Effect of mHealth Interventions on Glycemic Control and HbA1c Improvement among Type II Diabetes Patients in Asian Population: A Systematic Review and Meta-Analysis

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Abstract

Introduction: Due to the high prevalence of diabetes mellitus, it is pertinent to educate and inform diabetes patients about their self-management. It can be done effectively using innovative methods like mobile health (mHealth), which includes mobile applications, phone calls, and text messages. Thus, this meta-analysis was conducted to summarize the effectiveness of mHealth interventions for the management of diabetes compared with usual care in the Asian population. Materials and Methods: Searches were performed in electronic databases, namely PubMed, Scopus, Embase, and Cochrane Library, in August and September 2020. Search terms used were “Diabetes Mellitus,” “mHealth,” “glycemic control,” “HbA1c levels,” and “Blood glucose levels.” The primary outcome was glycated hemoglobin and blood glucose levels. Trials were pooled, and heterogeneity was quantified using the I² statistic. Results: The search yielded 3980 abstracts, of which 18 trials met the inclusion criteria. Lowering of Hba1c levels was reported in the majority of trials, which aided in Glycemic control. For post prandial blood glucose (PPBG) levels, a statistically significant reduction of value –20.13 (95%CI –35.16 to –5.10, P = 0.009, I² = 59%) was seen in the mean in the intervention group, whereas for HbA1c levels the mean reduction in the intervention group was –0.44 (95%CI, –0.79 to 0.10, P = 0.01, I² = 87%). Although these interventions proved beneficial for these outcomes, there was a difference in the amount of effects caused by different mHealth interventions. Conclusion: This study acknowledged the effects of different mHealth interventions as per their accessibility and availability in recent years. There is a need to include more studies in future reviews to generate a larger body of evidence for the reported outcomes. The researchers should give the utmost priority to the transparency while reporting the interventions for effective interpretation of the retrieved data.

Keywords: Diabetes mellitus, glycemic control, HbA1c, meta-analysis, mHealth
public health practice promoted and supported by mobile devices like mobile phones, personal digital assistants (PDAs), patient monitoring devices and other wireless devices.\cite{8,9}

The “International Telecommunication Union (ITU)” reported that the number of wireless subscribers has risen to over 5 billion, and nearly 70% of these users belong to LMIC.\cite{6} With this extensive market penetration of mobile and wireless technologies, it serves as an essential means to enhance the education and support for the patients and prove beneficial for health care professionals.\cite{9}

Various components of mHealth include mobile apps, phone calls, and text messages, which help in the fast and instant transmission of the information at a low cost to users and could become an ideal technique for diabetes self-management.\cite{8,9}

Diabetes Mellitus exhibits disparities in Asia compared to Western countries. The disease biology, etiology, and genetic predilection are different for Asians.\cite{10,11} Hence, it became pertinent for a systematic review and meta-analysis of the trials specifically confined to the Asian population to evaluate and assess the effects of mHealth interventions on glycemic control and HbA1c among type II diabetes patients. The review aimed to estimate the mean difference in blood glucose levels measured in mg/dL and mean the difference in glycated hemoglobin (HbA1c) measured in % (mmol/mol) levels intervention and control group.

**Materials and Methods**

This Systematic Review with Meta-Analysis was conducted and reported according to the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)” guidelines.\cite{12}

The protocol was duly submitted to the Institutional Research Review Board and PROSPERO. It has been registered in PROSPERO under the registration ID- CRD42020194063. Ethical approval for the same was also obtained from the Institutional Ethics Committee as letter no-AIIMS/IEC/20/710 dated 19th October 2020.

**Database and search strategies**

A comprehensive and thorough search strategy was conducted in August and September 2020 on electronic database searches, namely PubMed, Scopus, Embase, and Cochrane Library. Google Scholar was used to browsing gray literature, and the Trial registry - clinicaltrials.org was searched to track publications not indexed in other databases.

A standard and accepted search strategy was designed for PubMed and other databases to broadly search the publications starting from the month of January in 1990 to the month of August in 2020. It was later modified as per the requirement of other databases.

Various search strategies, according to database scanned, are given in the table below [Table 1]:

**Criteria for study inclusion and exclusion**

Randomized controlled trials (RCTs) or clinical trials that reported the clinical outcomes of the mHealth interventions in T2DM adults compared with conventional care or usual care were included. The mHealth intervention arm was needed to have one or more of the following categories:

1. Mobile Health applications targeting patients with type II DM
2. Text messages - SMS (Short Message Service) used to manage type II DM.
3. Phone calls used for management of type II DM.

The studies which were conducted in the Asian population and published in English were included.

The studies where diabetes patients reported severe diabetic complications such as diabetic foot, diabetic heart disease, etc., were excluded. Also, the studies with mixed population of patients such as type 1 and type 2 diabetics were excluded, along with the studies on pregnant women with type 2 diabetes.

**Study selection**

After the literature search, the titles and abstracts of the obtained studies were individually scanned by authors, and potentially eligible studies were identified. Consensus was obtained between the two reviewers in case of disagreement and the exclusion reasons were recorded. [Annexure I].

**Data extraction**

All the obtained records were then collected into the Zotero library for deletion of duplicate studies. The remaining references were then transported to an excel file that contained all the essential information required for screening.

**Outcome measures**

The primary outcomes assessed were the change in glycated hemoglobinA1c (HbA1c) and blood glucose levels post-intervention in both the arms.

**Assessment of risk of bias**

The “risk of bias” was assessed in the included studies as per “Cochrane Handbook for Systematic Reviews of Interventions.”\cite{7,13} Two reviewers independently evaluated the studies and the risk of bias was noted. The risk had a judgment as high risk, low risk, unclear risk, and the reason for every decision was further recorded. [Annexure II].

**Data analysis methods**

A quantitative synthesis of data was further done to have a pooled estimate of the included studies to estimate mHealth interventions’ effect in glycemic control outcomes and HbA1c Improvement on type 2 diabetes patients.

“Review Manager Software (version 5.3)” was used for statistical analysis. Cochrane’s Q statistic and inconsistency index (I²) was used to compute the statistical heterogeneity. Pooled effect size estimates along with a 95% confidence interval were calculated. The mean, standard deviation (SD), and the participant number given in both the groups (intervention and control) for each outcome at last follow-up were collected from each study. Funnel plots were used to assess publication bias.
Subgroup analysis was done based on the type of mHealth intervention used among the RCTs participants.

RESULT

After the combined database search, it resulted in a total number of 3980 records. Out of these, 72 articles were shortlisted based on their eligibility, and after the full-text screening, it resulted in 18 eligible trials for qualitative synthesis and 14 trials for quantitative synthesis (Meta-Analysis). Details of the screening process and results are presented in Supplementary Figure 1.

Characteristics of the studies

The studies included in the systematic review are listed in Table 2. 18 trials were obtained for the qualitative synthesis (Systematic Review), whereas only 14 trials were finalized for Quantitative synthesis (Meta-Analysis). A total of 3368 participants were recruited in these trials, whereas only 2931 participants could complete the trials. The majority of trials were conducted in the Southern Asian region, followed by the eastern region, western region, and the southeastern region. The region-wise distribution of included studies is given in Table 3.

Supplementary Figure 2 demonstrates the distribution of included trials based on the Asian region in which they are conducted.

The intervention duration was 7 months on average and ranged from 3 months to 24 months. Most of the trials were published in the current decade (2011–2020). In 6 trials, the mobile application was used as an intervention. Phone calls were used in 4 trials, and text messages were used in 7 trials. One trial involved both the use of text messages and phone calls in the intervention arm.

In most trials, the number of participants recruited ranged from 100 to 500. Seven trials reported only about HbA1c as an outcome measure. Seven trials reported fasting blood glucose (FBG) levels along with HbA1c levels, whereas one trial reported HbA1c and Post Prandial Blood glucose (PPBG) levels. Four trials reported all the three outcome measures i.e., HbA1c, FBG and PPBG. One trial reported only about FBG levels, whereas another reported only blood glucose levels, including FBG and PPBG levels.

Risk of bias

The risk of bias observed commonly was unclear bias, reported in all the studies due to insufficient evidence as no information was given regarding their protocol registration or publication. High risk of bias was also reported in maximum studies as no blinding of participants and researcher was possible due to the nature and requirement of these trials and thus, the majority of trials were open labeled. Figure 1 (a) demonstrates the risk of bias graph where each risk is given as low risk, unclear risk and high risk and Figure 1 (b) summarizes the risk of bias summary and assessment for every included study.

![Figure 1: (a) Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies (b) Risk of bias summary: review authors' judgements about each risk of bias item for each selected study](image_url)
Table 1: Various search strategies according to databases scanned

| Database          | Search Strategy                                                                 | No. of studies |
|-------------------|---------------------------------------------------------------------------------|----------------|
| Pubmed            | (("diabetes mellitus" OR "diabetes type 2") OR "type 2 diabetes") OR "DM type 2" OR "type 2 DM") OR "Diabetes Mellitus Type II" OR "type II Diabetes mellitus" OR "adult diabetes" OR "Type 2 diabetes patients" OR "Diabetes mellitus patients" OR "patients with type 2 diabetes" OR "Diabetes type 2 patients" OR "Diabetes in older age" OR "Maturity Onset Diabetes Mellitus" OR "Adult-Onset Diabetes Mellitus") AND ("mhealth" OR "mobile health" OR "m-health" OR "e-health" OR "electronic health" OR "e-health" OR "phone calls" OR "phone call management" OR "text messaging" OR "text messages" OR "SMS text" OR "mobile applications" OR "mobile apps" OR "mobile health applications" OR "mobile health apps") AND ("Glycemic control" OR "HbA1c" OR "HbA1c levels" OR "Haemoglobin A, Glycated" OR "Glycosylated Haemoglobin A" OR "blood glucose levels" OR "blood sugar levels" OR "Blood Glucose Self-Monitoring" OR "Blood Sugar Self-Monitoring" OR "Home Blood Glucose Monitoring").
| Embase            | #1: 'glycemic control'/exp OR 'hemoglobin a1c'/exp OR 'glucose blood level'/exp OR 'blood glucose monitoring'/exp #2: 'telehealth'/exp OR 'mhealth'/exp OR 'mobile application'/exp OR 'text messaging'/exp OR 'phone call'/exp #3: 'diabetes mellitus'/exp OR 'diabetic patient'/exp OR 'non-insulin dependent diabetes mellitus'/exp-305 #1 AND #2 AND #3 AND [(controlled clinical trial)/lim OR [randomized controlled trial]/lim] AND [embase]/lim AND [1-1-1990]/sd NOT [1-9-2020]/sd AND [1990-2020]/py #5 AND [iadult]/lim OR [aged]/lim OR [middle aged]/lim OR [very elderly]/lim OR [young adult]/lim #4‑ MeSH descriptor: [Blood Glucose Self‑Monitoring] explode all trees A18055641 | 1624 |
| Scopus            | (TITLE‑ABS‑KEY ("Diabetes Mellitus" OR "Non‑Insulin Dependent Diabetes Mellitus" OR "diabetic patient") AND TITLED‑ABS‑KEY ("telehealth" OR "mhealth" OR "mobile application" OR "text messaging" OR "SMS" OR "phone call") AND TITLE‑ABS‑KEY ("glycemic control" OR "hemoglobin a1c" OR "glucose blood level" OR "blood glucose monitoring") AND TITLE‑ABS‑KEY ("randomised controlled trial" OR "RCT" OR "clinical trial") AND (EXCLUDE (PUBYEAR, 1987) OR EXCLUDE (PUBYEAR, 1986) ) AND ( LIMIT‑TO (DOCTYPE, "ar" ) ) ) | 417 |
| Cochrane Library  | #1- MeSH descriptor: [Diabetes Mellitus, Type 2] explode all trees #2- MeSH descriptor: [Telemedicine] explode all trees #3- MeSH descriptor: [Glucated Hemoglobin A] explode all trees #4- MeSH descriptor: [Blood Glucose Self‑Monitoring] explode all trees #5= #1 AND #2 AND #3 OR #4 | 815 |
| Google Scholar    | "mhealth" AND "Diabetes mellitus type 2" AND "HbA1c" AND "Blood glucose"                                                  | 192 |
| Clinicaltrials.gov| Telemedicine, glycemic control | Available, Completed Studies | Interventional Studies|Diabetes Mellitus | 24 |

Table 2: Characteristics of Included Studies in the Systematic Review

| Author            | Year of study | Year of publication | Country   | Sample size (Recruited/Completed) | mhealth intervention Group | Control Group | Follow-up duration (months) | Outcome Measure Reported |
|-------------------|---------------|---------------------|-----------|-----------------------------------|---------------------------|---------------|----------------------------|-------------------------|
| Cheng et al.       | 2014-15       | 2017                | China     | 242/201                           | Phone calls               | usual care    | 5                          | HbA1c                   |
| Vinitha et al.     | 2014-15       | 2019                | India     | 248/218                           | SMS                      | usual care    | 24                         | -                       |
| Kusnanto et al.    | 2018          | 2019                | Indonesia | 30/30                             | Mobile application       | usual care    | 3                          | -                       |
| Adikusuma et al.   | 2017          | 2018                | Indonesia | 40/40                             | SMS                      | usual care    | 6                          | -                       |
| Dong et al.        | 2016          | 2018                | China     | 120/119                           | Mobile application       | usual care    | 12                         | -                       |
| Goodarzi et al.    | 2011          | 2012                | Iran      | 100/81                            | SMS                      | usual care    | 3                          | -                       |
| Gunawardena et al. | 2017-18       | 2019                | Sri Lanka | 67/52                             | Mobile application       | usual care    | 6                          | -                       |
| Kumar et al.       | 2015-16       | 2018                | India     | 955/852                           | SMS                      | usual care    | 12                         | -                       |
| Kim et al.         | 2005          | 2006                | South Korea | 60/51                            | SMS                      | usual care    | 6                          | -                       |
| Jarab et al.       | 2011-12       | 2012                | Jordan    | 171/156                           | Phone calls               | usual care    | 6                          | -                       |
| Jain et al.        | 2018          | 2018                | India     | 299/290                           | Phone calls               | usual care    | 6                          | -                       |
| Kleinman et al.    | 2015          | 2016                | India     | 91/80                             | Mobile application       | usual care    | 6                          | -                       |
| Lee et al.         | 2014-15       | 2018                | South Korea | 148/105                          | Mobile application       | usual care    | 12                         | -                       |
| Sun et al.         | 2016          | 2019                | China     | 91/91                             | Mobile application       | usual care    | 6                          | -                       |
| Oh et al.          | 2000-01       | 2003                | South Korea | 50/38                            | Phone calls               | usual care    | 3                          | -                       |
| Patnaik et al.     | 2012-13       | 2014                | India     | 100/55                            | SMS+Phone calls           | usual care    | 3                          | -                       |
| Sadanshiv et al.   | 2015-16       | 2020                | India     | 320/302                           | SMS                      | usual care    | 6                          | -                       |
| Islam et al.       | 2013-14       | 2015                | Bangladesh | 236/230                          | SMS                      | usual care    | 6                          | -                       |
Table 3: Region wise distribution of included studies from Asia

| Asian region (23) | Country of published study | No of studies |
|-------------------|-----------------------------|---------------|
| Eastern Asia n=6  | Korea                       | 3             |
|                   | China                       | 3             |
| Western Asia n=2  | Jordan                      | 1             |
|                   | Iran                        | 1             |
| Southern Asia n=8 | India                       | 6             |
|                   | Bangladesh                  | 1             |
|                   | Sri Lanka                   | 1             |
| South Eastern Asia n=2 | Indonesia               | 2             |
| Central Asia n=0  | No study published          | 0             |
| Total             |                             | 18            |

**META-ANALYSIS**

**Part A: Primary objective**

A meta-analysis of the effect of mHealth interventions on

(i) **Glycosylated Hemoglobin (HbA1c)**

The data from 13 eligible studies, included a total of 1713 type 2 diabetes patients, were pooled to find the effects of diverse mHealth interventions on HbA1c. The impact of mHealth intervention was favoring the intervention group as a statistically significant reduction was seen in the mean in the intervention group as −0.44 (95%CI, −0.79 to 0.10, \( P = 0.01, I^2 = 87\% \)), suggesting that HbA1c levels in the mHealth group were significantly lower than those in the usual care group [Figure 2a].

(ii) **Fasting Blood Glucose (FBG) levels**

8 studies which included a total of 1893 type 2 diabetes patients, were found eligible while reporting the effect of mHealth interventions on FBG levels. The result suggested that the effect of mHealth intervention was inconclusive and doesn’t affect FBG in T2DM patients in the intervention group. The studies sample showed no heterogeneity (\( I^2 = 0\% \)) with fixed-effects model [Figure 3a].

(iii) **Post-Prandial Blood Glucose (PPBG) Levels**

While reporting about the effect of mHealth interventions on PPBG levels, 6 studies were found eligible which included a total of 858 type 2 diabetes patients. The forest plot of these studies concluded the results as -20.13 (95%CI, −35.16 to −5.10, \( P = 0.009, I^2 = 59\% \)). There was a reduction in PPBG levels in mHealth group as compared to the usual care group. A moderate heterogeneity was seen with random-effects model [Figure 4a].

**Part B: Subgroup analysis**

Subgroup analyses were done for the different mHealth interventions on all the primary outcome measures- glycated hemoglobin (HbA1c), FBG, and PPBG levels.

The subgroup analysis done to assess the effect of different mHealth intervention on Glycosylated Hemoglobin (HbA1c) showed that when SMSs were used as an intervention, the result showed −0.58 (95%CI, −1.03 to −0.13, \( P = 0.01, I^2 = 84\% \)) suggesting that there was a reduction in HbA1c levels in T2DM patients of SMS group compared to a usual care group. Other interventions didn’t have any effect on HbA1c levels [Figure 2b-d].

To report the effect of different mHealth interventions on FBG levels, the result of subgroup analysis suggested that all three interventions showed an inconclusive result and no effect can be seen in FBG levels in any intervention group than usual care groups [Figure 3b-d].

The result of subgroup analysis on PPBG levels showed that mobile applications were the most effective intervention used to reduce PPBG levels in the intervention group compared with the usual care group. The result showed a reduction in mean of mHealth group as −21.70 (95%CI −35.28 to −8.12, \( P = 0.002, I^2 = 42\% \)). No conclusive result was seen in the use of other interventions. [Figure 4b-d].

Another Subgroup analyses were done based on duration of follow-up on all the primary outcome measures- glycated hemoglobin (HbA1c), FBG, and PPBG levels. There are two subgroups on the basis of follow-up period. One subgroup consists of studies whose follow-up duration was from 3 to 6 months. Second subgroup included the studies with a follow-up duration of 7–24 months.

The subgroup analysis done to assess the effect of follow-up duration on Glycosylated Hemoglobin (HbA1c) showed the result as −0.20 (95%CI, −0.33 to −0.07, \( P = 0.002, I^2 = 85\% \)) in studies with the duration of 3–6 months while in studies with follow-up period of 7–24 months, the result was as −0.85 (95%CI, −1.15 to −0.55, \( P < 0.00001, I^2 = 94\% \)). It suggested that there was a reduction in HbA1c levels in T2DM patients of mHealth group compared to a usual care group in both the subgroups [Supplementary Figure 3a-b].

To report the effect of different follow-up duration on FBG levels, the result of subgroup analysis of follow-up duration of 3–6 months was −4.72 (95%CI, −13.52 to 4.08, \( P = 0.29, I^2 = 0\% \)). The studies with duration of 7–24 months showed 2.72 (95%CI, −3.62 to 9.06, \( P = 0.40, I^2 = 0\% \)). No conclusive result was seen in the FBG levels on the basis of follow-up duration [Supplementary Figure 4a-b].

The result of subgroup analysis on PPBG levels showed that the result was −27.15 (95%CI, −39.33 to −14.08, \( P < 0.0001, I^2 = 50\% \)) in subgroup of 3–6 months follow-up period, whereas the subgroup with 7–24 months showed −5.09 (95%CI, −17.99 to 7.81, \( P = 0.44, I^2 = 0\% \)). The result showed a reduction in mean of mHealth group when follow-up continued for 3–6 months and no conclusive result was seen in the other subgroup [Supplementary Figure 5a-b].

**Funnel plots**

Publication bias was assessed by a funnel plot for each outcome measure [Figure 5 (a), (b) and (c)]. The symmetrical presentation of the funnel plot for HbA1c and PPBG levels indicated slight
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Figure 2: (a) Effect of mHealth interventions on HbA1c (b) Effect of mobile applications as an intervention on HbA1c (c) Effect of phone calls as an intervention on HbA1c (d) Effect of SMS as an intervention on HbA1c

Figure 3: (a) Effect of mHealth interventions on FBG (b) Effect of mobile applications as an intervention on FBG (c) Effect of phone calls as an intervention on FBG (d) Effect of SMS as an intervention on FBG

Figure 4: (a) Effect of mHealth interventions on PPBG (b) Effect of mobile applications as an intervention on PPBG (c) Effect of phone calls as an intervention on PPBG (d) Effect of SMS as an intervention on PPBG
publication bias. For FBG levels, no significant publication bias was observed. Each study was symmetrically distributed on both sides [Figure 5a-c].

**DISCUSSION**

This systematic review and meta-analysis gave a vast horizon on the effects of mHealth interventions on managing type 2 diabetes patients in the Asian population. This study acknowledged the effects of different mHealth interventions as per their accessibility and availability in recent years. The effects of various mHealth interventions are very well reported in the Asian population. It is also evident that these interventions can also be utilized to increase the quality of diabetes self-management and serve to collect patients’ clinical data.

In most of the studies, there was an improvement in HbA1c levels and glycemic control. Although these interventions proved beneficial for these outcomes, there was a difference in the effects it caused in specific trials.

When meta-analysis was done based on any mHealth interventions, it reduced HbA1c and PPBG levels. No effect can be seen in FBG levels.

After the subgroup analysis, the most effective mHealth intervention was the use of SMSs while reporting their effect on HbA1c levels. No remarkable change in HbA1c levels was reported in mobile applications and phone calls as mHealth intervention. When subgroup analysis was done for FBG levels, no specific mHealth intervention proved to be conclusive about their effect in reducing FBG levels. While reporting about PPBG levels, the most effective intervention was seen in the form of mobile applications. They help reduce the PPBG levels while given in the intervention arm compared to the usual care arm. The other two interventions produce no conclusive result on PPBG levels.

Among the included trials, there is vast difference in sample size and intervention duration. Also, there was a considerable variability in the types of mHealth technology used. This wide variation may have caused the observed heterogeneity. Compared with usual care, the addition of mHealth intervention appeared to have a significant effect on people with type 2 diabetes. Although there was substantial heterogeneity, the pooled analyses showed that mHealth intervention lowered HbA1C levels and Post Prandial blood glucose levels. The effect of intervention on Fasting Blood Glucose levels remains inconclusive.

The difference in effects can be attributed to the different technology which was incorporated for various mHealth interventions. The mixed results can be attributed to having different lengths of intervention periods and a large difference in the number of participants included in separate trials.

Most mobile applications were linked with a glucometer to record the patients’ values of different clinical outcomes, which was later used for person-specific recommendations to all the patients as per their needs. Although these mobile apps are very beneficial, they might have posed difficulty using their technical advancement, specifically in the elderly population. Compared to mobile apps, phone calls and SMSs are considered an easy option to transmit information quickly. But due to various additional features available in mobile applications, we can still consider them as one of

**Figure 5:** (a) Funnel plot of comparison: 1 mHealth intervention v/s usual care, outcome: 1.1 HbA1c Outcome (b) Funnel plot of comparison: 1 mHealth intervention v/s usual care, outcome: 1.5 Fasting Blood Glucose levels (c) Funnel plot of comparison: 1 mHealth intervention v/s usual care, outcome: 1.9 Post prandial blood glucose levels
the most promising platforms compared to phone calls and SMSs.

These interventions were strong evidence that their effectiveness was based on the users’ awareness and education, and the type of behavior change communication methods used. Hence, these interventions must be designed in a user-friendly manner and should be able to produce similar effects in all the patients. The health care professionals should also take the patients’ economic condition into account while developing a mHealth intervention to obtain full use and services. Also, patients’ needs should be prioritized, and their present situation and complexities should be assessed before any intervention is administered. Our findings suggest that all three mHealth interventions can be a highly effective mechanism for linking providers to patients with diabetes.

**Limitations**

This review was confined to the Asian population, so it included the studies conducted only in the Asian population. Since there is a remarkable difference in terms of income and education compared to Asians and non-Asians, this review’s results may not apply to global studies. As our systematic review included fewer studies, there was a limitation of the inclusion of constituent trials. There is a need to include more studies in future reviews to generate a larger body of evidence and establish their integration with already published research. Some of the trials reported a smaller sample size, insufficient blinding, and shorter trial duration, which is inadequate to determine the effects of mHealth interventions on this population over a long period. We did not report the data regarding the effects of mHealth on cost-effectiveness or amount of care satisfaction. The effectiveness of these interventions on various self-management aspects such as dietary management, more physical activity, or increased medication adherence was not considered in this review.

**Implications**

Further exploration of the relationships between different intervention strategies and their components is recommended. Patients’ beliefs and attitudes focused on the design aspects and physical features of various interventions/mobile applications, text messages, and phone calls need to be explored further. After exploring the patients’ belief regarding the mHealth usage, the factors regarding its acceptability and utility need to be put forward in future research. The evaluation of these interventions based on their cost-effectiveness aspect should also be assessed, as it is crucial for their impact and applicability in clinical practice. The use of these mHealth interventions can be prioritized in National Health Programs, and their cost-effectiveness can be assessed at larger levels.

**Conclusion**

In conclusion, the current research has assessed mHealth interventions on glycemic control and HbA1c improvement in T2DM patients in the Asian population. Although the evidence that is generated by this review shows a mixed result, mHealth interventions can be seen as a suitable medium to improve the glycemic index among diabetic patients. The available literature about assessing the use of mHealth is limited and inconsistent to draw any robust conclusions.

This review recommends that mHealth researchers give the utmost priority to the transparency in the reporting of interventions based on their contexts, aims, delivery pathway and mechanisms of impact for effective interpretation of the retrieved data. These interventions work on the following aspects: easy transmission of health-related information and timely notifications for various health-related behaviors, including medication adherence, proper dietary intake, and regular exercise and also give the patients a chance to provide their feedback, which can enhance the further development of these interventions. More innovative and robust research work concerning various mHealth intervention strategies is needed in the near future.

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**Conflicts of interest**

There are no conflicts of interest.

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### Annexure I: Characteristics of Excluded studies

| Title                                                                 | Author            | Reason for Exclusion                                      |
|----------------------------------------------------------------------|-------------------|-----------------------------------------------------------|
| SMS education for the promotion of diabetes self-management in low & middle income countries: a pilot randomized controlled trial in Egypt | Abaza et al       | Not Asian                                                 |
| Diabetes and TelecommunicationS (DATES) study to support self-management for people with type 2 diabetes: a randomized controlled trial | Al-Ozairi et al   | Only protocol reported                                     |
| DialBetics: A Novel Smartphone-based Self-management Support System for Type 2 Diabetes Patients | Waki et al        | Website based intervention used                           |
| Effects of mobile phone application combined with or without self-monitoring of blood glucose on glycemic control in patients with diabetes: A randomized controlled trial | Yu et al          | 4 intervention arms are used in the study                 |
| Effect of case management on glycemic control and behavioral outcomes for Chinese people with type 2 diabetes: A 2-year study | Yuan et al        | Patient centered case management intervention used        |
| Electronic messaging intervention for management of cardiovascular risk factors in type 2 diabetes mellitus: A randomised controlled trial | Fang et al        | No usual care intervention                                |
| Impact of web-based nurse’s education on glycosylated haemoglobin in type 2 diabetic patients | Kim et al         | Sub study reported                                         |
| Effects of Mobile Text Messaging on Glycemic Control in Patients With Coronary Heart Disease and Diabetes Mellitus: A Randomised Clinical Trial | Huo et al         | Coronary heart disease patients also included             |
| Effectiveness of mobile and internet intervention in patients with obese type 2 diabetes | Kim et al         | Internet based intervention used                           |
| Automated Feedback Messages With Shichifukujin Characters Using IoT System-Improved Glycemic Control in People With Diabetes: A Prospective, Multi-center Randomised Controlled Trial | Kobayashi et al   | No full text available                                    |
| Effectiveness of short message service-based intervention (SMS) on self-care in type 2 diabetes: A feasibility study | Peimani et al     | No full text available                                    |
| Feasibility study of automated interactive voice response telephone calls with community health nurse follow-up to improve glycaemic control in patients with type 2 diabetes | Pichayapinyo et al | No full text available                                  |
| Efficacy of a telephone-based intervention among patients with type-2 diabetes; a randomized controlled trial in pharmacy practice | Sarayani et al    | No full text available                                    |
| Effects of a patient oriented decision aid for prioritising treatment goals in diabetes: pragmatic randomised controlled trial | Denig et al       | Not Asian                                                 |
| The development and feasibility of a web-based intervention with diaries and situational feedback via smartphone to support self-management in patients with diabetes type 2 | Nes et al         | Not Asian                                                 |
| Reduced HbA1c levels in type 2 diabetes patients: An interaction between a pedagogical format for students and psycho-educational intervention for patients | Sarid et al       | No full text available                                    |
| Mobile phone intervention to improve diabetes care in rural areas of Pakistan: a randomized controlled trial | Shahid et al      | No full text available                                    |
| Reinforcement of adherence to prescription recommendations in Asian Indian diabetes patients using short message service (SMS)--a pilot study | Shetty et al      | Different outcome reported                                |
| Effects of continuous care for patients with type 2 diabetes using mobile health application: A randomised controlled trial | Wang et al        | No full text available                                    |
| Effectiveness of Smartphone App–Based Interactive Management on Glycemic Control in Chinese Patients With Poorly Controlled Diabetes: Randomized Controlled Trial | Zhang et al       | 3 intervention arms used                                   |
| Welltang – A smart phone-based diabetes management application – Improves blood glucose control in Chinese people with diabetes | Zhou et al        | Type 1 and type 2 Diabetes patients included              |
| Web-Based Care Management in Patients With Poorly Controlled Diabetes | McMohan et al     | Not Asian                                                 |
| Remote Lifestyle Coaching Plus a Connected Glucose Meter with Certified Diabetes Educator Support Improves Glucose and Weight Loss for People with Type 2 Diabetes | Bollyky et al     | Not Asian                                                 |
| Design and patient characteristics of the randomized controlled trial TExT-MED+FANS A test of mHealth augmented social support added to a patient-focused text-messaging intervention for emergency department patients with poorly controlled diabetes | Burner et al      | Not Asian                                                 |

Contd...
| Title                                                                 | Author          | Reason for Exclusion            |
|----------------------------------------------------------------------|-----------------|---------------------------------|
| Effectiveness and safety of a glucose data-filtering system with automatic response software to reduce the physician workload in managing type 2 diabetes | Cho et al       | Different intervention used      |
| Mobile communication using a mobile phone with a glucometer for glucose control in Type 2 patients with diabetes: as effective as an Internet-based glucose monitoring system | Cho et al       | Different intervention used      |
| Impact of web-based nurse’s education on glycosylated haemoglobin in type 2 diabetic patients | Kim et al       | Sub study reported               |
| Design and rationale of the Cardiovascular Health and Text Messaging (CHAT) Study and the CHAT-Diabetes Mellitus (CHATDM) Study: two randomised controlled trials of text messaging to improve secondary prevention for coronary heart disease and diabetes | Huo et al       | CHD patients included            |
| The Effect of a Smartphone-Based, Patient-Centered sDiabetes Care System in Patients With Type 2 Diabetes: A Randomized, Controlled Trial for 24 Weeks | Kim et al       | Control group is logbook user    |
| A randomized controlled trial of a nurse short-message service by cellular phone for people with diabetes | kim et al       | Substudy                         |
| A randomised, controlled trial of the effects of a mobile telehealth intervention on clinical and patient reported outcomes in people with poorly controlled diabetes | Baron et al     | Not Asian                        |
| Mobile Phone-Based Video Messages for Diabetes Self-Care Support | Bell et al      | Not Asian                        |
| Feasibility study of portable technology for weight loss and HbA1c control in type 2 diabetes | Bentley et al   | Not Asian                        |
| Automated Insulin Dosing Guidance to Optimize Insulin Management in Patients with Type 2 Diabetes; A Multi-Center Randomized-Controlled Trial | Bergenstal et al | Not Asian                       |
| Effectiveness of diabetes self-management education via a smartphone application in insulin treated type 2 diabetes patients – design of a randomised controlled trial (‘TRIGGER study’) | Boels et al     | Not Asian                        |
| Efficacy of an Electronic Health Management Program for Patients With Cardiovascular Risk: Randomized Controlled Trial | Yun et al       | Other diseases also included      |
| Effectiveness and cost effectiveness of a mobile phone text messaging intervention for prevention of cardiovascular risk factors among patients with type 2 diabetes: A randomized controlled trial | Islam et al     | Substudy                         |
| Effects of Face-to-Face and Telephone-Based Family-Oriented Education on Self-Care Behavior and Patient Outcomes in Type 2 Diabetes: A Randomized Controlled Trial | Maslakpak et al | 3 intervention arms used         |
| The long-term effect of community-based health management on the elderly with type 2 diabetes by the Markov modeling | Chao et al       | Different intervention (Markov modeling) used |
| Mobile phone text messaging and Telephone follow-up in type 2 diabetic patients for 3 months: A comparative study | Zolfaghari et al | Both arms used intervention       |
| Effectiveness of a Video-Based Lifestyle Education Program Compared to Usual Care in Improving HbA1c and Other Metabolic Parameters in Individuals with Type 2 Diabetes: An Open-Label Parallel Arm Randomized Control Trial (RCT) | gupta et al     | Different intervention used      |
| A smartphone app to improve medication adherence in patients with type 2 diabetes in Asia: Feasibility randomized controlled trial | Huang et al     | Different outcome reported       |
| A nurse short message service by cellular phone in type-2 diabetic patients for six months | kim et al       | Substudy                         |
| The effectiveness, reproducibility, and durability of tailored mobile coaching on diabetes management in policyholders: A randomized, controlled, open-label study | lee et al       | Different intervention used      |
| Effectiveness of an mHealth-Based Electronic Decision Support System for Integrated Management of Chronic Conditions in Primary Care The mWellcare Cluster-Randomized Controlled Trial | Prabhakarn et al | Hypertensive patients also included |
| Effects of telephone-delivered lifestyle support on the development of diabetes in participants at high risk of type 2 diabetes: J-DOIT1, a pragmatic cluster randomised trial | Sakane et al    | no diabetes patients are included (only the risky patients) |
| Effect of a mobile phone-based glucose-monitoring and feedback system for type 2 diabetes management in multiple primary care clinic settings: Cluster randomized controlled trial | Yang et al       | no full text available            |
### Annexure I: Contd...

| Title                                                                 | Author       | Reason for Exclusion |
|-----------------------------------------------------------------------|--------------|-----------------------|
| Use of a Novel, Remotely Connected Diabetes Management System Is      | Mora et al   | Not Asian             |
| Associated with Increased Treatment Satisfaction, Reduced Diabetes    |              |                       |
| Distress, and Improved Glycemic Control in Individuals with Insulin-   |              |                       |
| Treated Diabetes: First Results from the Personal Diabetes Management  |              |                       |
| Study                                                                  |              |                       |
| The impact of a structured education and treatment programme (FLASH)  | Hermanns et al| Not Asian             |
| for people with diabetes using a flash sensor-based glucose monitoring |              |                       |
| system: Results of a randomized controlled trial                      |              |                       |
| Effect of structured self-monitoring of blood glucose, with and       | Parsons et al| Not Asian             |
| without additional TeleCare support, on overall glycaemic control     |              |                       |
| in non-insulin treated Type 2 diabetes: the SMBG Study, a 12-month     |              |                       |
| randomized controlled trial                                           |              |                       |

### Annexure II: Risk of bias of included studies

**Adikusuma et al**

| Bias                                                                 | Authors’ judgement | Support for judgement |
|---------------------------------------------------------------------|--------------------|-----------------------|
| Random sequence generation (selection bias)                          | Unclear risk       | Insufficient evidence to permit judgement |
| Allocation concealment (selection bias)                              | Unclear risk       | Insufficient evidence to permit judgement |
| Blinding of participants and personnel (performance bias)            | High risk          | No blinding           |
| Blinding of outcome assessment (detection bias)                      | High risk          | No blinding           |
| Incomplete outcome data (attrition bias)                             | Unclear risk       | Insufficient evidence to permit judgement |
| Selective reporting (reporting bias)                                 | Unclear risk       | Insufficient evidence to permit judgement |
| Other bias                                                           | Unclear risk       |                       |

**Cheng et al**

| Bias                                                                 | Authors’ judgement | Support for judgement |
|---------------------------------------------------------------------|--------------------|-----------------------|
| Random sequence generation (selection bias)                          | Low risk           | a computer generated block randomization list using a block size of 4 at 1:1 ratio |
| Allocation concealment (selection bias)                              | Low risk           | the enrolling investigators opened the sealed envelope after participant’s name was written on next available envelopes; the enrolling investigators were blinded to the trial design and study hypotheses |
| Blinding of participants and personnel (performance bias)            | Low risk           | the trained outcome assessors were blinded to trial hypotheses and group allocation throughout the study period |
| Blinding of outcome assessment (detection bias)                      | Low risk           | no group differences in attrition rate was observed |
| Incomplete outcome data (attrition bias)                             | Low risk           | insufficient evidence to permit judgement |
| Selective reporting (reporting bias)                                 | Unclear risk       |                       |
| Other bias                                                           | Unclear risk       |                       |

**Dong et al**

| Bias                                                                 | Authors’ judgement | Support for judgement |
|---------------------------------------------------------------------|--------------------|-----------------------|
| Random sequence generation (selection bias)                          | High risk          | Diabetes patients were randomly classified into control (n=60) and intervention (n=60) group |
| Allocation concealment (selection bias)                              | Unclear risk       | Insufficient evidence to permit judgement |
| Blinding of participants and personnel (performance bias)            | High risk          | No blinding           |
| Blinding of outcome assessment (detection bias)                      | High risk          | No blinding           |
| Incomplete outcome data (attrition bias)                             | Unclear risk       | Insufficient evidence to permit judgement |
| Selective reporting (reporting bias)                                 | Unclear risk       | Insufficient evidence to permit judgement |
| Other bias                                                           | Unclear risk       |                       |
### Goodarzi et al

| Bias                                                                 | Authors’ judgement | Support for judgement                                                                                                                                 |
|----------------------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)                         | Low risk           | Finally 100 patients were selected on a random sampling scheme where in a list of random numbers was provided before data collection using the software. |
| Allocation concealment (selection bias)                             | Low risk           | For allocation to exp. and cont. groups, the researchers use RAS software and randomized by random permuted block design by a size of 2.              |
| Blinding of participants and personnel (performance bias)           | High risk          | No blinding                                                                                                                                   |
| Blinding of outcome assessment (detection bias)                     | High risk          | No blinding                                                                                                                                   |
| Incomplete outcome data (attrition bias)                            | Low risk           | Therefore, we report data from the 81 subjects who remained to complete the study protocol.                                                    |
| Selective reporting (reporting bias)                                | Unclear risk       | Insufficient evidence to permit judgement                                                                                                     |
| Other bias                                                           | Unclear risk       |                                                                                                                                                 |

### Gunawardena et al

| Bias                                                                 | Authors’ judgement | Support for judgement                                                                                                                                 |
|----------------------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)                         | Low risk           | randomized, using a computer-generated random sequence method created by Sealed Envelope Ltd                                                   |
| Allocation concealment (selection bias)                             | Low risk           | Insufficient evidence to permit judgement                                                                                                        |
| Blinding of participants and personnel (performance bias)           | High risk          | No blinding                                                                                                                                   |
| Blinding of outcome assessment (detection bias)                     | High risk          | No blinding                                                                                                                                   |
| Incomplete outcome data (attrition bias)                            | Unclear risk       | Insufficient evidence to permit judgement                                                                                                        |
| Selective reporting (reporting bias)                                | Unclear risk       | Insufficient evidence to permit judgement                                                                                                        |
| Other bias                                                           | Unclear risk       |                                                                                                                                                 |

### Islam et al

| Bias                                                                 | Authors’ judgement | Support for judgement                                                                                                                                 |
|----------------------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)                         | Low risk           | randomly assigned 1:1 to SMS intervention and standard care groups.                                                                              |
| Allocation concealment (selection bias)                             | Unclear risk       | Insufficient evidence to permit judgement                                                                                                        |
| Blinding of participants and personnel (performance bias)           | High risk          | no blind                                                                                                                                       |
| Blinding of outcome assessment (detection bias)                     | High risk          | no blind                                                                                                                                       |
| Incomplete outcome data (attrition bias)                            | Unclear risk       | Insufficient evidence to permit judgement                                                                                                        |
| Selective reporting (reporting bias)                                | Unclear risk       | Insufficient evidence to permit judgement                                                                                                        |
| Other bias                                                           | Unclear risk       |                                                                                                                                                 |

### Jain et al

| Bias                                                                 | Authors’ judgement | Support for judgement                                                                                                                                 |
|----------------------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)                         | Low risk           | The study participants were randomized into 2 groups                                                                                             |
| Allocation concealment (selection bias)                             | Unclear risk       | Insufficient evidence to permit judgement                                                                                                        |
| Blinding of participants and personnel (performance bias)           | Unclear risk       | Insufficient evidence to permit judgement                                                                                                        |
| Blinding of outcome assessment (detection bias)                     | Low risk           | by a blinded investigator                                                                                                                        |
| Incomplete outcome data (attrition bias)                            | Low risk           | We were able to include 299 patients out of estimated 322 patients in our study (92.8%)                                                         |
| Selective reporting (reporting bias)                                | Unclear risk       | Insufficient evidence to permit judgement                                                                                                        |
| Other bias                                                           | Unclear risk       |                                                                                                                                                 |
| Bias                                                                 | Authors' judgement | Support for judgement                                                                 |
|----------------------------------------------------------------------|---------------------|--------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)                         | Low risk            | Study participants were randomly assigned to intervention and control groups via a minimization technique using Minim software |
| Allocation concealment (selection bias)                             | Unclear risk        | insufficient evidence to permit judgement                                              |
| Blinding of participants and personnel (performance bias)           | High risk           | No blinding                                                                         |
| Blinding of outcome assessment (detection bias)                     | High risk           | No blinding                                                                         |
| Incomplete outcome data (attrition bias)                            | Low risk            | Therefore, a total of 156 patients (77 intervention; 79 usual care) completed the 6-month study period |
| Selective reporting (reporting bias)                                | Unclear risk        | insufficient evidence to permit judgement                                              |
| Other bias                                                           | Unclear risk        |                                                                                      |

Kim et al

| Bias                                                                 | Authors' judgement | Support for judgement                                                                 |
|----------------------------------------------------------------------|---------------------|--------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)                         | Low risk            | They were randomized by random permuted block design using a random number table and assigned to one of two groups, either intervention (n=30) or control (n=30) |
| Allocation concealment (selection bias)                             | Unclear risk        | Insufficient evidence to permit judgement                                              |
| Blinding of participants and personnel (performance bias)           | High risk           | No blinding                                                                         |
| Blinding of outcome assessment (detection bias)                     | High risk           | No blinding                                                                         |
| Incomplete outcome data (attrition bias)                            | Low risk            | Only 51 subjects completed the entire study, 25 interventions and 26 controls.        |
| Selective reporting (reporting bias)                                | Unclear risk        | Insufficient evidence to permit judgement                                              |
| Other bias                                                           | Unclear risk        |                                                                                      |

Klienman et al

| Bias                                                                 | Authors' judgement | Support for judgement                                                                 |
|----------------------------------------------------------------------|---------------------|--------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)                         | Low risk            | The randomization sequence was investigator generated, stratified by site, with a 1:1 allocation |
| Allocation concealment (selection bias)                             | Low risk            | The allocation sequence was concealed from implementing staff through sequentially numbered, opaque, sealed, and stamped envelopes |
| Blinding of participants and personnel (performance bias)           | High risk           | open-label                                                                         |
| Blinding of outcome assessment (detection bias)                     | High risk           | open-label                                                                         |
| Incomplete outcome data (attrition bias)                            | Low risk            | 80 returning participants                                                            |
| Selective reporting (reporting bias)                                | Unclear risk        | Insufficient evidence to permit judgement                                              |
| Other bias                                                           | Unclear risk        |                                                                                      |

Kumar et al

| Bias                                                                 | Authors' judgement | Support for judgement                                                                 |
|----------------------------------------------------------------------|---------------------|--------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)                         | Low risk            | 955 study individuals were randomized                                               |
| Allocation concealment (selection bias)                             | Low risk            | Insufficient evidence to permit judgement                                              |
| Blinding of participants and personnel (performance bias)           | High risk           | No blinding                                                                         |
| Blinding of outcome assessment (detection bias)                     | High risk           | No blinding                                                                         |
| Incomplete outcome data (attrition bias)                            | Low risk            | The endline assessment for 6 months was done in 852 patients (intervention: 441 and control: 411) with 11.0% drop out rate |
| Selective reporting (reporting bias)                                | Unclear risk        | Insufficient evidence to permit judgement                                              |
| Other bias                                                           | Unclear risk        |                                                                                      |
### Kusnanto et al

| Bias                                           | Authors' judgement | Support for judgement                                                                 |
|------------------------------------------------|--------------------|---------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)    | Low risk           | Randomization                                                                         |
| Allocation concealment (selection bias)        | Low risk           | Determination of research samples using random allocation.                             |
| Blinding of participants and personnel (performance bias) | Low risk           | Respondents in both groups did not know whether they belonged to the experimental group or the control group single blind |
| Blinding of outcome assessment (detection bias) | High risk          | In the third month there are 30 respondents who are able to follow the program to completion |
| Incomplete outcome data (attrition bias)       | Low risk           |                                                                                       |
| Selective reporting (reporting bias)           | Uncl ear risk      | Insufficient evidence to permit judgement                                              |
| Other bias                                     | Uncl ear risk      |                                                                                       |

### Lee et al

| Bias                                           | Authors' judgement | Support for judgement                                                                 |
|------------------------------------------------|--------------------|---------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)    | Low risk           | randomly assigned into 2 groups                                                       |
| Allocation concealment (selection bias)        | Unclear risk       | Insufficient evidence to permit judgement                                              |
| Blinding of participants and personnel (performance bias) | High risk          | open label                                                                             |
| Blinding of outcome assessment (detection bias) | High risk          | open label                                                                             |
| Incomplete outcome data (attrition bias)       | Low risk           | Among 148 participants, 136 completed phase 1 of the study                             |
| Selective reporting (reporting bias)           | Uncl ear risk      | Insufficient evidence to permit judgement                                              |
| Other bias                                     | Uncl ear risk      |                                                                                       |

### Oh et al

| Bias                                           | Authors' judgement | Support for judgement                                                                 |
|------------------------------------------------|--------------------|---------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)    | Low risk           | randomized by a toss of a coin                                                        |
| Allocation concealment (selection bias)        | Unclear risk       | Insufficient evidence to permit judgement                                              |
| Blinding of participants and personnel (performance bias) | High risk          | no blinding                                                                           |
| Blinding of outcome assessment (detection bias) | High risk          | no blinding                                                                           |
| Incomplete outcome data (attrition bias)       | Low risk           | only 38 subjects completed the entire study                                           |
| Selective reporting (reporting bias)           | Uncl ear risk      | Insufficient evidence to permit judgement                                              |
| Other bias                                     | Uncl ear risk      |                                                                                       |

### Patnaik et al

| Bias                                           | Authors' judgement | Support for judgement                                                                 |
|------------------------------------------------|--------------------|---------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)    | Low risk           | Starting at random, the patients were allocated to control group and test group      |
| Allocation concealment (selection bias)        | Unclear risk       | Insufficient evidence to permit judgement                                              |
| Blinding of participants and personnel (performance bias) | High risk          | no blinding                                                                           |
| Blinding of outcome assessment (detection bias) | High risk          | no blinding                                                                           |
| Incomplete outcome data (attrition bias)       | Low risk           | Out of 100 participants, total 55 patients (control-21, Intervention-34) came for follow up |
| Selective reporting (reporting bias)           | Uncl ear risk      | Insufficient evidence to permit judgement                                              |
| Other bias                                     | Uncl ear risk      |                                                                                       |
## Sadanshiv et al

| Bias                                                                 | Authors’ judgement | Support for judgement                                                                 |
|----------------------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)                          | Low risk           | randomization was done                                                                 |
| Allocation concealment (selection bias)                              | Low risk           | The codes were given to the principal investigator in sequentially labeled sealed opaque envelopes to randomly allocate patients |
| Blinding of participants and personnel (performance bias)            | High risk          | Openlabeled                                                                          |
| Blinding of outcome assessment (detection bias)                      | High risk          | Openlabeled                                                                          |
| Incomplete outcome data (attrition bias)                             | Low risk           | A total of 18 people failed to follow-up                                              |
| Selective reporting (reporting bias)                                 | Unclear risk       | Insufficient evidence to permit judgement                                             |
| Other bias                                                           |                    |                                                                                       |

## Sun et al

| Bias                                                                 | Authors’ judgement | Support for judgement                                                                 |
|----------------------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)                          | Low risk           | Patients were randomly assigned to the intervention and control groups using the random number sequence |
| Allocation concealment (selection bias)                              | Unclear risk       | Insufficient evidence to permit judgement                                             |
| Blinding of participants and personnel (performance bias)            | High risk          | no blinding                                                                          |
| Blinding of outcome assessment (detection bias)                      | High risk          | no blinding                                                                          |
| Incomplete outcome data (attrition bias)                             | Unclear risk       | Insufficient evidence to permit judgement                                             |
| Selective reporting (reporting bias)                                 | Unclear risk       | Insufficient evidence to permit judgement                                             |
| Other bias                                                           |                    |                                                                                       |

## Vinitha et al

| Bias                                                                 | Authors’ judgement | Support for judgement                                                                 |
|----------------------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------|
| Random sequence generation (selection bias)                          | Low risk           | Diabetes patients were randomly classified into control (n=60) and intervention (n=60) group by using a set of 120 random numbers, according to 1:1 ratio |
| Allocation concealment (selection bias)                              | Unclear risk       | No random allocation reported                                                          |
| Blinding of participants and personnel (performance bias)            | Low risk           | Respondents in both groups did not know whether they belonged to the experimental group or the control group. single blind |
| Blinding of outcome assessment (detection bias)                      | High risk          | In the third month there are 30 respondents who are able to follow the program to completion |
| Incomplete outcome data (attrition bias)                             | Low risk           | insufficient evidence to permit judgement                                             |
| Selective reporting (reporting bias)                                 | Unclear risk       |                                                                                        |
| Other bias                                                           | Unclear risk       |                                                                                        |
Supplementary Figure 1: PRISMA flow Diagram
Supplementary Figure 2: Graph showing the distribution of included trials on the basis of Asian region in which they are conducted. Source: emapsworld.com

Supplementary Figure 3: (a) Effect of follow up duration (3-6 months) on HbA1c (b) Effect of follow up duration (7-24 months) on HbA1c

Supplementary Figure 4: (a) Effect of follow up duration (3-6 months) on FBG (b) Effect of follow up duration (7-24 months) on FBG

Supplementary Figure 5: (a) Effect of follow up duration (3-6 months) on PPBG (b) Effect of follow up duration (7-24 months) on PPBG