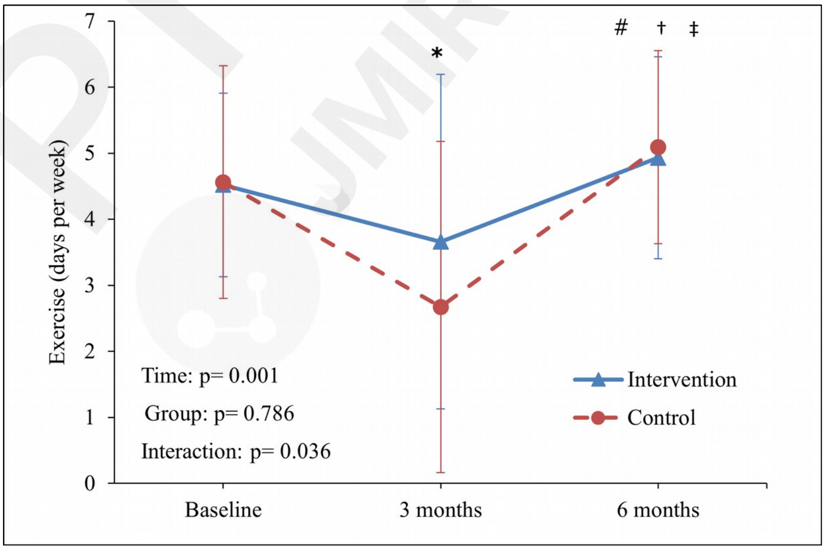


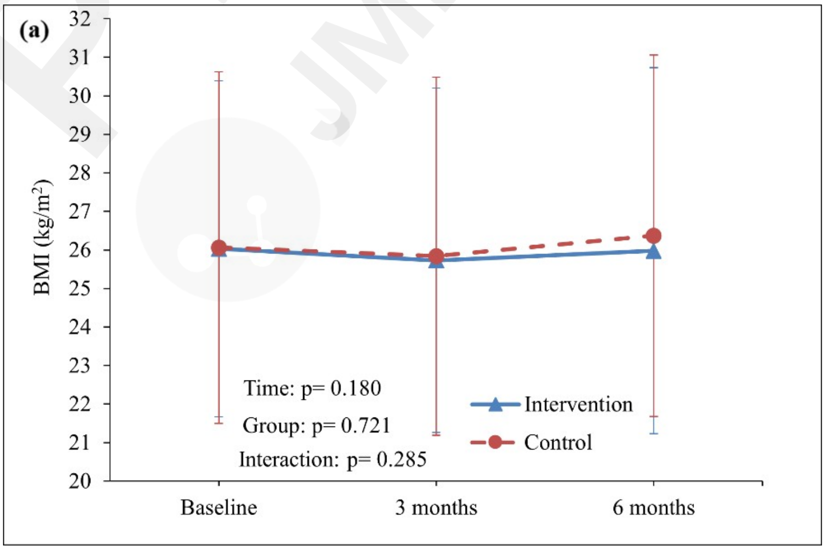
Figure 3 Frequencies of physical activity (days per week, mean±SD) of IV and CT groups at baseline, 3 and 6 months. Solid line, IV group; dashed line, CT group. Data were analyzed using a two-way repeated-measures ANOVA with post hoc Fisher's Least Significant Difference (LSD). # =

exercise frequencies in IV group at 6 months were significantly different from those at baseline (p=0.040). * = exercise frequencies in the CT group at 3 months were significantly different from those at baseline (p=0.044). † = exercise frequencies in IV group at 6 months were significantly different from those at 3 months (p=0.020). ‡ = exercise frequencies in the CT group at 6 months were significantly different from those at 3 months (p=0.003).

Anthropometric parameters and Diabetic risk score

For anthropometric parameters, there was no significant difference between groups, time and interactions effects (group*time) for BMI (p>0.05) (Fig 4a). In addition, a significant difference for interaction effect on WC (p=0.027) was noted, with decreasing of WC in the IV group for overtime period while the CT group was likely no changed. (Figure 4b).

For diabetic risk score, there was no significant difference between groups (p=0.716) and interactions effects (p=0.358). However, diabetic risk score showed a significant time effect (p=0.043). Diabetic risk scores in CT group at 6 months showed significantly higher than those at baseline (p=0.049), while there was no change in the IV group (Figure 4c).



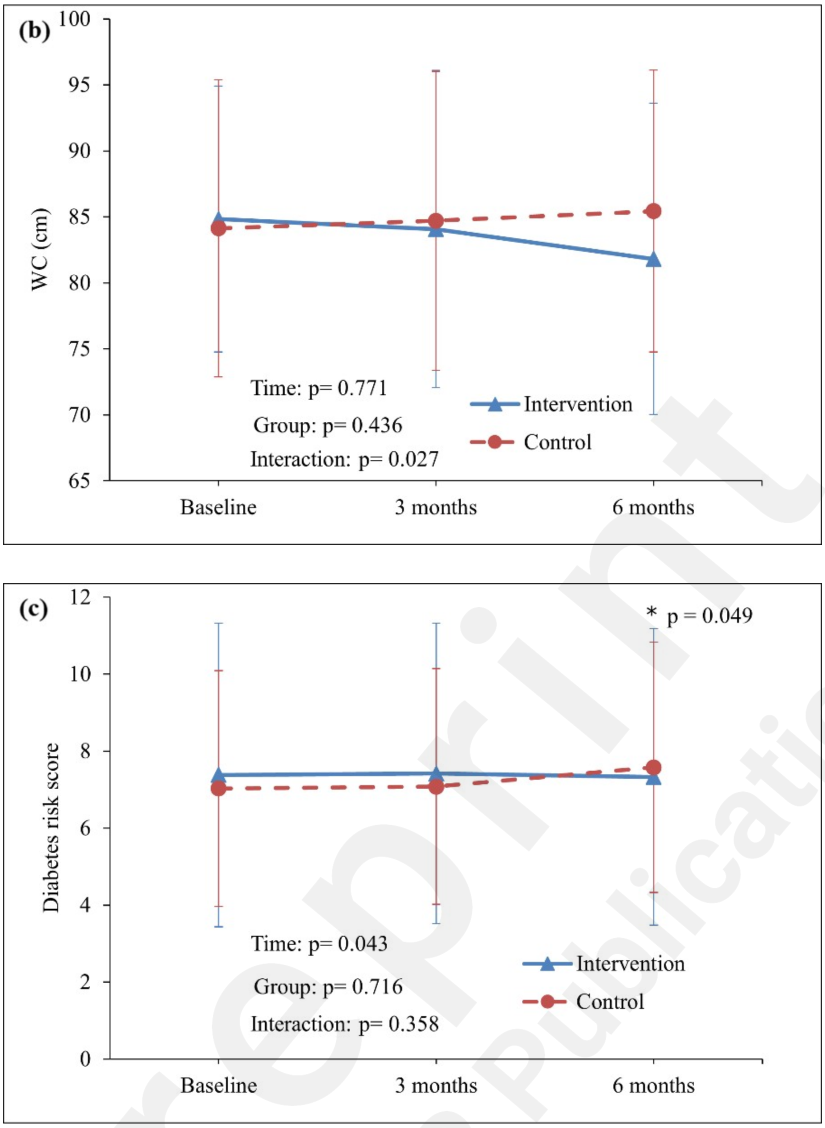


Figure 4 The differences of (a) BMI, (b) WC and (c) diabetic risk score (mean±SD) between the IV group and the CT group at baseline, 3 and 6 months. Solid line; IV: dashed line; CT. Data were analyzed using a two-way repeated-measures ANOVA with post hoc Fisher's Least Significant Difference (LSD). * = diabetic risk score significantly different in CT group compared to baseline (p=0.049).

Biochemical parameters

There was no significant difference of every biochemical parameter between both groups at baseline (p>0.05). In addition, biochemical parameters were no significant difference between groups at 3 months (p>0.05). The differences of biochemical parameters from baseline to 3 months in each group were assessed by paired T-test. FBS of IV group at 3 months showed significantly decreased (p=0.035), when compared to those at baseline, while the control group did not show any change in their FBS. Total cholesterol in IV group (p<0.001) and CT group (p=0.017) at 3 months showed significantly decreased, when compared to those of IV group and CT group, respectively at baseline. HDL-C in IV group (p<0.008) and CT group (p=0.025) at 3 months showed significantly decreased, when compared to those of IV group and CT group, respectively at baseline. Triglycerides, LDL cholesterol, SBP and DBP at 3 months in both groups did not significant difference from baseline (p>0.05) (Table 2).

Table 2 Comparison of biochemical parameters between the intervention group and the control group at baseline and 3 months and the difference of biochemical parameters from baseline to 3 months in each group

Variables	Intervention (n=124)				Control (n=75)			
(mean±SD)	Baseline	3 Months	p-value¥	p-value#	Baseline	3 Months	p-value†	p-value‡
FBS (mg/dl)	99.22±10.00	97.31±13.76	0.852	0.035*	99.48±8.08	99.28±10.46	0.645	0.775
Total cholesterol (mg/dl)	203.47±33.24	194.46±30.48	0.910	<0.001*	205.38±39.89	197.05±35.68	0.628	0.017*
Triglycerides (mg/dl)	135.06±61.17	133.72±106.03	0.286	0.882	150.60±115.24	134.47±68.36	0.961	0.191
HDL-C (mg/dl)	57.70±13.79	55.07±13.77	0.180	0.008*	55.03±13.18	52.88±12.83	0.323	0.025*
LDL-C (mg/dl)	121.96±41.99	123.31±55.72	0.644	0.838	132.02±63.56	122.19±50.79	0.899	0.295
SBP (mmHg)	121.28±15.89	123.03±15.89	0.69	0.160	121.86±18.78	123.49±14.88	0.958	0.438
DBP (mmHg)	79.63±10.79	79.26±15.19	0.707	0.813	80.18±13.22	77.58±9.81	0.904	0.146

¥ Independent-samples T test were analyzed biochemical parameters between the intervention group and the control group at baseline, # Pair T-test were assessed biochemical parameters from baseline to 3 months in the intervention group, †Independent-samples T test were analyzed biochemical parameters between the intervention group and the control group at 3 months, ‡Pair T-test were assessed biochemical parameters from baseline to 3 months in the control group, *p< 0.05 level

Application satisfaction

Satisfaction score evaluated at 6 months in the IV group was high with a mean (±SD) of the overall satisfaction score of 4.19±0.82 (out of 5). Usefulness for health promotion scored 4.20 ± 0.77, complete content of menu scored 4.12 ± 0.78, and consistency in use for health promotion scored 4.07 ± 1.00. Mostly users (84%) provided very and quite satisfaction levels for application (Figure 5).

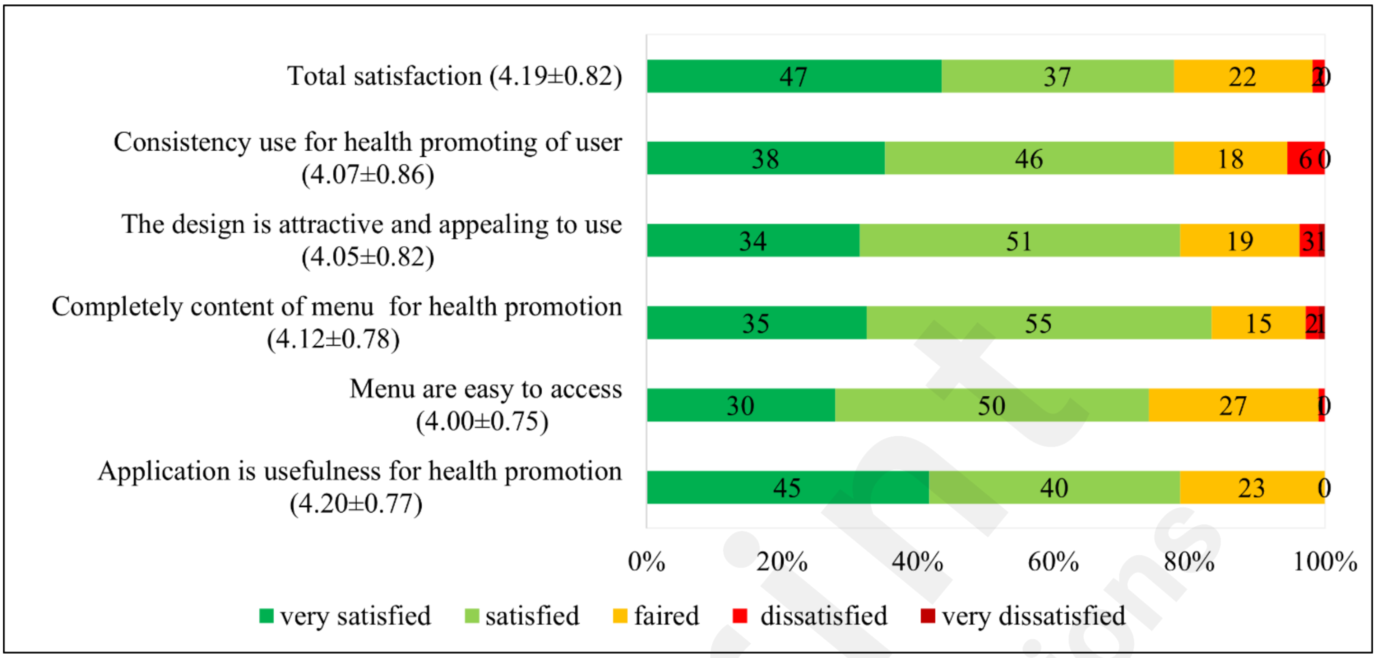


Figure 5 Satisfaction level of the DM Winner application at 6 months.

Discussion

The general characteristics, health behaviors, anthropometries, biochemical parameters and diabetes risk score were not significant difference between two group at baseline. The main findings are that the DM winner application showed the improving the healthy behaviors of adults with prediabetes. These are the most likely that the effect of DM winner application on a trend of decreasing of unhealthy foods (high fat foods, fast foods and soft drinks) consumption among adults with prediabetes. At 6 months, IV group are likely less unhealthy foods consumption than CT group. IV group was also found to significantly reduce their unhealthy food intake at 6 months, when compared to baseline and 3 months. In addition, there were no significant differences of group, time and interactions (group*time) for intake of regular foods. In contrast, the TRIANGLE application study in Germany women with risk of gestational diabetes showed that no significant change of fat, and saturated fat intake at 6-months compared to baseline [12]. Our results are different from the Jom Mama application trial of the study in women with risk of diabetes in Malaysia [13] and a digital platforms-based lifestyle coaching program of young adults with prediabetes in the U.S. [14] that demonstrated no significant difference of unhealthy foods between two groups. The DM winner application is likely to be more effectively promoting the reducing of unhealthy foods consumptions, when compared with other apps.

Although, the application failed to show significant difference in the increasing physical activities between two groups but showed significant difference in time and interaction effect. The IV group showed a greater increase in physical activity at 6 months when compared to baseline, but the CT group did not. At 3 months compared with baseline, a decreasing physical activity was found in the IV group and less than those in CT group. These results indicated that the IV group demonstrated at least greater ability to sustain physical activities than CT group. The present study is likely in accordance with previous research of a Randomized Controlled Trial study (RCT) aims to examine the effect of Alive-PD application in adults with diabetes, the results showed that two groups had increasing changed of physical activity at 6 months, with the IV were significantly increased their physical activity more than the CT [5]. The findings appear to be opposite to the study of a smartphone app-based lifestyle change program (D'LITE study) for Asian population with prediabetes, which showed that the significant increasing physical activities in IV group than those of the CT group at 3 months but did not at 6 months [8]. In contrast, there was a mobile application RCT promoting physical activity among newly diagnosed T2DM subjects in India was found no significant difference of physical activity between two groups over 2 years [15]. The reason is that Thailand, including the study sites, remained under lockdown due to a late outbreak of Covid-19; therefore, the participants could not do regular exercises as outdoor activities e.g., aerobic exercise, walking/running, and playing sports.

Although anthropometric parameters relevant to the risk of T2DM were obviously known, this study showed no significant difference between groups, time and interactions effects for BMI and WC. These may be due to less effect of physical activities and unhealthy food consumption on anthropometric parameters of both groups, during a lock down period due to covid-19 pandemics. Similarly, the Jom Mama application project in Malaysia [13] showed no significant differences in women's WC, weight, and BMI between two groups over the 8-month study period. However, opposite with the present study, several apps were reported to reduce weight BMI and WC of IV group. For the 6-months study in the U.S., obese sedentary young adults with prediabetes used Alive-PD application was reported a decreasing trend of BMI after 12 weeks of IV group [16]. Several Health applications used by adults with prediabetes showed a significant difference between groups of weight, BMI and WC at 6 months [8, 17, 18]. In addition, the 2-year results of a single-arm longitudinal study via web-based diabetes prevention program among prediabetes showed that users of the prevent program experienced significant reductions in body weight [19]. The DM winner app may further be required to improve effective features and essential contents to reduce weight, BMI and WC of individuals with prediabetes.

The present results showed no significant difference of biochemical parameters between two groups at base line and 3 months. The IV group showed significantly decreased their FBS level at 3 months, compared to baseline, while the CT did not. This may result from DM winner app usage promoting more physical activities, less consumption of unhealthy foods. These results are in accordance to the Jom Mama application project in Malaysia [13], the 6 months RCT using Alive-PD app among persons with prediabetes in the U.S. [16], the internet-based Korea DP [20] and a digital DPP (d-DPPs) [21] showed the greater reduction of FBS and HbA1c in IV group than in CT group. In addition, the previous studies of health applications in prediabetes showed that a significant difference between groups of FBS and HbA1c at 12 months [8, 12, 18]. Total cholesterol and HDL-levels in the two group was reduced, because the participants could not go outside, resulting in having a low chance to take unhealthy foods and do physical activities during lockdown period.

Limitations

The limitations of this study are that prediabetes among voluntary participants was identified through self-reported physician diagnoses and retrospective screening using laboratory random glucose testing (FBS) over a five-year period, based on data obtained from health-promoting hospitals. Screening data has not been updated for at least a year. Secondly, the data collected in 2022 may have been affected by the COVID-19 pandemic's locking/unlocking policy in Thailand.

Conclusion

In summary, the main finding of this study is that the DM winner application showed preventative effects on diabetes in adults with prediabetes, which included increasing physical activities, less junk food and sweet drink consumption, leading to feasibly reducing risk of diabetes. Interestingly, fast blood glucose levels were found to be reduced among adults with prediabetes who used DM winner application. The overall evaluation among users was found to be high satisfaction on DM winner application.

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/ or publication of this article.

Author Contributions

JH developed the study design, collected, analyzed, interpreted the data, and wrote the manuscript. DA was involved with developing the study design, data interpretation, and writing of the manuscript. PM and SS were involved in the data interpretation and review of the manuscript. NS contributed to the study design, data analysis and interpretation and writing of the manuscript. All authors contributed to and approved the final manuscript.

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Abbreviation

T2DM: type 2 diabetes mellitus

FBS: fasting blood sugar

HDL-C: high-density lipoprotein cholesterol

LDL-C: low-density lipoprotein cholesterol

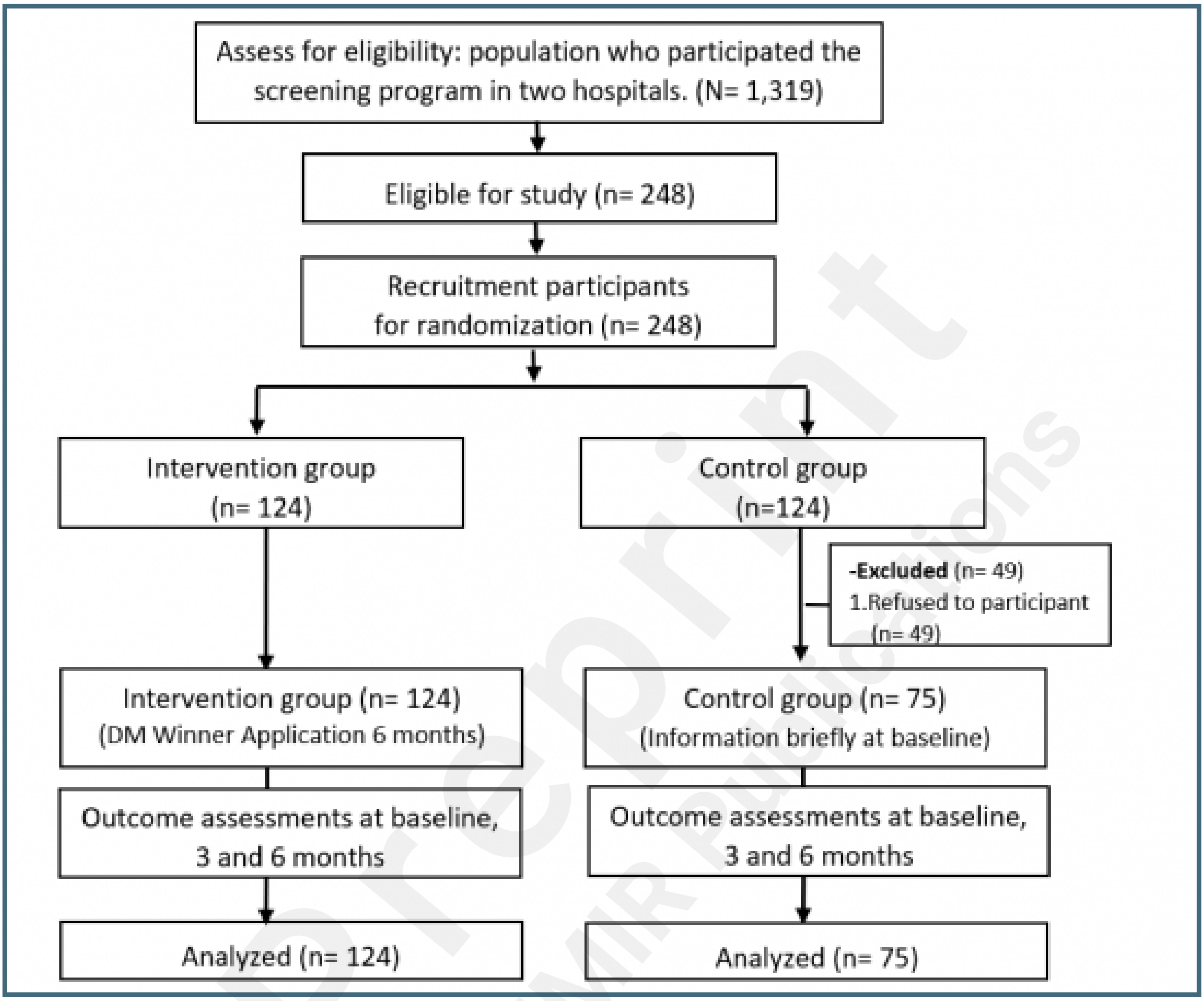
mHealth: mobile health

BMI: body mass index

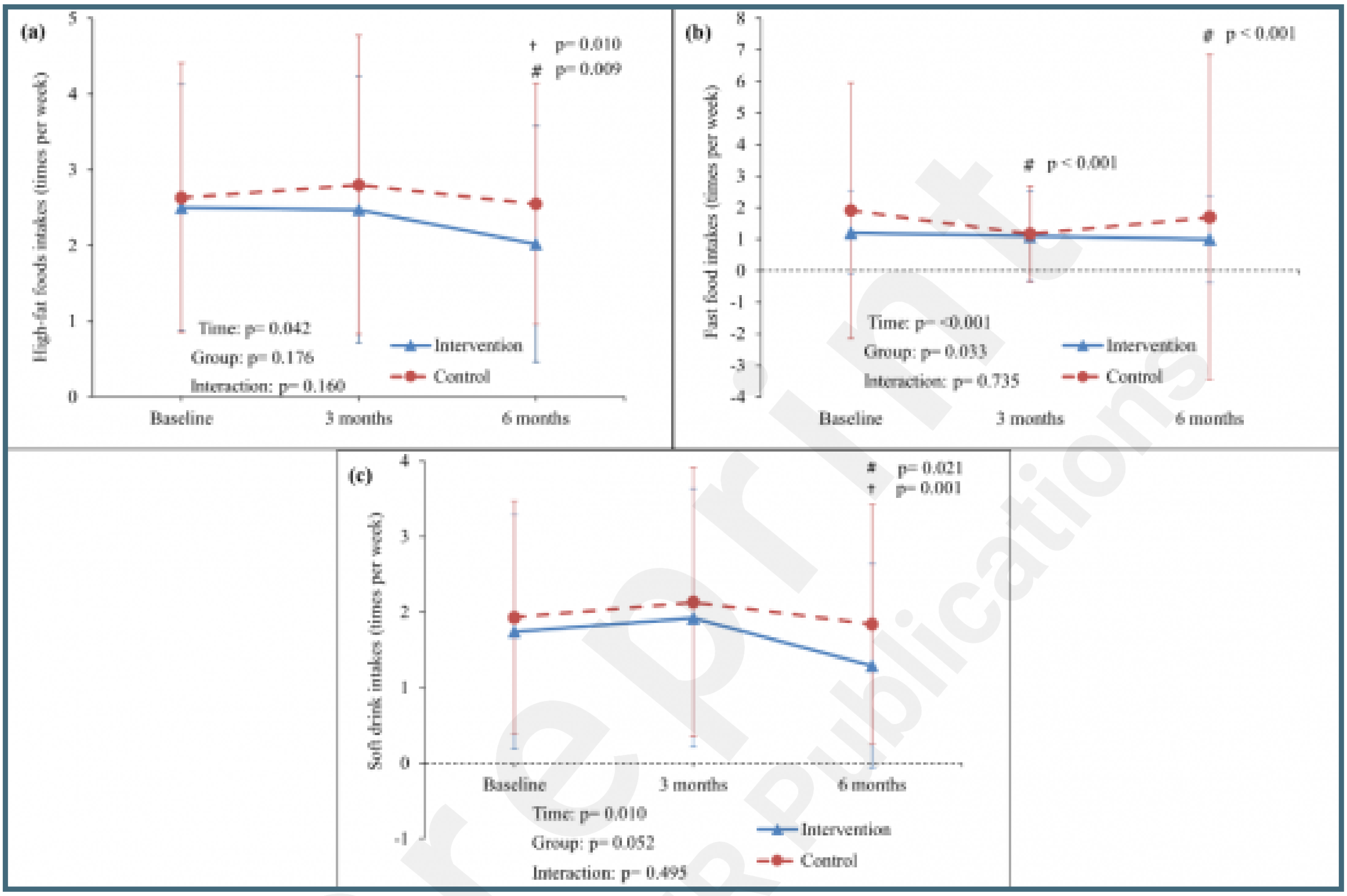
Supplementary Files

Figures

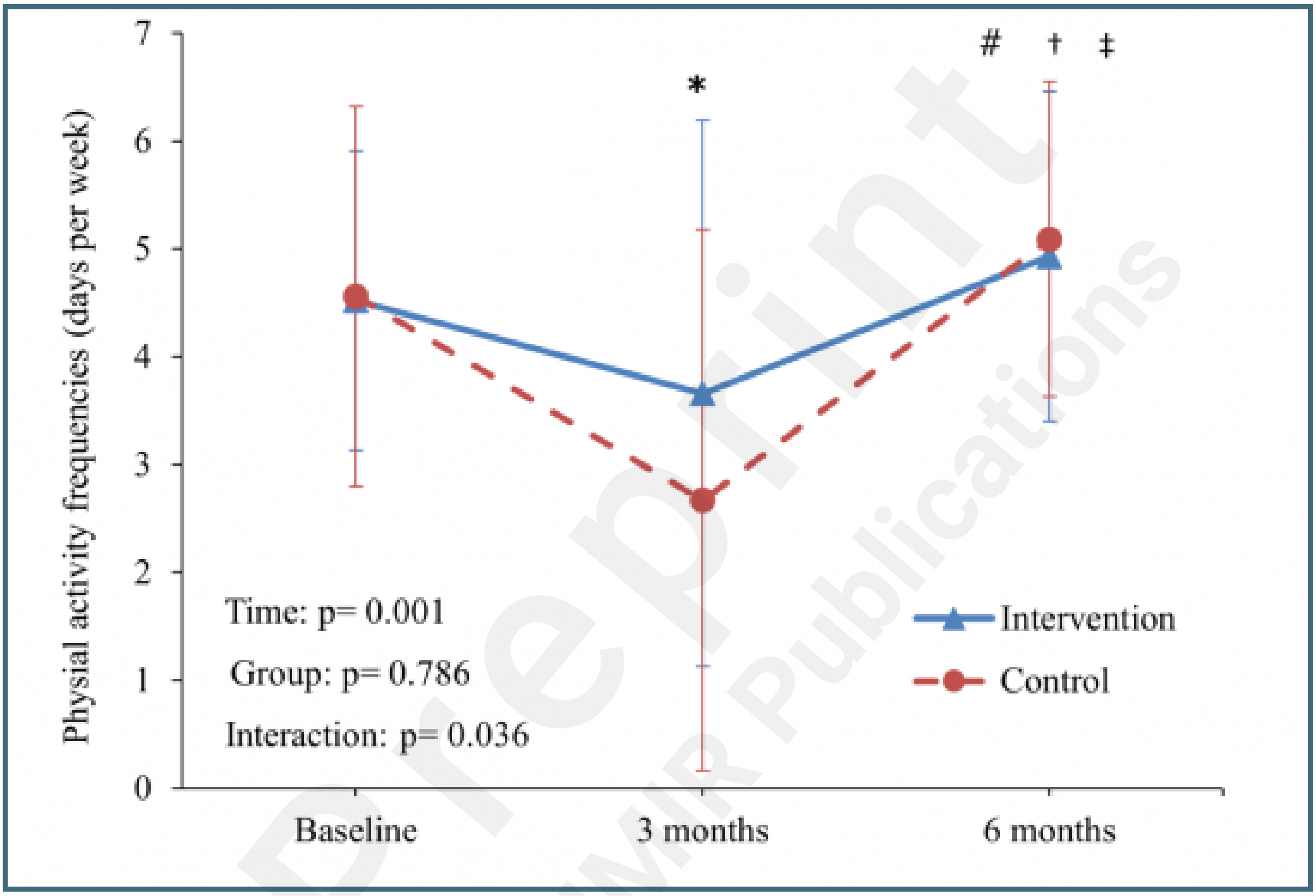
Study population and data collection of the randomized control trial study.



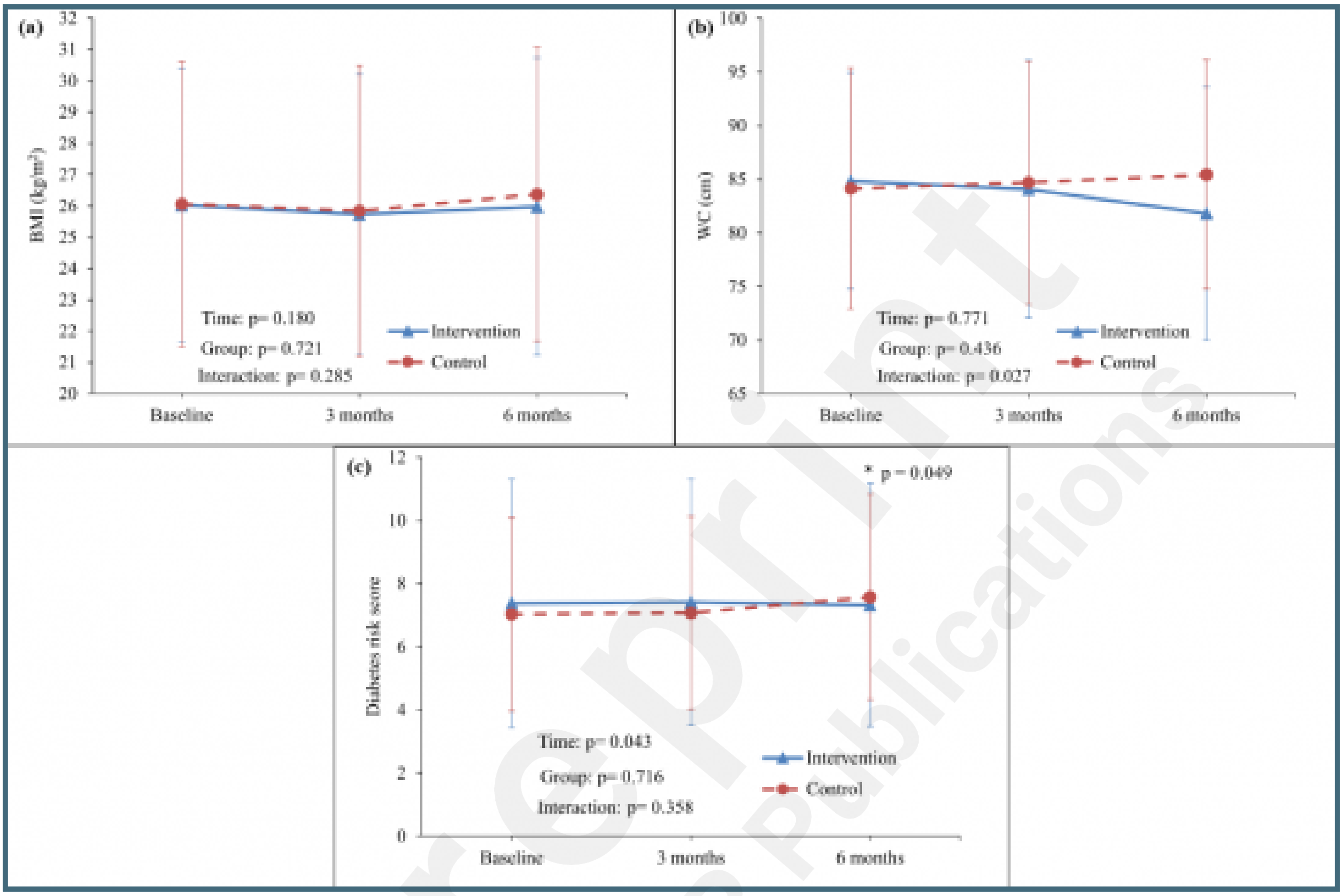
Frequencies of dietary habits (mean±SD) form baseline, 3 and 6 months (a= high-fat foods, b= fast food and c= soft drink). Solid line, intervention; dashed line, control. Data were analyzed using a two-way repeated-measures ANOVA with post hoc Fisher's Least Significant Difference (LSD). # = dietary habits were significantly difference in the IV group compared to baseline. † = dietary habits were significantly difference in the IV group compared to 3 months.



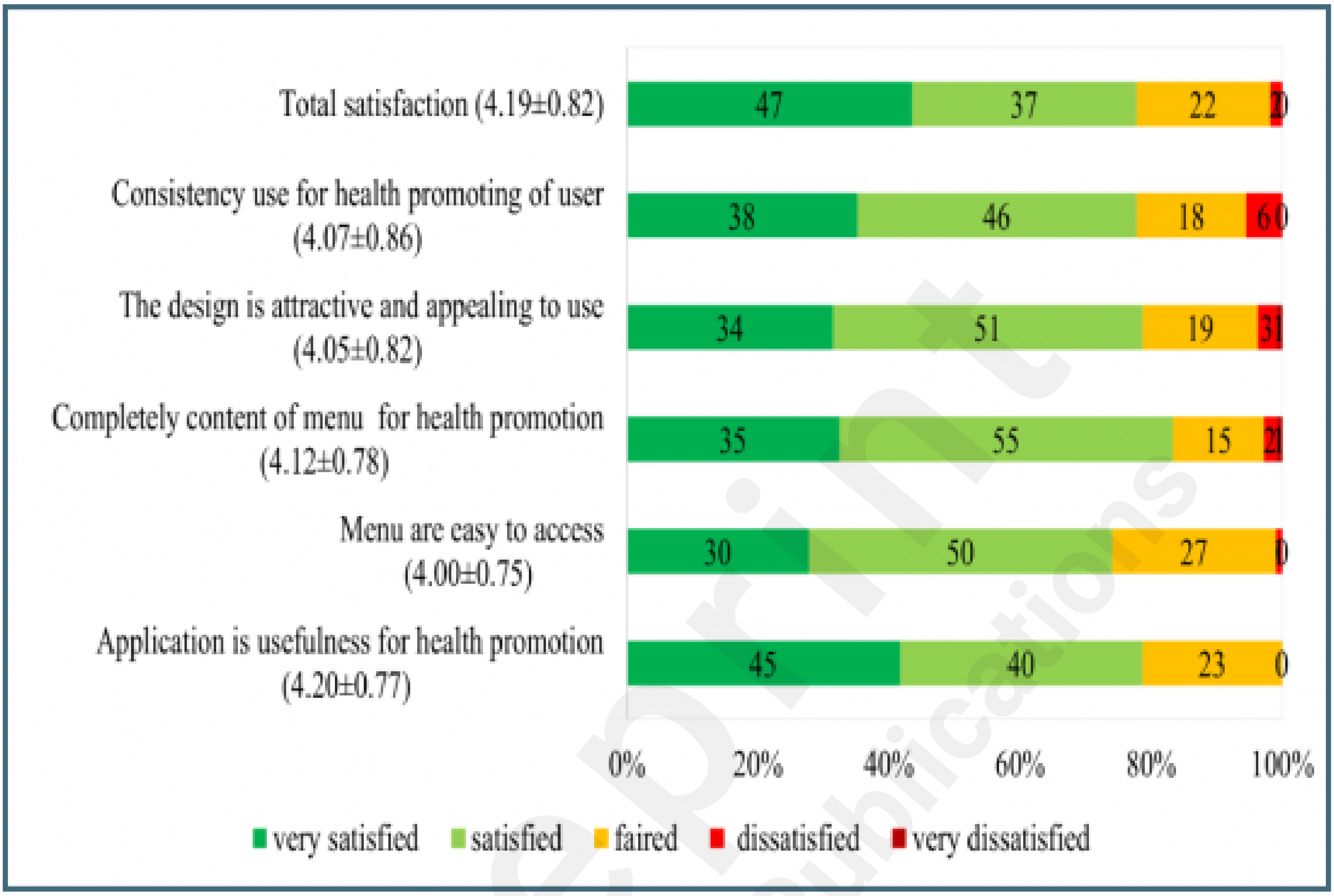
Frequencies of physical activity (days per week, mean±SD) of IV and CT groups at baseline, 3 and 6 months. Solid line, IV group; dashed line, CT group. Data were analyzed using a two-way repeated-measures ANOVA with post hoc Fisher's Least Significant Difference (LSD). # = exercise frequencies in IV group at 6 months were significantly different from those at baseline (p=0.040). * = exercise frequencies in the CT group at 3 months were significantly different from those at baseline (p=0.044). † = exercise frequencies in IV group at 6 months were significantly different from those at 3 months (p=0.020). ‡ = exercise frequencies in the CT group at 6 months were significantly different from those at 3 months (p=0.003).



The differences of (a) BMI, (b) WC and (c) diabetic risk score (mean±SD) between the IV group and the CT group at baseline, 3 and 6 months. Solid line; IV: dashed line; CT. Data were analyzed using a two-way repeated-measures ANOVA with post hoc Fisher's Least Significant Difference (LSD). * = diabetic risk score significantly different in CT group compared to baseline (p=0.049).



Satisfaction level of the DM Winner application at 6 months.



Multimedia Appendixes

CONSORT-EHEALTH (V 1.6.1) - Submission/Publication Form.
URL: http://asset.jmir.pub/assets/ebf9ebf3b05859bd23d3c0b88da042cd.pdf