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The Effectiveness of Mobile Phone Messaging-Based Interventions to Promote Physical Activity in Type 2 Diabetes Mellitus: A Systematic Review and Meta-Analysis”

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Abstract

Background: Type 2 diabetes mellitus (T2DM) is increasing in prevalence worldwide. Physical activity (PA) is an important aspect of self-care and first-line management for T2DM. Mobile text messages (SMS) can be used to support self-management in people with T2DM, but the effectiveness of mobile text messages-based interventions in increasing physical activity is still unclear.

Objective: The study aimed to assess the effectiveness of mobile phone messaging on PA in people with T2DM by summarizing and pooling the findings of previous literature.

Methods: A systematic review was conducted to accomplish this objective. Search sources included 5 bibliographic databases (MEDLINE, Cochrane Library, CINAHL, Web of Science, EMBASE), the search engine “Google Scholar”, and backward and forward reference list checking of the included studies and relevant reviews. Two reviewers independently carried out the study selection, data extraction, risk of bias assessment, and quality of evidence evaluation. Results of included studies were synthesized narratively and statistically, as appropriate.

Results: We included 6 of 541 retrieved studies. Four of the studies showed a statistically significant effect of text messages on physical activity. Although a meta-analysis of results of two studies showed a statistically significant effect (P=.05) of text messages on physical activity, the effect was not clinically important. A meta-analysis of findings of 2 studies showed a non-significant effect (P=.14) of text messages on glycaemic control. Two studies found a non-significant effect of text messages on anthropometric measures (weight and BMI).

Conclusions: Text messaging interventions show promise for increasing physical activity. However, it is not possible to conclude from this review whether text messages have a significant effect on physical activity, glycaemic control, or anthropometric measures among patients with T2DM. This is due to the limited number of studies, the high overall risk of bias in most of the included studies and the low quality of meta-analysed evidence. There is a need for more high-quality primary studies.

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The Effectiveness of Mobile Phone Messaging-Based Interventions to Promote Physical Activity in Type 2 Diabetes Mellitus: A Systematic Review and Meta-Analysis

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Abstract

Background: Type 2 diabetes mellitus (T2DM) is increasing in prevalence worldwide. Physical activity (PA) is an important aspect of self-care and first-line management for T2DM. Mobile text messages (SMS) can be used to support self-management in people with T2DM, but the effectiveness of mobile text messages-based interventions in increasing physical activity is still unclear.
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Results: We included 6 of 541 retrieved studies. Results of individual studies were contradictory regarding the effectiveness of mobile text messaging on physical activity. However, a meta-analysis of results of five studies showed no statistically significant effect (*P*=.16) of text messages on physical activity in comparison with no intervention. A meta-analysis of findings of 2 studies showed

a non-significant effect (*P*=.14) of text messages on glycaemic control. Two studies found a non-significant effect of text messages on anthropometric measures (weight and BMI).
Conclusions: We could not draw a definitive conclusion regarding the effectiveness of text messaging on physical activity, glycaemic control, weight, or BMI among patients with T2MD given the limited number of the included studies and their high risk of bias. Therefore, there is a need for more high-quality primary studies.
Keywords: Type 2 diabetes mellitus; physical activity; mobile phone messaging; systematic review; meta-analysis.

Introduction

Background

The burden of diabetes is growing, the number of people with type 2 diabetes mellitus (T2DM) across the world has reached 387 million and is expected to increase to 592 million by 2035 [1]. This prevalence imposes a high and rising burden of life-long multi-organ complications, leading to an increased disability and risk of premature deaths mainly in low and middle-income countries [2]. A considerable amount of literature suggests that better management of T2DM would delay the onset of short-and long-term complications among people diagnosed with T2DM [3-5]. Over the past decades, physical activity (PA) has been part of the first line T2DM care management [6]. PA includes all movement that increases energy use, however, there are three main kinds of exercise—aerobic, strength training, and flexibility work [7]. PA can help people with T2DM to achieve a variety of goals, including increased vigour, improved glycaemic haemoglobin control, decreased insulin resistance, increased cardiorespiratory fitness, improved lipid profile, blood pressure (BP) reduction, and maintenance of weight loss [8]. Unfortunately, patients with T2DM are less likely to engage in regular PA, with recent estimates demonstrating a lower participation rate compared to the national average [9]. There have been many attempts to explore alternative approaches to improve PA in people with T2DM, mobile phone messaging revolution has brought entirely new opportunities and increased access to self-management education [1]. The literature shows that text messaging-based interventions can be effective in improving health change related behaviours and bridging the gaps between patients and healthcare services for people living with chronic diseases [10, 11]. Text messaging may be one-way (unidirectional) or two-way (bidirectional), they can be standardised or tailored to specific patients and sent at varied frequencies based on the intervention design[12].Multiple meta-analyses have demonstrated the overall success of mobile phone messaging in promoting various aspects of behaviour change for PA and mental health related disorders [1, 13, 14].

Research problem and aim

Several studies have assessed the effect of mobile text messaging on physical activity in patients with T2DM. It is crucial to summarise and aggregate findings of such studies to produce a more generalisable and definitive conclusions about the effectiveness of such interventions. Four previous systematic reviews did not bring together the evidence from studies with text messaging interventions that specifically targeted physical activity. Specifically, the first review focused on the impact of education about T2DM delivered via mobile text messaging [15]. The second review assessed the effectiveness of text-messaging interventions on HbA1c in patients with T2DM and that included all self-management strategies [1]. The third review identified randomized trials conducted to improve glycaemic control in T2DM which involved the delivery of behaviour change content through a range of digital platforms and approaches (e.g. short-message service: SMS, multimedia message services: MMS, or instant messaging such as WhatsApp [12]. The fourth review assessed the effectiveness of technology-based interventions to promote physical activity in T2DM; for this review, technology included mobile phones and text messages, websites, CD-ROMs and computer-learning-based based technology [16]. This review was conducted approximately seven years ago but studies involving technology-based interventions are rapidly emerging and there may be new published evidence. Therefore, this study aimed to assess the effectiveness of mobile phone messaging on PA in patients with T2DM by summarising and pooling the findings of previous literature.

Methods

A systematic review was conducted and reported in keeping with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Appendix 1) [17]. The protocol for this review is registered at PROSPERO (ID: CRD42020156465).

Search strategy

Search sources

We used the following electronic databases in our search: MEDLINE, Cochrane Library, CINAHL, Web of Science, EMBASE. These databases were searched on April 19, 2020 by the lead author. Auto Alerts were set after searching the databases to conduct an automatic search weekly for 16 weeks (ending on August 9, 2020), and send us the retrieved studies. We also searched the search engine "Google Scholar" to identify grey literature. To identify further studies of relevance to the review, we screened the reference lists of included studies (i.e., backward reference list checking) and identified and screened studies that cited the included studies (i.e., forward reference list checking).

Search terms

The search terms were identified by consulting 2 experts in e-health intervention for patients with diabetes and by checking systematic reviews of relevance to the review. These terms were chosen based on the target population (e.g., type 2 diabetes, diabetes type 2, and type II diabetes), target intervention, (e.g., text messaging, text messages, and short messages), target outcome (e.g., physical activity, physical exercise, HbA1C, weight), and target study design (e.g., trial, experiment, RCT). Appendix 2 shows the detailed search query used for searching MEDLINE.

Study eligibility criteria

The population of interest was adult patients (≥18 years) with T2DM regardless of their gender and ethnicity. We excluded patients with T1DM, gestational diabetes, and pre-diabetes. The target intervention in this review is mobile phone text messages (SMS and MMS), but not mobile applications, web-delivered interventions, wearables, or emails. The aim of the text messages had to improve solely physical activity, but not diet, lifestyle, diabetic literacy, or other aspects of self-care. The primary outcomes of interest are subjectively and/or objectively measured physical activity (e.g., step counts), glycaemic control (e.g., hemoglobin A1C (HbA1c), fasting glucose), and anthropometric measures (e.g. change in weight, body mass index (BMI), etc.). Only randomized controlled trials (RCTs) were eligible for inclusion in this review. We considered studies published only in the English language. No restrictions were applied to year of publication, country of publication, comparator, type of publication, or study settings.

Study selection

We followed two steps in the study selection process. In the first step, two reviewers (MJ and AA) independently sifted the titles and abstracts of all retrieved studies. In the second step, the two reviewers independently scrutinised the full texts of studies included from the first step. In both steps, any disagreements between the reviewers were resolved through discussion and consensus.

Cohen κ in this review indicated a very good level of interrater agreement in the first (0.88) and second step (0.95) of the selection process [18].

Data extraction

Appendix 3 shows the data extraction form that was used in this review to precisely and systematically extract the data from the included studies. The two reviewers (MJ and AA) independently conducted data extraction from the included studies, and they resolved any disagreements through discussion and consensus. Cohen κ showed a very good level of interrater agreement between the reviewers (0.85) [18].

Risk of bias assessment

To assess the risk of bias in the included studies, we used Risk-of-Bias 2 (RoB 2) tool, which is recommended by Cochrane Collaboration [19]. This tool assesses RCTs in terms of 5 domains: randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result [19]. Then, the overall risk of bias is determined for each study based on the risk of bias judgments in the 5 domains [19]. Two reviewers (MJ and AA) independently assessed the risk of bias in the included studies, and any disagreements were resolved through discussion and consensus. Interrater agreement between the reviewers was very good (Cohen κ=0.86) [18]. We presented results of the risk of bias assessment using a graph showing the reviewers' judgments about each "risk of bias" domain in the result section. We also showed reviewers' judgments about each "risk of bias" domain for each included study using a figure in Appendix 4.

Data synthesis

We synthesised the extracted data using narrative and statistical approaches. Specifically, meta-analysis was carried out when at least two studies assessed the same outcome of interest and reported enough data for the analysis (e.g., mean difference, standard deviation (SD), number of participants in each intervention group). When the above-mentioned conditions were not met, we narratively synthesised findings of the included studies. We grouped and synthesised the findings according to the measured outcome (i.e., physical activity, glycaemic control, and weight change).

We conducted a meta-analysis using Review Manager (RevMan 5.4), which is a software developed by Cochrane. We used the mean difference (MD) to assess the effect of each trial and the overall effect when the outcome data were continuous, and outcome measure of each outcome was identical in the meta-analysed studies. However, we used the standardized mean difference (SMD) when, between studies, the outcome was measured using different tools. We selected a random-effects model in the analysis due to the clinical heterogeneity between the meta-analysed studies in terms of intervention characteristics (e.g., its directionality, purpose, and frequency) and population characteristics (e.g., sample size and mean age).

We assessed clinical heterogeneity of the meta-analysed studies by inspecting characteristics of their interventions, outcomes, participants, and comparator. Further, we evaluated statistical heterogeneity of the meta-analysed studies. To do so, we calculated a chi-square *P* value and I^2 to evaluate the statistical significance of heterogeneity and the degree of heterogeneity, respectively. We judged the meta-analysed studies as heterogeneous when chi-square *P* value is 0.05 or lower [20]. The degree of heterogeneity was considered unimportant, moderate, substantial, or considerable when I^2 ranged between 0%-40%, 30%-60%, 50%-90%, or 75%-100%, respectively [20].

The overall quality of meta-analysed evidence was examined using Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach [21, 22]. This approach assessed the quality of evidence based on five main criteria: risk of bias, inconsistency (i.e. heterogeneity), indirectness, imprecision, and publication bias [21]. Two reviewers (MJ and AA) independently assessed the overall quality of meta-analysed evidence, and any disagreements were resolved through discussion and consensus. Interrater agreement between the reviewers was very good (Cohen κ=0.81) [18].

Results

Search results

We retrieved 541 citations by searching the 6 bibliographic databases (Figure 1). Out of those citations, 83 duplicates were identified and excluded. We screened titles and abstracts of the remaining 458 citations and excluded 423 citations due to reasons shown in Figure 1. By checking the full texts of the remaining 35 studies, 31 studies were not eligible for this review for several reasons (Figure 1). We identified 2 additional studies by backward reference list checking. Overall, we included 6 studies in this review [23-28]. At all steps, consensus was agreed between the two reviewers, and referral to third reviewer was not required.

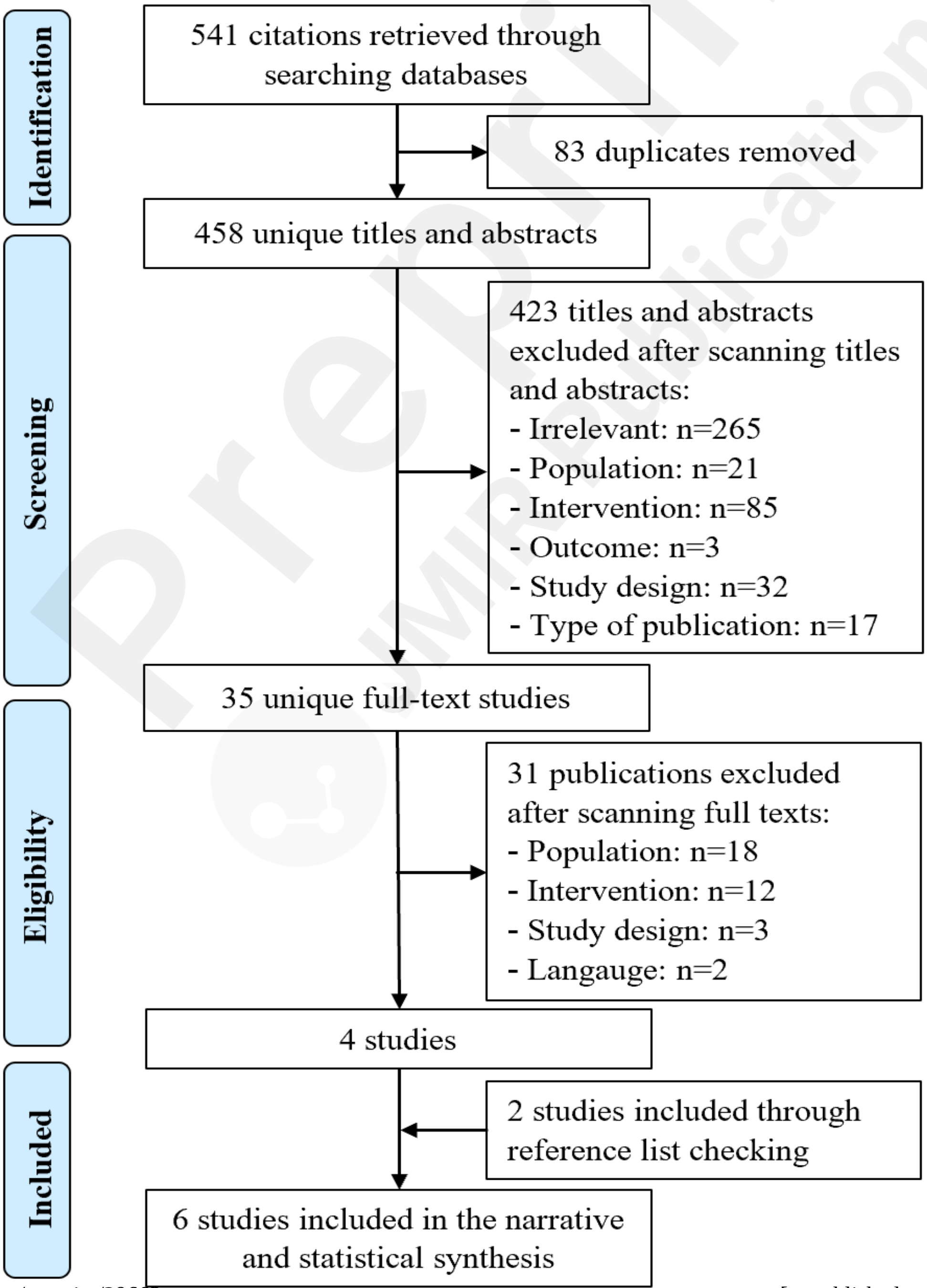


Figure 1: Flow chart of the study selection process

Characteristics of included studies

As detailed in Table 1, all included studies were randomized controlled trials (RCTs). The included studies were conducted in 3 countries: United States of America (USA) (n=3), Iran (n=2), and Indonesia (n=1); 4 of the studies were published in 2018. The sample size in the included studies ranged between 28 and 138 with an average of 81. The mean age of participants in the included studies varied from 44.6 to 65.5 years, with an average of 51.6 years. Percentage of males in the included studies ranged from 23.3% to 57.9%, with an average of 42.2%. All studies recruited patients with T2DM. The included studies recruited participants from healthcare (n=5) and community (n=1).

Table 1: Characteristics of studies and population.

Author[ID]	Year	Country	Study design	Sample size	Mean age	Sex (male)	Health condition	Setting
Agboola[21]	2016	USA	RCT	126	51.4	48.4%	T2DM	Health centers
Arovah[22]	2018	Indonesia	RCT	43	65.5	37.2%	T2DM	Public hospital
Lari[23]	2018	Iran	RCT	73	47.6	53.4%	T2DM	Diabetes clinics
Lari[24]	2018	Iran	RCT	76	48.2	57.9%	T2DM	Diabetes clinics
Polgreen[25]	2018	USA	RCT	138	44.6	23.3%	T2DM	Community
Ramirez[26]	2017	USA	RCT	28	52	33%	T2DM	Ambulatory care clinic

The intervention in the included studies were text messages only (n=1), text messages and educational CD about physical activity (n=1), and text messages and pedometers (n=4) (Table 2). Text messages were unidirectional (n=1), bidirectional (n=4), and both (i.e., most messages were unidirectional, and some messages were bidirectional) (n=1). The purposes of the text messages in the included studies were to educate participants about physical activity (n=4), remind them to wear the pedometer, review goals, and/or self-monitor and record their steps (n=4), provide them with feedback about their previous day's activity (n=3), motivate them to walk and exercise more (n=2), and set step goals (n=1). The frequency of text messages sent to participants ranged between 2 per week and 3 per day. The intervention was delivered for 12 weeks in 4 studies and 24 weeks in 2 studies. The intervention in 5 studies was theoretically informed. Specifically, the following theories/ models were used to develop the intervention: Social Cognitive Theory (n=2), Health Promotion Models (n=2), and Transtheoretical Model and Grounded Theory (n=1).

Table 2: Characteristics of interventions.

Study[ID]	Intervention	Directionality	Purpose	Frequency	Period	Theory used
Agboola[21]	SMS & pedometers	1 & 2-way	Education, motivation, reminder, feedback	2/day	24 weeks	Transtheoretical Model & Grounded Theory
Arovah[22]	SMS & pedometers	2-way	Motivation & reminder	1-3/day	12 weeks	Social Cognitive Theory
Lari[23]	SMS	2-way	Education	Phase 1: 2-3/day Phase 2: 2/week	Phase 1: 2 weeks; Phase 2: 10 weeks	Health Promotion Models
Lari[24]	SMS + Educational CD	1-way	Education	2/week	12 weeks	Health Promotion Models
Polgreen[25]	Int 1: SMS (reminder) + SMS (goal setting) + pedometer. Int 2: SMS (reminder) + pedometer	2-way	Reminders, feedback, setting goals	Int 1:2/day Int 2: 1/day	24 weeks	-

Ramirez[26]	Int1: SMS + pedometer	2-way	Education reminders, feedback	≥4 per week	12 weeks	Social Cognitive Theory

The comparison group received pedometers in 4 of the studies or no intervention in 2 studies. The pedometers were used by participants for 12 weeks (n=2) or 24 weeks (n=2). The follow-up period ranged from 4 weeks to 24 weeks. The following outcomes of interest were assessed in the included studies: physical activity (n=6), glycaemic control indicators (n=3), weight (n=1), and BMI (n=1). Step count was the most common outcome measure used in the included studies (n=4), then HbA1c (n=2), weight scale (n=2), metabolic equivalent of task (MET) questionnaire (n=2).

Table 3: Characteristics of comparators and outcomes

Study[ID]	Comparator	Period (week)	Follow-up (week)	Outcome	Outcome measure
Agboola[21]	Pedometers	24	24	Physical activity, glycaemic control, weight	Step count, weight scale, HbA1C
Arovah[22]	Pedometers	12	12 & 24	Physical activity, glycaemic control	Step count, Physical Activity Rating (PAR) questionnaire, HbA1c, fasting glucose, 2-h glucose
Lari[23]	No intervention	-	4 & 12	Physical activity	Metabolic equivalent of task (MET) questionnaire
Lari[24]	No intervention	-	4 & 12	Physical activity	Metabolic equivalent of task (MET) questionnaire
Polgreen[25]	Pedometers	24	12 & 24	Physical activity, BMI	Step count, weight scale, stadiometer
Ramirez[26]	Pedometers	12	6 & 12	Physical activity	Step count

Risk of bias results

Although all studies used an appropriate random allocation sequence for the randomisation process and had comparable groups, only 2 studies concealed the allocation sequence until participants were enrolled and assigned to interventions. Accordingly, only these 2 studies were rated as low risk of bias in the randomization process (Figure 2). In all studies, participants, their healthcare professional, researchers, and/or individuals delivering the interventions were aware of assigned intervention during the trial. The study also did not report any information about whether a deviation from the intended intervention occurred due to the experimental contexts. Thus, none of the studies were rated as low risk of bias in deviations from the intended interventions (Figure 2).

Outcome data were not available for all participants in the included studies, and there was no evidence that the findings were not biased by missing outcome data. However, the reasons for missing outcome data were not related to the true value of the outcome in all studies. Thus, all studies were judged as low risk of bias in the domain of missing outcome data.

In 4 studies, the outcomes of interest were assessed using appropriate measures (e.g., pedometer and HbA1C), which were comparable between intervention groups. For this reason, these studies were rated as low risk of bias in measuring the outcome. Yet, the remaining 2 studies were judged as high risk of bias in this domain because they used subjective outcome measures that depend on participants' recall, and participants and outcome assessors were not blinded in the 2 studies (Figure 2).

Only one study was judged as low risk of bias in the selection of the reported studies (Figure 2). This judgment is attributed to the fact that the remaining studies did not publish a pre-specified analysis plan or reported outcome measurements and analyses different from those specified in the analysis plan. Given that 5 studies were judged as high risk of bias in at least one domain, they were rated as high risk in the domain of overall bias. The remaining study was judged to raise some concerns in the domain of overall bias as it had some concerns in one of the domains. Reviewers' judgements about each 'risk of bias' domain for each included study are presented in Appendix 4.

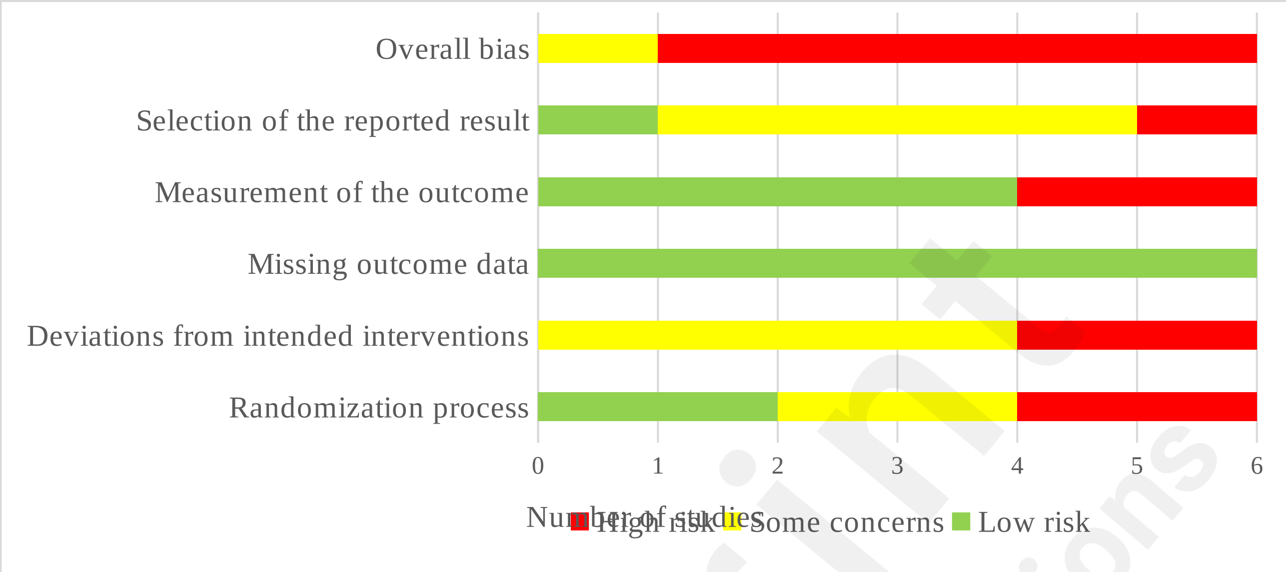


Figure 1: Review authors' judgements about each 'Risk of bias' domain.

Results of studies

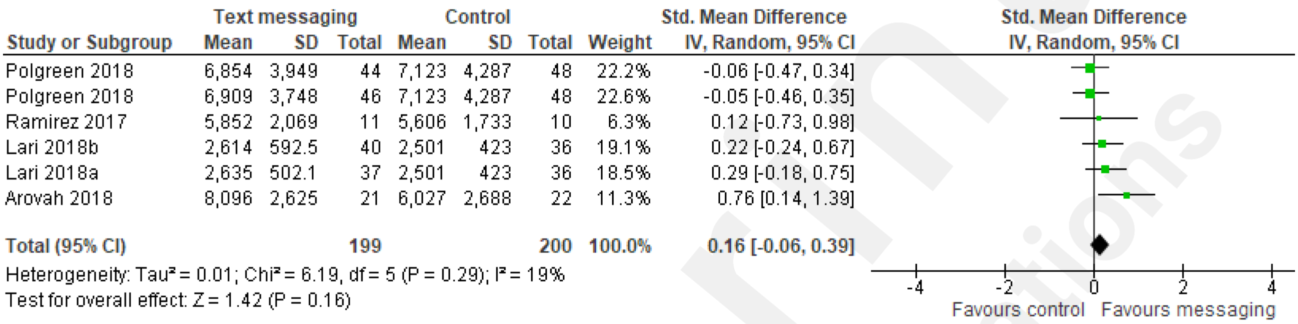
Physical activity

All included studies assessed the effect of using text messages on physical activity among T2DM patients. Three studies showed a statistically significant effect of text messages on physical activity [24-26, 28]. To be more precise, Arovah et al. compared the effect of text messages plus pedometers to only pedometers on physical activity as measured by daily step count, self-reported walking (min/ week), and self-reported moderate-to-vigorous-intensity physical activity (MVPA) (min/ week) [24]. The study showed a statistically significant effect of 12-week text messages plus pedometers to only pedometers on daily steps (P<.001), self-reported walking (P=.001), and MVPA (P<.001) [24]. In two further studies, where data were analysed from different arms of a single RCT in each 'study', Lari et al. compared the effect of text messages only [25] and text messages plus educational CD [26] to no intervention on physical activity as measured by MET questionnaire. Both studies found a statistically significant effect of text messages only (P<.001) [25] and text messages plus educational CD (P<.001) [26] on physical activity compared with no intervention.

The three remaining studies did not find a statistically significant effect of text messages on physical activity [23, 27, 28]. Specifically, Agboola et al. [23] compared the effect of text messages plus pedometers to pedometers only on physical activity as measured by monthly step count. Although the study found that step counts over 6 months were higher in the intervention group than the control group, this difference was not statistically significant (P=.17) [23]. Another study assessed the effect of text messages plus pedometers and only pedometers on physical activity as assessed by daily steps [28]. The study did not show any statistically significant difference (P=.78) in the physical activity between the two groups [28]. In the last study, Polgreen et al. compared the effect of two interventions to only pedometers on physical activity as measured by daily step count [27]. The first intervention was pedometers plus text-message reminders to wear the pedometers (reminders & pedometers) whereas the second intervention was the same as the first intervention plus text messages asking participants to set a step goal (goal setting, reminders & pedometers) [27]. The study found no statistically significant difference in physical activity between the three groups [27].

Five studies were included in the statistical analysis (i.e., meta-analysis) as they reported enough and appropriate data for the analysis [24-28]. The meta-analysis contained 6 comparisons as we included a comparison from each of 4 studies [24-26, 28] and 2 comparisons from the remaining study [27], which compared 2 types of text messages to no intervention. The meta-analysis showed no statistically significant difference in the physical activity (*P*=0.16) between text messages group and control group (SMD 0.16, 95% CI -0.06 to 0.39) (Figure 3). The heterogeneity of the evidence was not a concern (*P*=0.29; I^2= 19%). The quality of the evidence was very low due to the high risk of bias and impression (Appendix5).

Glycaemic control



Two studies examined the effect of text messages on glycaemic control as assessed by HbA1C [23, 24]. The results of both studies were meta-analysed. The meta-analysis showed no statistically significant difference (*P*=.14) between intervention and control groups, with no difference observed between text messages plus pedometers and only pedometers on HbA1C (MD -0.16, 95% CI -0.36 to 0.05) (Figure 4). There was moderate heterogeneity of the evidence (I^2= 44%), but it was not statistically significant (*P*=.18) (Figure 4). The quality of evidence was low as it was downgraded by 1 level due to high risk of bias (Appendix 5). It is worth mentioning that one of the two studies compared the effect of text messages plus pedometers to only pedometers on glycaemic control as measured by fasting plasma glucose and 2-h plasma glucose [24]. The study did not find a statistically significant difference between the groups in terms of fasting plasma glucose (*P*=.18) and 2-h plasma glucose (*P*=.90) [24].

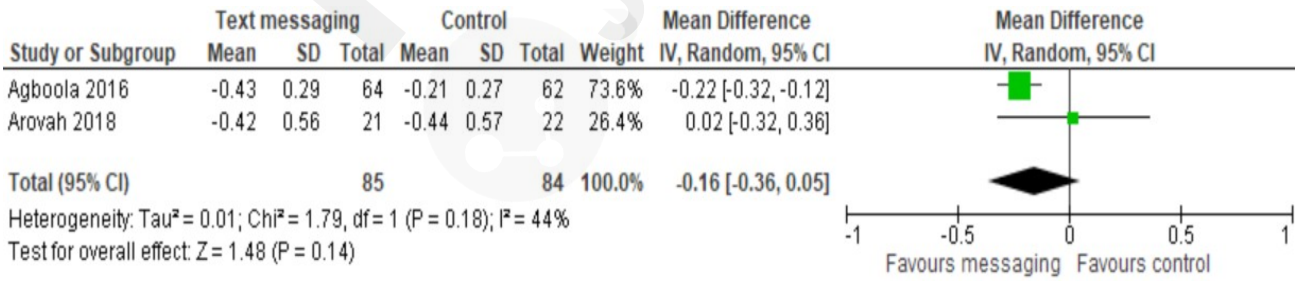


Figure 3: Forest plot of two studies assessing the effect of the text messaging on HbA1C

Anthropometric measures

Two studies assessed anthropometric measures as outcomes (weight and/or BMI) [23, 27]. Results of the two studies could not be statistically synthesised as they assessed different outcomes. The first study showed no statistically significant difference between intervention and control groups, with no effect of text messages plus pedometers on weight (*P*=.77) in comparison with only pedometers

[23] . In the second study, Polgreen et al. compared the effect of two interventions to only pedometers on BMI [27]. The first intervention was pedometers plus text-message reminders to wear the pedometers (reminders & pedometers) whereas the second intervention was the same as the first intervention plus text messages asking participants to set a step goal (goal setting, reminders & pedometers) [27]. The study found no statistically significant difference in BMI between the three groups [27].

Other outcomes

Secondary outcome measures reported in the examined studies included the following variables and parameters: reports of the usability, satisfaction and adherence to the intervention in [23], quality of life and/or psychological outcomes (e.g. self-efficacy, outcome expectations, self-regulation, and social support) in [24]. Lari et al. assessed the Health Promotion Model (HPM) constructs (e.g. perceived benefits, perceived barriers, perceived social support and self-efficacy) [10, 26]. Ramirez et al. also investigated the feasibility, perceived usefulness, and potential effectiveness [28]

Discussion

Principal findings

This systematic review assessed the effectiveness of mobile text messaging as a method to promote solely physical activity in people with T2DM. The meta-analysis of results of 5 studies (6 comparisons) showed no statistically significant effect of mobile text messaging on physical activity in comparison with no intervention. The insignificant effect may be attributed to the fact that three studies showed a statistically significant effect of mobile text messaging on physical activity whereas two studies did not find any significant effect of text messages on physical activity. There are a number of potential reasons for the significant increase in physical activity in three studies. Firstly, the intervention in one study [24] was combined with pedometers, and some studies have found greater effects when using objective measures compared with subjective measures [29]. It is possible that participants in these studies were more active as a result of knowledge that they are wearing the pedometer [30]. The remaining two RCTs [25, 26] were rated high risk of bias because they used self-recall questionnaires to measure physical activity. However, these measures can present limitations in capturing physical activity due to poor reliability and validity, participant recall bias and differences in the interpretation of questions [31]. Our findings are consistent with previous reviews that assessed the effect of text messaging on physical activity in participants with different chronic conditions [32]. Some studies observed only small improvements in daily steps and self-reported physical activity, other studies did not observe any statistically significant changes in physical activity despite the use of different physical activity measurement strategies [32].

Our review found no statistically significant effect of mobile text messaging on glycaemic control as assessed by HbA1C, fasting plasma glucose, and 2-h plasma glucose. Our findings are consistent with previous studies which showed no significant difference in HbA1c levels in people with T2DM following text messaging interventions [33]. This could be contributed to the duration effect, our meta-analysis had short interventions and follow-up durations (median, 12 weeks), thus, outcomes such HbA1c are less likely to change over a short timescale (three months), in other words, it might take longer for the intervention effects to become apparent [34].

The narrative synthesis in this review showed no statistically significant effect of mobile text messaging on either weight or BMI. We could not synthesise these measures in our meta-analysis due to high heterogeneity in the included studies. Our findings are consistent with previous reviews, a meta-analysis showed no statistically significant in BMI and weight following mobile messaging interventions in people with T2DM [35]. However, it is important to be realistic about the period of interventions, a longer period is required to determine the desired improvements in such clinical outcomes [36]. Aforementioned studies had short interventions (median, 12 weeks), thus, outcomes such weight and BMI are less likely to change on a short time scale [34].

Strengths and limitations

Strengths

Our study is the first review and meta-analysis that focused on the effectiveness of text messages targeting only physical activity among T2DM patients. This enables us to ensure that the effect of text messaging on physical activity outcomes is attributed to physical activity-related message content, and no other contents such as diet, lifestyle, and general diabetic education. Our study is considered a robust and high-quality review given that we followed well-recommended guidelines (i.e., PRISMA) in developing, executing, and reporting it.

To run as sensitive a search as possible, we searched the most popular databases in health and information technology fields using a very comprehensive list of search terms. The risk of publication bias is minimal in this review because we searched grey literature databases (i.e., Web of Science and Google Scholar) and conducted backward and forward reference list checking. We did not restrict our search to specific countries of publication, year of publication, comparators, nor settings; thus, this resulted in a more comprehensive review.

The risk of selection bias is minimal in the current review as two authors independently selected studies, extracted data, and assessed the risk of bias and quality of evidence, and they had a very good interrater agreement in all processes. When possible, we meta-analysed results of the included studies, and this improved the power of studies and the estimates of the likely size of effect of text messaging on different outcomes.

Limitations

The intervention of interest in this review was restricted to physical activity-related text messaging, so we have not examined the impact of other digital interventions, such as mobile applications, wearables, or other e-health tools. We also focused on patients with T2DM rather than other types of diabetes. Accordingly, our results may not be generalisable to other e-health interventions nor patients with T1DM or gestational DM. In this review, we included only RCTs published in the English language, thus, it is possible that we missed results from some non-English RCTs. We applied these restrictions due to the high internal validity of RCTs over other study designs [37] and lack of resources to translate non-English studies. The included studies were conducted in only 3 countries (USA, Iran, and Indonesia); therefore, the generalisability of our findings to other countries may be limited. The findings are based on a small number of studies that met review criteria. Although six studies were included in this review, two of the studies were from a single RCT where two separate analyses and had been undertaken with data taken from different arms. Only two studies were included in each of the two meta-analyses conducted in this review. This is attributed to the lack of reported data that were appropriate for the analysis, and incomparable outcome measures and comparators between studies. As such, it is not possible draw firm conclusions about effectiveness.

Implications for research

The current review found relatively few studies assessing the effectiveness of text messages in promoting physical activity in T2DM, thus, RTCs with larger sample sizes are needed. Future studies should seek to include objective outcome measures (e.g. physical activity, glycaemic control and anthropometric measures), be consistent in terms of selected outcome measures, and measure outcomes after longer follow-up periods in order to be able to compare study findings and make firm conclusions about intervention effectiveness. More research is needed to determine what type of text message content, frequency of messaging and duration of intervention is most likely to have positive outcomes. Additional research needs to include an estimation of the cost-effectiveness of text messages and an examination of their long-term impact.

Conclusion

We could not draw a definitive conclusion regarding the effectiveness of text messaging on physical activity, glycaemic control, weight, or BMI among patients with T2MD given the low number of the included studies and their high risk of bias. Thus, the findings of this study suggest that texting messaging should not substitute, but rather supplement clinical support. In addition, there is a pressing need for further RCTs with large sample sizes, low risk of bias, and more consistency in terms of intervention duration, outcome measures, the follow-up period, and comparator.

Conflicts of interest

None declared

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Abbreviations

AA: Alaa Abd-Alrazaq

BMI: Body mass index

DM: Diabetes mellitus

DM: Diabetes mellitus

GRADE: Grading of recommendations assessment and development and evaluation

MCID: Minimal clinically important difference

MET: Metabolic equivalent of task

MJ: Mohammed Jamaan

PA: Physical activity

RCTs: Randomized controlled trial

SD: standard deviation

T1DM: Type 1 diabetes mellitus

T2DM: Type 2 diabetes mellitus

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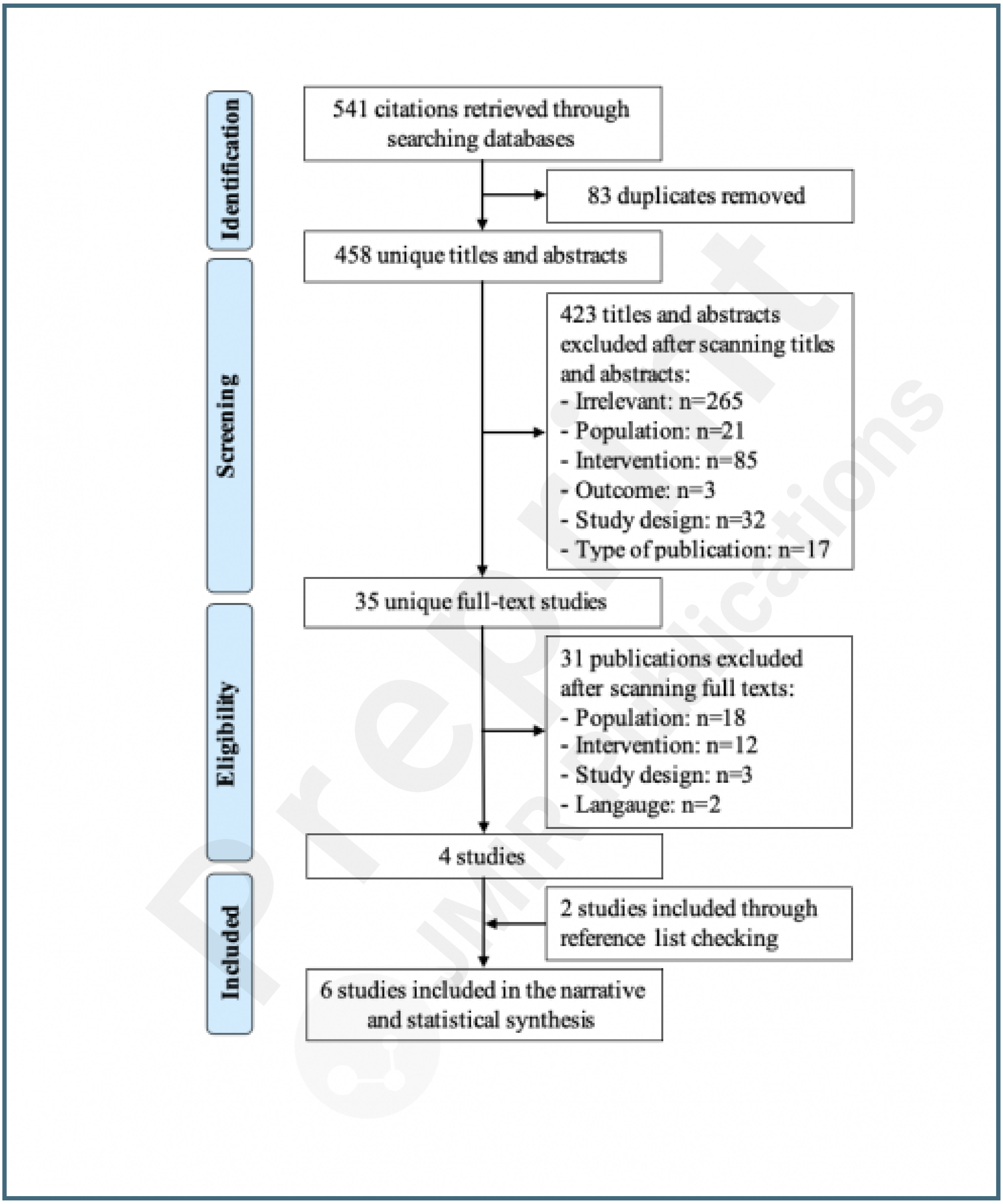
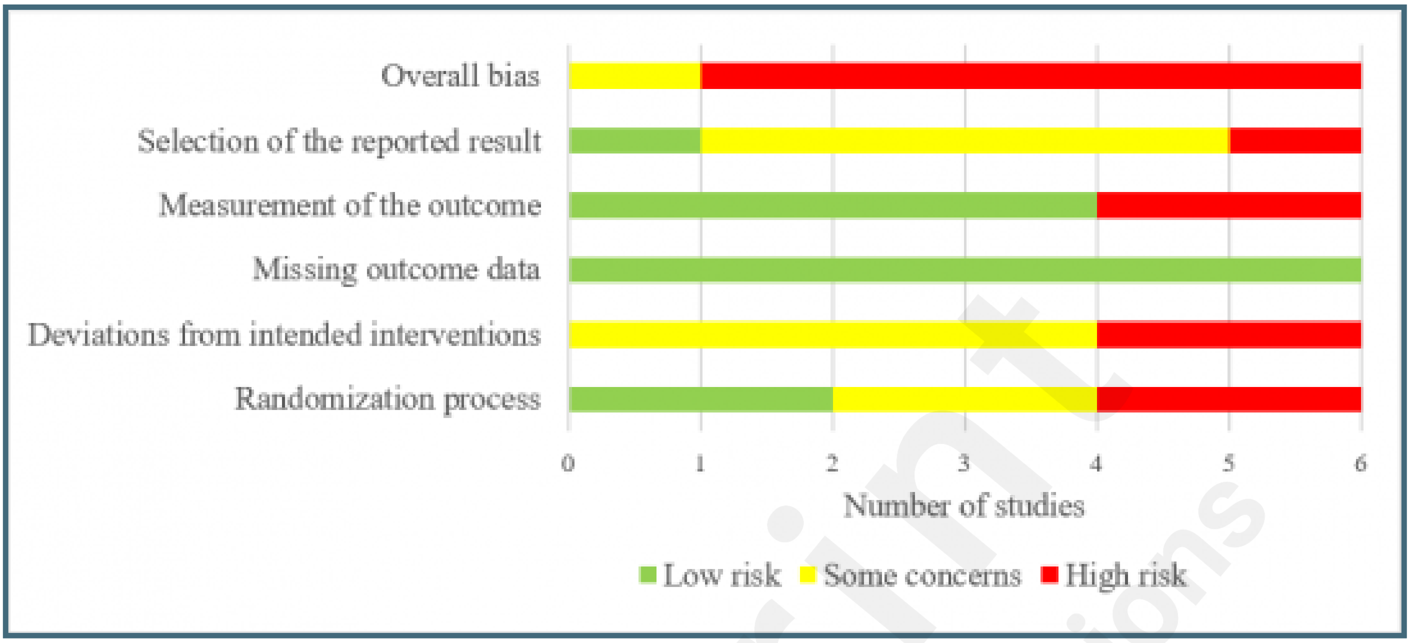
Supplementary Files

Figures

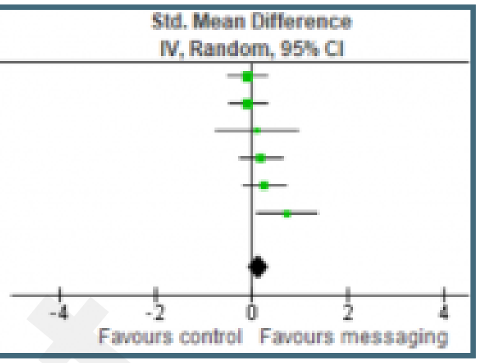
Flow chart of the study selection process.



Review authors' judgements about each 'Risk of bias' domain.



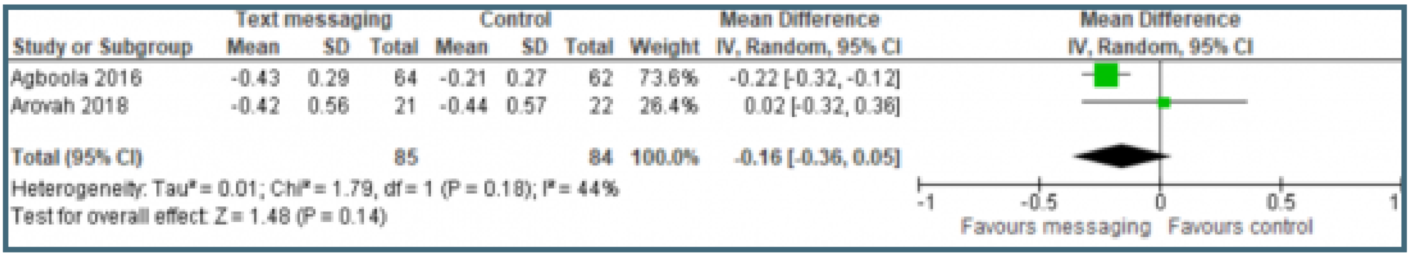
Forest plot of six studies assessing the effect of the text messaging on physical activity.



	Text messaging			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Polgreen 2018	6,854	3,949	44	7,123	4,287	48	22.2%	-0.06 [-0.47, 0.34]
Polgreen 2018	6,909	3,748	46	7,123	4,287	48	22.6%	-0.05 [-0.46, 0.35]
Ramirez 2017	5,852	2,069	11	5,606	1,733	10	6.3%	0.12 [-0.73, 0.98]
Lari 2018b	2,614	592.5	40	2,501	423	36	19.1%	0.22 [-0.24, 0.67]
Lari 2018a	2,635	502.1	37	2,501	423	36	18.5%	0.29 [-0.18, 0.75]
Arovah 2018	8,096	2,625	21	6,027	2,688	22	11.3%	0.76 [0.14, 1.39]
Total (95% CI)			**199**			**200**	**100.0%**	**0.16 [-0.06, 0.39]**

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 6.19$, $df = 5$ ($P = 0.29$); $I^2 = 19\%$
Test for overall effect: $Z = 1.42$ ($P = 0.16$)

Forest plot of two studies assessing the effect of the text messaging on HbA1C.



Multimedia Appendixes

PRISMA checklist.
URL: http://asset.jmir.pub/assets/4e0c93d899c8ef5ff1dde2efebea72be.docx

Search query used for searching MEDLINE.
URL: http://asset.jmir.pub/assets/ba53bec8458f42ad70981792fd7a75bb.docx

Data extraction form.
URL: http://asset.jmir.pub/assets/1697618ed0dbd51521879ff8b37eae0c.docx

Reviewers' judgements about each "risk of bias" domain for each included RCT.
URL: http://asset.jmir.pub/assets/fc9857ef5219d44a16a225ccee3252bd.docx

GRADE profile.
URL: http://asset.jmir.pub/assets/f7a267ed334300118f328f9fdfd6a093.docx