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Review Article

Screen-Based Sedentary Behaviour-Focused Digital Interventions for Adults with or at Risk of Type 2 Diabetes Mellitus: A Systematic Review

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Abstract: Screen-based sedentary behaviour is an important health concern among adults with or at risk of type 2 diabetes mellitus (T2DM). This systematic review aimed to synthesise evidence on digital interventions targeting screen-based sedentary behaviour and their effects on behavioural and metabolic outcomes among adults with or at risk of T2DM. Systematic searches were conducted in PubMed, Scopus, Web of Science Core Collection, Embase, CINAHL, and the Cochrane Library from database inception to June 2026, following the PRISMA 2020 guidelines. Three reviewers independently conducted study selection, data extraction, and methodological appraisal using Joanna Briggs Institute critical appraisal tools. Nine studies involving 3,933 participants from seven countries were included. Interventions comprised smartphone applications, WeChat-based programmes, workplace interventions, and other mobile health approaches incorporating reminders, self-monitoring, feedback, education, and goal setting. Findings indicated potentially favourable effects on sedentary behaviour. For example, one workplace intervention reported a post-intervention difference in sitting time of −66.3 minutes per day between intervention and comparator groups, calculated from the reported group means. Another study reported an unadjusted post-intervention difference in glycated hemoglobin test (HbA1c) of −0.50 percentage points. Other studies reported improvements in sitting breaks, physical activity, glucose tolerance, fasting blood glucose, or lifestyle-related outcomes. However, findings were not consistent across all outcomes or follow-up periods. Substantial clinical and methodological heterogeneity, together with incomplete and incompatible numerical data, precluded quantitative meta-analysis. Digital interventions may help reduce sedentary or sitting time and support selected behavioural and metabolic outcomes among adults with or at risk of T2DM, but the overall effectiveness remains uncertain

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1. Introduction

Type 2 diabetes mellitus (T2DM) is a major and growing global public health challenge. The International Diabetes Federation projects a substantial increase in the number of adults living with diabetes over the coming decades. Beyond morbidity and premature mortality, T2DM imposes considerable financial demands on health systems and can adversely affect quality of life. These

challenges underscore the need for effective strategies to prevent diabetes and support its long-term management [1].

Lifestyle modification is central to the prevention and management of T2DM. Sedentary behaviour is recognised as an independent behavioural risk factor for metabolic health, including among people who meet recommended levels of moderate-to-vigorous physical activity [2–4]. It is defined as any waking behaviour characterised by an energy expenditure of ≤ 1.5 metabolic equivalents while sitting, reclining or lying [5]. In the context of this review, particular attention is given to screen-based sedentary behaviour and interventions intended to reduce prolonged sitting among adults with or at increased risk of T2DM [2, 6–8].

Screen-based activities account for an increasingly substantial proportion of sedentary behaviour in contemporary adult life. The widespread use of smartphones, computers, tablets and televisions for work, education, communication and leisure creates opportunities for prolonged screen exposure [6, 7]. Adults with T2DM, as well as those at increased risk of developing the condition, may spend considerable periods sitting in front of screens because of occupational or academic demands, digitally mediated lifestyles and limited opportunities to interrupt sitting with movement [9–11]. Accordingly, interventions that reduce screen-related sedentary time have attracted interest as a potential behavioural strategy to support metabolic health and diabetes prevention and management [12–14].

The rapid development of digital health technologies has created opportunities to deliver lifestyle interventions at scale and to tailor behavioural support to individual needs. Mobile health (mHealth), smartphone applications, web-based programmes, wearable devices and mobile messaging can incorporate strategies such as self-monitoring, personalised feedback, reminders, goal setting and real-time interaction [15–17]. However, the availability of these technologies does not, in itself, demonstrate that they are effective in reducing screen-based sedentary behaviour. Although digital interventions have been evaluated for diabetes self-management and broader lifestyle modification, evidence specifically concerning interventions designed to reduce screen-based sedentary behaviour among adults with, or at increased risk of, T2DM has not been adequately synthesised [18–20]. It also remains unclear which delivery modalities and behaviour change components are most consistently associated with improvements in sedentary behaviour and related metabolic outcomes. These gaps warrant a focused systematic review.

Previous systematic reviews have examined digital health interventions for chronic disease management, diabetes self-management, glycaemic control, physical activity and sedentary behaviour across a range of populations [15, 16, 19, 21]. However, these reviews have generally addressed broader intervention objectives, multiple health conditions or sedentary behaviour in populations not restricted to people with, or at increased risk of, T2DM. Consequently, evidence on digital interventions specifically designed to reduce screen-based sedentary behaviour in this population remains insufficiently synthesised. Differences in delivery modalities, behavioural targets and metabolic outcomes may also complicate interpretation across studies. A focused review is therefore needed to characterise these interventions and synthesise their reported effects on sedentary behaviour and relevant behavioural and metabolic outcomes [16, 22–24].

This systematic review aimed to synthesise the available evidence on digital interventions specifically targeting screen-based sedentary behaviour among adults with, or at increased risk of, T2DM. Specifically, it examined the effects of these interventions on sedentary behaviour and relevant behavioural and metabolic outcomes, and characterised the digital delivery modalities and populations represented in the evidence.

2. Materials and Methods

2.1.Study Design and Reporting Guideline

This systematic review synthesised evidence on digital interventions designed specifically to address screen-based sedentary behaviour among adults with T2DM or at increased risk of developing the condition. The review protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO; registration number CRD420261473963). The review was planned and reported in accordance with the PRISMA 2020 statement [25] and the methodological guidance in the Joanna Briggs Institute (JBI) Manual for Evidence Synthesis [26]. Findings were synthesised

narratively; meta-analysis was not undertaken because of heterogeneity across the included studies and the limited availability of comparable numerical data.

2.2 Information Sources and Search Strategy

Systematic searches were conducted in six electronic bibliographic databases: PubMed, Scopus, Web of Science Core Collection, Embase, CINAHL and the Cochrane Library. Each database was searched from inception to June 2026, with no restriction on publication year.

The search strategy combined controlled vocabulary, including Medical Subject Headings (MeSH) and Emtree terms, with free-text terms relating to T2DM, prediabetes, metabolic syndrome, screen-based sedentary behaviour, sedentary behaviour, screen time, digital interventions, digital health, mHealth, smartphone applications, telehealth, mobile messaging and behaviour change. Boolean operators (AND/OR), truncation and database-specific syntax were applied as appropriate to maximise retrieval of potentially relevant records. Full search strategies for each database are provided in Supplementary table S1.

To identify additional studies that might not have been retrieved through database searching, the reference lists of all eligible studies and relevant systematic reviews were screened manually.

2.3. Eligibility Criteria

Studies were eligible for inclusion if they met all of the following criteria:

- Adults aged 18 years or older with diagnosed T2DM or at increased risk of developing T2DM were eligible. This included individuals with prediabetes, metabolic syndrome, a history of gestational diabetes mellitus (GDM) or intermediate hyperglycaemia. Adults with overweight or obesity, central adiposity or elevated blood pressure were also eligible when the original studies used these characteristics to identify populations at increased risk of T2DM. Smoking and alcohol consumption were considered relevant participant characteristics but were not treated as independent eligibility criteria.
- Digital interventions specifically designed to reduce screen-based sedentary behaviour or interrupt prolonged sitting were eligible. These included smartphone applications, mHealth programmes, web-based interventions, messaging platforms and other technology-enabled behavioural interventions.
- Comparator: Usual care, standard education, minimal intervention, or another behavioural intervention, where applicable.
- At least one behavioural outcome, such as screen-based sedentary time, total sitting time, sitting breaks or physical activity, or a relevant metabolic outcome, such as glycated haemoglobin (HbA1c), fasting blood glucose, glucose tolerance, body weight, cardiometabolic risk or T2DM incidence.
- Study design: Randomised controlled trials (RCTs), cluster-randomised controlled trials, and quasi-experimental studies evaluating the effects of eligible digital interventions.
- Publication characteristics: Full-text articles published in peer-reviewed journals and written in English.

Studies were excluded if they involved children or adolescents; focused exclusively on chronic diseases other than T2DM without including participants who met the predefined T2DM risk criteria; did not include a digital intervention specifically targeting screen-based sedentary behaviour or prolonged sitting; reported only associations between sedentary behaviour and health outcomes without evaluating an intervention; provided insufficient information to determine eligibility or extract relevant outcomes; or were conference abstracts, editorials, commentaries, protocols, dissertations or review articles.

2.4. Study Selection

Records retrieved through database searches and supplementary reference-list searches were collated, and duplicates were removed before screening. Titles and abstracts were independently screened against the predefined eligibility criteria. Full texts of potentially eligible reports were then assessed to determine whether they met all inclusion criteria.

Reports were excluded at the full-text stage if they did not meet the population, intervention, outcome, study design or publication criteria. Particular attention was paid to whether each study evaluated a digital intervention specifically intended to reduce screen-based sedentary behaviour or interrupt prolonged sitting, rather than merely examining associations between screen time and health outcomes.

The selection process was documented, including the numbers of records identified, duplicates removed, records screened, full-text reports assessed and studies included in the final qualitative synthesis. The process is summarised in the PRISMA 2020 flow diagram (Figure 1).

2.5. Data Extraction

Three reviewers independently extracted data using a standardised form. Extracted information included the first author and year of publication, country, study design, participant characteristics, sample size, age, sedentary behaviour targeted, intervention characteristics and duration, comparator, outcome measures, follow-up period, reported effect estimates, principal findings and methodological quality.

Where available, numerical outcome data were extracted from the original publications, including group-specific results, measures of variability, effect estimates, confidence intervals and p-values. Extracted estimates were checked against the corresponding outcome definitions, comparison groups and assessment time points to support accurate interpretation.

Discrepancies between reviewers were resolved through discussion until consensus was reached. Where extracted values were unclear or inconsistent, the original publication was re-examined. Data that could not be verified from the available reports were neither assumed nor recalculated without sufficient supporting information.

2.6. Methodological Quality Assessment

Three reviewers independently assessed the methodological quality of the included studies using the JBI critical appraisal checklist appropriate to each study design. The checklist was selected according to the methodological characteristics of each study; a single appraisal instrument was not applied across different designs.

Individual checklist items were rated using the response categories specified by the relevant JBI tool. Disagreements were resolved through discussion and consensus. Appraisal findings were summarised by study design and taken into account when interpreting the review findings.

Methodological limitations identified through critical appraisal were reported transparently. Overall judgements followed the criteria of the selected appraisal tools; results from different study designs were not treated as directly equivalent [10].

2.7. Data Synthesis

A narrative synthesis was undertaken to describe the included studies, digital intervention components, targeted sedentary behaviours, participant characteristics and reported behavioural and metabolic outcomes. Findings were organised by intervention characteristics and outcome domains to facilitate comparison across studies.

Meta-analysis was not undertaken because of clinical and methodological heterogeneity in participant populations, intervention characteristics, outcome definitions, measurement methods and follow-up periods. In addition, several studies did not report sufficient or compatible numerical data, including measures of variability, to permit reliable calculation of pooled effect estimates. Findings were therefore synthesised descriptively and interpreted in the context of each study's design, reported outcomes and methodological limitations. No pooled intervention effect was estimated.

2.8. Assessment of Heterogeneity

Clinical and methodological heterogeneity was assessed descriptively by comparing participant characteristics, intervention modalities and durations, outcome measures and follow-up periods across

the included studies. Statistical heterogeneity was not assessed using Cochran's Q test or the I^2 statistic because no meta-analysis was conducted [27].

2.9. Subgroup and Sensitivity Analyses

Subgroup and sensitivity analyses were not conducted because no quantitative meta-analysis was undertaken. Differences in participant characteristics, intervention modalities, intervention duration and methodological quality were considered descriptively when interpreting the findings.

2.10. Publication Bias

Publication bias was not formally assessed because no meta-analysis was conducted; funnel plots and Egger's regression test were therefore not performed. The possibility of publication bias was considered when interpreting the available evidence.

2.11. Certainty of the Evidence

A formal assessment of the certainty of the evidence using the Grading of Recommendations Assessment, Development and Evaluation approach was not conducted [28].

2.12. Statistical Analysis

No statistical pooling or inferential analysis across studies was performed. Numerical results reported in the original publications were extracted and presented descriptively where available. Effect estimates were interpreted in accordance with the outcome definitions and comparison groups used in the respective studies. Because no quantitative synthesis was undertaken, pooled effect estimates and corresponding confidence intervals were not calculated.

3 Results

3.1 Study Selection

After duplicate removal, the remaining records were screened by title and abstract against the predefined eligibility criteria. Potentially relevant reports were retrieved for full-text assessment. Reports that did not meet the inclusion criteria were excluded, and reasons for exclusion were documented.

Following title and abstract screening and full-text assessment, nine studies met the eligibility criteria and were included in the qualitative synthesis. The availability and comparability of numerical outcome data were considered when determining whether quantitative synthesis was feasible. Meta-analysis was not undertaken because of clinical and methodological heterogeneity and insufficiently complete or comparable numerical data, including measures of variance, across outcome domains. Accordingly, no pooled effect estimates were calculated. The selection process is presented in the PRISMA 2020 flow diagram (Figure 1).

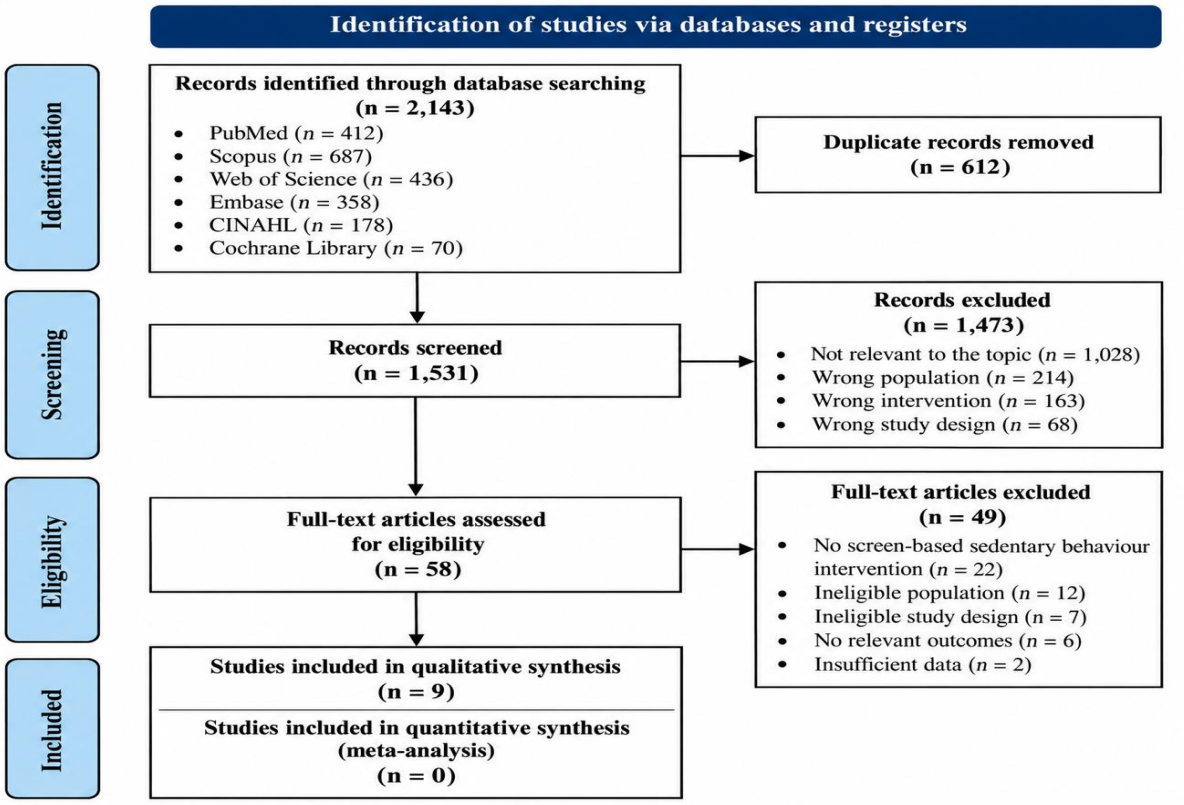


Figure 1: PRISMA 2020 flow diagram illustrating the study selection process.

3.2 Characteristics of Included Studies

Following reassessment against the eligibility criteria, nine studies were included in the qualitative synthesis. Published between 2020 and 2026, these studies were conducted in seven countries: China, Spain, the United States, the United Kingdom, India, Singapore and Bangladesh [29–37].

The included studies comprised five individually (RCTs, three cluster-randomised controlled trials and one quasi-experimental study. Populations included adults with established T2DM, individuals at increased risk of T2DM, women with a history of GDM, adults with intermediate hyperglycaemia, desk-based and office-based employees, and adults with metabolic syndrome.

Across the nine studies, 3,933 participants were included; individual study sample sizes ranged from 20 to 2,470. The interventions comprised smartphone applications, WeChat-based programmes, workplace interventions and other mHealth approaches. Intervention periods ranged from four weeks to 48 months.

Outcomes included sedentary time, sitting breaks, physical activity, dietary behaviour, HbA1c, fasting blood glucose, glucose tolerance, body weight, cardiometabolic risk and T2DM incidence. The characteristics of the included studies are summarised in table 1.

Table 1: Characteristics of the included studies.

Author (Ref.)	Country	Study Design	Population	Sample Size (n)	Age	Screen-Based Sedentary Behaviour Targeted	Intervention and Duration	Primary Outcomes	Follow-up	Reported Effect Estimate	Main Findings	Risk of Bias
Xu *et al.* [29]	China	Randomised controlled trial	Adults at high risk of T2DM	79	23–67 years	Smartphone-related sedentary behaviour (WeChat)	Mobile-based intervention; 6 months	Dietary behaviour and physical activity	3 and 6 months	exp(β) = 2.05	Reported improvements in dietary behaviour and physical activity. The effect estimate should be interpreted according to the original statistical model.	Some concerns
Pereira *et al.* [30]	USA	Cluster-randomised controlled trial	Office employees	630	44.6 years	Occupational computer-based sitting	Stand and Move at Work multicomponent intervention; 12 months	Sitting time and cardiometabolic risk	12 months	Mean difference = −66.3 min/day in the extracted post-intervention comparison; the original study also reports an adjusted estimate	Sitting time was lower in the intervention group, with improvements in selected cardiometabolic outcomes.	Low
Bailey *et al.* [31]	UK	Randomised controlled trial	Adults with T2DM	20	18–65 years	Prolonged smartphone-related sitting	MyHealthAvatar-Diabetes smartphone application; 8 weeks	Sitting breaks and glucose tolerance	8 weeks	Large effect (as described in the manuscript); exact estimate to be verified	Reported improvements in sitting breaks and glucose tolerance.	Low
Zongpa *et al.* [32]	India	Cluster-randomised controlled trial	Desk-based employees	53	25–60 years	Occupational sedentary behaviour	Smartphone-directed physical activity programme; 4 weeks	Fasting blood glucose and VO_2max	4 weeks	ES = 0.674	Reported improvements in fasting blood glucose and aerobic capacity.	Low
Sathish [33]	Bangladesh	Cluster-randomised controlled trial	Adults with intermediate hyperglycaemia	2,470	≥30 years	Mobile-assisted sedentary behaviour reduction	Mobile health intervention; 14 months	T2DM incidence	2 years	Adjusted OR = 1.02	The manuscript reports no significant effect of mHealth alone on T2DM incidence.	Low
Lim *et al.* [34]	Singapore	Randomised controlled trial	Adults with T2DM	204	51 years	Smartphone-assisted sedentary lifestyle	Smartphone application; 6 months	HbA1c and body weight	6 months	The manuscript reports HbA1c of 6.7% (SD 1.2) versus 7.2% (SD 1.0), with an unadjusted mean difference of −0.50 percentage points	Reported improvements in glycaemic control and body weight.	Low
Chen *et al.* [35]	China	Quasi-experimental study	Adults with metabolic syndrome	138	51.5 years	Smartphone-mediated sedentary lifestyle	Individualised mHealth-based intervention; 12 weeks	Lifestyle behaviour and ASCVD risk	12 weeks	ES = 0.60	Reported improvements in lifestyle behaviour and self-efficacy.	High
Alòs *et al.* [36]	Spain	Randomised controlled trial	Adults with T2DM	54	54.5 years)	Television viewing and sitting associated with home-screen use	Digital intervention; 13 weeks	Sedentary time and HbA1c	6 and 12 months	ES = 0.50	Reported reductions in leisure sitting and improvements in HbA1c.	Low
Highton *et al.* , [37]	UK	Randomised controlled trial	Women with previous gestational diabetes mellitus	285	35.2 years	Leisure sedentary behaviour	Structured group education and accompanying mHealth intervention; 48 months	Physical activity and HbA1c	48 months	RR = 0.75 (as reported in the manuscript; outcome and estimate require verification)	No significant long-term improvement was reported in the principal physical activity outcome.	Some concerns

Note: T2DM = type 2 diabetes mellitus; ES = effect size; β = regression coefficient; RR = risk ratio; OR = odds ratio; SD = standard deviation; HbA1c = glycated haemoglobin; VO_2max = maximal oxygen uptake; ASCVD = atherosclerotic cardiovascular disease; mHealth = mobile health.

3.3 Characteristics of Screen-Based Sedentary Behaviour–Focused Digital Interventions

The digital interventions evaluated in the included studies are characterised in table 2. Delivery modalities included smartphone applications, mobile health platforms, WeChat-based programmes and technology-supported workplace interventions. The technologies and delivery approaches differed across studies, reflecting variation in settings, target populations, and behavioural objectives [29–37].

The behaviours targeted included sitting associated with smartphone use, occupational computer-based sitting, television viewing, leisure-related screen exposure and other forms of prolonged sedentary behaviour explicitly addressed by the interventions. Intervention periods ranged from four weeks to 48 months; however, intervention duration and follow-up duration were not necessarily equivalent (Table 2).

Table 2: Characteristics of screen-based sedentary behaviour–focused digital interventions.

Intervention characteristic	Summary
Digital delivery modalities	Smartphone applications, mHealth platforms, WeChat-based programmes, and technology-supported workplace interventions
Targeted sedentary behaviours	Smartphone-related sitting, occupational computer-based sitting, television viewing, leisure-related screen exposure, and other prolonged sedentary behaviours explicitly targeted by the interventions
Behaviour change components	Self-monitoring, goal setting, personalised feedback, prompts or reminders, and health education, where reported
Intervention duration	4 weeks–48 months; verify whether the reported period refers to intervention duration or follow-up
Behavioural outcomes	Sedentary time, sitting breaks, physical activity, lifestyle behaviour, and self-efficacy, where assessed
Metabolic and cardiometabolic outcomes	HbA1c, fasting blood glucose, glucose tolerance, body weight, VO_2max, cardiometabolic risk, ASCVD risk, and T2DM incidence, where assessed

Reported behaviour change components included self-monitoring, goal setting, personalised feedback, behavioural prompts or reminders, and health education. The combination of components varied between studies. Where implemented, these strategies were intended to support changes in sedentary behaviour and physical activity; some interventions also assessed related lifestyle and metabolic outcomes (Table 2).

Outcomes included behavioural measures, such as sedentary time, sitting breaks, physical activity and lifestyle behaviours, as well as metabolic and cardiometabolic measures, including HbA1c, fasting blood glucose, glucose tolerance, body weight and other reported risk indicators. The outcomes varied across studies, limiting direct comparison. Overall, the interventions differed in their digital delivery modalities, behavioural targets, duration, behaviour change components and outcome measures. These differences were considered in the narrative synthesis, particularly when assessing the comparability of findings across studies.

3.4 Methodological Quality Assessment

The methodological quality of the nine included studies varied. Item-level appraisal results and overall classifications are presented in tables 3 and 4 and were considered when interpreting the narrative synthesis.

Table 3: Item-level risk of bias assessment of randomised controlled trials.

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Overall judgement
Xu *et al.* [29]	Yes	Unclear	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Unclear	Yes	Some concerns
Pereira *et al.* [30]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
Bailey *et al.* [31]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
Zongpa *et al.* [32]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Low
Sathish [33]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
Lim *et al.* [34]	Unclear	Unclear	Yes	Unclear	Yes	Yes	No	Yes	Yes	Yes	Yes	Some concerns
Alòs *et al.* [36]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
Highton *et al.* [37]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low

Table 4: Item-Level Risk of Bias Assessment of the Quasi-Experimental Study.

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Overall judgement
Chen *et al.* [35]	Yes	Unclear	Yes	Unclear	No	Unclear	Yes	Unclear	Yes	High

Note for tables 3 and 4: Yes = criterion met; Unclear = criterion unclear or not reported; No = criterion not met. Q1–Q11 refer to the individual items in the JBI critical appraisal checklist for randomised controlled trials, including cluster-randomised trials. Q1–Q9 refer to the checklist for quasi-experimental studies.

3.5 Narrative Synthesis of Findings

The findings were synthesised narratively because differences in intervention characteristics, outcome definitions, measurement methods, follow-up periods and statistical reporting limited comparability across studies. Although some studies reported numerical outcome data, the available evidence was insufficient to support reliable quantitative pooling.

For sedentary behaviour, Pereira *et al.* [30] reported mean sitting times of 278.4 ± 79.8 min/day in the intervention group and 344.7 ± 73.1 min/day in the comparator group. The difference between the extracted post-intervention group means was −66.3 min/day; this represents an unadjusted mean difference. Alòs *et al.* [36] reported a reduction in sedentary time, while Bailey *et al.* [31] reported improvements in sitting breaks. These findings should be interpreted in light of the outcome measures and analyses used in the original studies.

For physical activity and lifestyle-related outcomes, Xu *et al.* [29] reported a favourable finding for physical activity, although the reported effect estimate must be interpreted in the context of the original statistical model. Highton *et al.* [37] found no significant long-term improvement in the principal physical activity-related outcome. Chen *et al.* [35] reported improvements in lifestyle behaviour and self-efficacy following the intervention.

For glycaemic outcomes, Lim *et al.* [34] reported mean HbA1c values (mean ± standard deviation [SD]) of 6.7 ± 1.2% in the intervention group and 7.2% ± 1.0% in the comparator group. The difference between the extracted post-intervention group means was −0.50 percentage points. This represents an unadjusted calculation and should not be interpreted as an adjusted effect estimate reported by the original study. Alòs *et al.* [36] also reported improvements in HbA1c. Zongpa *et al.* [32] reported findings for fasting blood glucose; however, the extracted estimate was based on a median change and an estimated standard deviation. Bailey *et al.* [31] reported improvements in glucose tolerance following the intervention.

For T2DM incidence, Sathish [33] reported findings relating to a mobile health intervention. The effect estimate should be interpreted in accordance with the original study, including its comparator and measure of statistical uncertainty.

Overall, the included studies reported potentially favourable findings for selected behavioural and metabolic outcomes, although results were not consistent across outcomes. Differences in study

populations, intervention characteristics, outcome definitions, follow-up periods and statistical reporting limited direct comparisons. Meta-analysis was therefore not undertaken, and no pooled intervention effect was calculated. Outcome-specific findings are summarised in table 5.

Table 5: Summary of quantitative and qualitative evidence by outcome.

Outcome	Included studies	Summary of findings	Quantitative pooling
Sedentary behaviour	Pereira *et al.* [30]; Bailey *et al.* [31]; Alòs *et al.* [36]	Reported reductions in sedentary or sitting time and improvements in sitting breaks.	Not performed; findings were synthesised narratively.
Physical activity	Xu *et al.* , [29]; Highton *et al.* , [37]	Findings differed: Xu *et al.* reported improvement, whereas Highton *et al.* reported no significant long-term improvement in the principal outcome.	Findings differed: Xu *et al.* reported improvement, whereas Highton *et al.* reported no significant long-term improvement in the principal outcome.
HbA1c	Lim *et al.* [34]; Alòs *et al.* [36]; Highton *et al.* , [37]	Some studies reported improvements; findings were not consistent across studies and follow-up periods.	Some studies reported improvements; findings were not consistent across studies and follow-up periods.
Fasting blood glucose	Zongpa *et al.* [32]	Improvement was reported; the extracted estimate was based on a median change.	Not performed.
Glucose tolerance	Bailey *et al.* [31]	Improvement was reported following the intervention.	Improvement was reported following the intervention.
Lifestyle behaviour	Chen *et al.* [35]	Improvements in lifestyle behaviour and self-efficacy were reported.	Not performed.
Cardiometabolic outcomes	Pereira *et al.* [30]; Chen *et al.* [35]	Findings covered sitting-related and cardiometabolic or lifestyle-related outcomes; the specific outcome for each study should be stated precisely.	Not performed.
T2DM incidence	Sathish [33]	Report the exact effect estimate, comparator, and statistical significance as presented in the original study.	Not performed.

Note: MD, mean difference; HbA1c, glycated haemoglobin; T2DM, type 2 diabetes mellitus. The unadjusted mean differences for Pereira *et al.* (2020) and Lim *et al.* (2021) were calculated from the extracted post-intervention group means and should not be interpreted as adjusted estimates reported by the original studies.

3.6 Heterogeneity

The nine included studies showed substantial clinical and methodological heterogeneity. Populations ranged from adults with established T2DM to individuals at increased risk of the condition, including those with metabolic syndrome, a history of GDM and intermediate hyperglycaemia. Digital interventions also varied, encompassing smartphone applications, WeChat-based programmes, technology-supported workplace interventions and other mHealth-supported behavioural programmes. Intervention periods ranged from four weeks to 48 months [29–31, 33–35, 37].

The sedentary behaviours targeted and the outcomes used to evaluate intervention effects also varied. Target behaviours included occupational computer-based sitting, television viewing, home-based screen use, smartphone-related sitting and other forms of prolonged sedentary behaviour addressed by the interventions. Outcomes included sedentary time, sitting breaks, physical activity, HbA1c, fasting blood glucose, glucose tolerance, body weight, cardiometabolic risk and T2DM incidence [29–37].

Statistical heterogeneity was not quantified because no meta-analysis was conducted. Differences in intervention characteristics, outcome definitions, follow-up periods and statistical reporting, together with the lack of sufficiently comparable numerical data across outcome domains, precluded reliable quantitative pooling. Heterogeneity was therefore assessed descriptively by comparing the clinical and methodological characteristics of the included studies. These differences should be considered when interpreting the findings and their applicability across populations and settings.

3.7 Subgroup Analysis

Subgroup analyses by diabetes status, intervention modality, intervention duration and outcome type were planned in the review protocol [26, 27]. However, formal statistical subgroup analyses were not conducted because no meta-analysis was undertaken and insufficient comparable numerical data were available within the individual outcome categories.

The included studies involved diverse populations and intervention modalities, further limiting direct statistical comparisons. Differences between participants with established T2DM and those at increased risk, as well as differences among smartphone-based, workplace-based, WeChat-based and other mHealth interventions, were therefore explored descriptively. These comparisons were used to characterise variation across studies, not to establish differences in intervention effectiveness [29–35, 37].

3.8 Sensitivity Analysis

Sensitivity analysis was planned to assess the robustness of the findings, including the potential influence of studies with methodological limitations, as specified in the review protocol [27]. However, formal sensitivity analysis was not conducted because no quantitative meta-analysis was undertaken and pooled effect estimates could not be calculated.

The methodological quality of the included studies was assessed using the relevant JBI critical appraisal checklists. The potential implications of methodological limitations for the interpretation of the findings were therefore considered qualitatively rather than through formal sensitivity analysis methods, such as leave-one-out analysis.

3.9 Publication Bias

Publication bias was not formally assessed using funnel plots or Egger's regression test because no meta-analysis was conducted. Consequently, publication bias cannot be ruled out and should be considered when interpreting the findings.

3.10 Certainty of the Evidence

Several studies reported improvements in sedentary behaviour and selected behavioural or metabolic outcomes, including sedentary time, sitting breaks, physical activity, HbA1c, fasting blood glucose and lifestyle behaviour. However, findings were not consistent across all studies or outcome domains [29–35, 37]. For example, Highton *et al.* [37] reported no significant long-term improvement in the principal physical activity-related outcome.

The available evidence suggests that digital interventions targeting sedentary behaviour may offer benefits for adults with, or at risk of, T2DM. However, the consistency and generalisability of these findings remain uncertain. As no formal assessment of the certainty of the evidence was undertaken, the findings should be interpreted cautiously.

4 Discussion

This systematic review synthesised evidence on digital interventions targeting screen-based sedentary behaviour among adults with established T2DM or at increased risk of the condition. The interventions used a range of delivery modalities, including smartphone applications, mHealth platforms, WeChat-based programmes and technology-supported workplace strategies. Several incorporated behaviour change components such as self-monitoring, reminders, feedback, health education and goal setting [20, 36, 38, 39]. Overall, the findings suggest that digital interventions may help reduce sedentary behaviour and may be associated with improvements in selected physical activity, glycaemic, lifestyle and cardiometabolic outcomes. However, effects varied across studies, limiting conclusions about overall effectiveness.

The findings suggest that digital interventions may support reductions in sitting time and improvements in sedentary behaviour patterns. Pereira *et al.* [30] reported lower sitting time following the intervention, while Alòs *et al.* [36] reported reduced sedentary time. Bailey *et al.* [31] also reported an increase in sitting breaks. Taken together, these findings suggest that digital prompts and

behavioural support may help individuals recognise and interrupt prolonged sitting [14, 16, 22]. Similar findings have been reported in studies of interventions targeting sedentary behaviour among adults with T2DM and other chronic conditions [39–43]. Nevertheless, these results should be interpreted in light of differences in intervention approaches, outcome definitions, measurement methods and follow-up periods. Sedentary behaviour is a distinct behavioural outcome and should not be treated simply as the absence of physical activity.

Findings for physical activity were less consistent. Xu *et al.* [29] reported an improvement in physical activity, whereas Highton *et al.* [37] found no significant long-term improvement in the principal physical activity-related outcome. Variation in intervention intensity and duration, participant characteristics, personalisation and engagement may partly explain these differences. Importantly, reducing sedentary behaviour does not necessarily result in a corresponding increase in moderate-to-vigorous physical activity. Individuals may replace prolonged sitting with standing or light-intensity movement rather than structured exercise. Therefore, interventions designed to interrupt sedentary behaviour should not automatically be expected to produce equivalent improvements in overall physical activity [14, 44–46].

Findings for metabolic outcomes were also variable. Lim *et al.* [34] reported lower HbA1c values in the intervention group, while other included studies reported outcomes relating to fasting blood glucose, glucose tolerance, lifestyle behaviour and selected cardiometabolic indicators. These findings suggest potential benefits for selected metabolic outcomes; however, they do not establish a consistent metabolic effect across interventions. Comparisons are complicated by differences in baseline glycaemic status, participant risk profiles, intervention duration, outcome definitions, measurement procedures and follow-up periods. Moreover, changes in metabolic indicators may depend on the duration and sustainability of behavioural changes. Favourable findings from individual studies should therefore not be interpreted as evidence of a uniform or definitive metabolic benefit across digital interventions.

The potential benefits of digital interventions may depend not only on the delivery technology but also on the behaviour change strategies incorporated. Self-monitoring, reminders, feedback, education and goal setting were reported as components of several interventions. These strategies may support self-regulation by increasing awareness of sedentary behaviour, providing timely cues for change and enabling individuals to monitor progress towards behavioural goals. This interpretation is consistent with research highlighting the role of behaviour change techniques in mobile applications designed to support diabetes self-management [47–49]. However, because the included interventions differed in the combinations and implementation of these components, the independent contribution of each technique cannot be established from the available evidence.

The setting in which digital interventions are delivered may also influence their applicability. Workplace programmes can address occupational sitting in environments where prolonged computer use is common, whereas smartphone-based interventions can deliver prompts and facilitate self-monitoring across different daily contexts [50–53]. Other digital approaches, including web-based platforms and activity trackers, may offer additional opportunities for behavioural feedback and goal-oriented support [50–52]. Nevertheless, their practical benefits may depend on accessibility, participant engagement, implementation context and sustained use. Comparative research is needed to determine which delivery modalities are most suitable for particular populations and settings.

Heterogeneity across the included studies is an important consideration when interpreting this review. Differences in participant populations, intervention modalities, behavioural targets, intervention duration, outcome definitions, measurement methods and follow-up periods limited direct comparisons. Incomplete reporting of numerical data and measures of variance also restricted quantitative synthesis. The findings were therefore synthesised narratively rather than statistically pooled. They should be interpreted as a summary of results across different intervention contexts, not as an estimate of a single common intervention effect. The average magnitude of benefit across interventions could not be established from the available data [54–56].

From a clinical and public health perspective, digital interventions may provide an additional means of supporting diabetes prevention and management by delivering repeated prompts, self-monitoring, feedback and reinforcement of behavioural goals between clinical encounters. These

approaches may complement face-to-face health education and lifestyle counselling. However, digital interventions should be regarded as adjuncts rather than substitutes for comprehensive diabetes prevention and management. Implementation should be integrated with established approaches to physical activity, dietary management, lifestyle modification and appropriate clinical care [57–59].

This review has several strengths. First, it focused specifically on screen-based sedentary behaviour rather than digital health interventions for diabetes more broadly. Second, the search covered six major databases, and study selection and data extraction were undertaken independently by three reviewers. Third, methodological quality was assessed using JBI critical appraisal tools appropriate to the included study designs. Finally, the decision not to pool results when the available data were insufficiently comparable avoided producing a potentially misleading summary estimate from heterogeneous studies. These features support a structured synthesis of the available evidence, although they do not eliminate limitations in the underlying studies.

Several limitations should also be acknowledged. Clinical and methodological heterogeneity limited direct comparisons of intervention effects. Incomplete statistical reporting, particularly the absence of some measures of variance, restricted quantitative synthesis. Differences in study design also affected the strength of causal inferences that could be drawn. In addition, methodological limitations identified through critical appraisal may have influenced the reliability of individual study findings. Publication bias could not be formally assessed because no meta-analysis was conducted and the available study estimates were insufficient for a meaningful statistical assessment. These limitations should be considered when interpreting the consistency, precision and generalisability of the findings.

Future research should prioritise adequately powered RCTs with clearly defined sedentary behaviour targets and standardised outcome measures. Where feasible, objective measures of sedentary behaviour should complement self-reported data. Researchers should also report the specific behaviour change techniques used, their frequency and intensity, and participants' engagement with the intervention [18, 60–62]. More complete statistical reporting is needed, including group-specific means, standard deviations, change scores, effect estimates and corresponding confidence intervals. Longer follow-up periods would help establish whether reductions in sedentary behaviour are sustained and whether sustained behavioural changes translate into clinically meaningful metabolic benefits. Future studies should also investigate which intervention components and delivery contexts are associated with better outcomes.

Overall, digital interventions targeting screen-based sedentary behaviour may help reduce sedentary time and support improvements in selected behavioural and metabolic outcomes among adults with T2DM or at increased risk of developing the condition. However, variation across interventions and the limited availability of comparable quantitative data prevent definitive conclusions about their overall effectiveness. Behaviour change strategies, including reminders, self-monitoring, feedback and goal setting, may contribute to these potential benefits, although their independent effects remain uncertain. Further rigorous research is needed to establish the effectiveness, sustainability and applicability of these interventions across populations and settings.

5 Conclusions

Digital interventions targeting screen-based sedentary behaviour may help reduce sedentary or sitting time and improve selected behavioural and metabolic outcomes among adults with, or at risk of, T2DM. Interventions incorporating behaviour change strategies such as reminders, self-monitoring, feedback and goal setting appear promising; however, the available evidence does not establish a definitive overall intervention effect.

Substantial heterogeneity in participant populations, intervention characteristics, outcome measures and follow-up periods, together with incomplete numerical reporting, precluded quantitative pooling and limited the certainty of the findings. Future research should prioritise adequately powered RCTs, standardised measures of sedentary behaviour, clearly specified behaviour change components, longer follow-up and complete reporting of effect estimates and measures of variability. These improvements would strengthen the evidence base and facilitate robust future meta-analyses.

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References

[1] International Diabetes Federation, *International Diabetes Federation Diabetes Atlas*, 10th ed. Brussels, Belgium: International Diabetes Federation, 2021. [Online]. Available: https://diabetesatlas.org/.

[2] M. S. Tremblay *et al.* , "Sedentary behavior research network (SBRN)—Terminology consensus project process and outcome," *International Journal of Behavioral Nutrition and Physical Activity*, vol. 14, no. 1, p. 75, Jun. 2017, doi: 10.1186/s12966-017-0525-8.

[3] N. Owen, G. N. Healy, C. E. Matthews, and D. W. Dunstan, "Sedentary behavior and public health: Integrating the evidence and identifying potential solutions," *Annual Review of Public Health*, vol. 41, pp. 265–287, Apr. 2020, doi: 10.1146/annurev-publhealth-040119-094201.

[4] G. Moschonis *et al.* , "Effectiveness, reach, uptake, and feasibility of digital health interventions for adults with type 2 diabetes: A systematic review and meta-analysis of randomised controlled trials," *The Lancet Digital Health*, vol. 5, no. 3, pp. e125–e143, Mar. 2023, doi: 10.1016/S2589-7500(22)00233-3.

[5] B. Singh *et al.* , "A systematic umbrella review and meta-meta-analysis of eHealth and mHealth interventions for improving lifestyle behaviours," *Nature Partner Journals Digital Medicine*, vol. 7, p. 179, 2024, doi: 10.1038/s41746-024-01172-y.

[6] U. Ekelund *et al.* , "Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: Systematic review and harmonised meta-analysis," *British Medical Journal*, vol. 366, p. l4570, Aug. 2019, doi: 10.1136/bmj.l4570.

[7] F. C. Bull *et al.* , "World Health Organization 2020 guidelines on physical activity and sedentary behaviour," *British Journal of Sports Medicine*, vol. 54, no. 24, pp. 1451–1462, Dec. 2020, doi: 10.1136/bjsports-2020-102955.

[8] N. T. Hadgraft *et al.* , "Effects of sedentary behaviour interventions on biomarkers of cardiometabolic risk in adults: Systematic review with meta-analyses," *British Journal of Sports Medicine*, vol. 55, no. 3, pp. 144–154, Feb. 2021, doi: 10.1136/bjsports-2019-101154.

[9] R. Patterson *et al.* , "Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: A systematic review and dose-response meta-analysis," *European Journal of Epidemiology*, vol. 33, no. 9, pp. 811–829, 2018, doi: 10.1007/s10654-018-0380-1.

[10] T. Fredensborg Holm *et al.* , "The effectiveness of digital health lifestyle interventions on weight loss in people with prediabetes: A systematic review, meta-analysis, and meta-regression," *Journal of Diabetes Science and Technology*, vol. 20, no. 2, pp. 419–435, Mar. 2026, doi: 10.1177/19322968241292646.

[11] M. Stowell, R. Dobson, K. Garner, M. Baig, N. Nehren, and R. Whittaker, "Digital interventions for self-management of prediabetes: A scoping review," *Public Library of Science ONE*, vol. 19, no. 5, p. e0303074, 2024, doi: 10.1371/journal.pone.0303074.

[12] T. J. Saunders, H. F. Atkinson, J. Burr, B. MacEwen, C. M. Skeaff, and M. C. Peddie, "The acute metabolic and vascular impact of interrupting prolonged sitting: A systematic review and meta-analysis," *Sports Medicine*, vol. 48, no. 10, pp. 2347–2366, Oct. 2018, doi: 10.1007/s40279-018-0963-8.

[13] C. M. Ng, W. L. Cheong, C. W. Chong, S. L. Teoh, W. S. Yap, and S. W. H. Lee, "Digital technologies for prediabetes: A systematic review and meta-analysis," *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, vol. 19, no. 2, p. 103206, Feb. 2025, doi: 10.1016/j.dsx.2025.103206.

[14] D. Kerr, D. Ahn, K. Waki, J. Wang, B. Breznen, and D. C. Klonoff, "Digital interventions for self-management of type 2 diabetes mellitus: Systematic literature review and meta-analysis," *Journal of Medical Internet Research*, vol. 26, p. e55757, Jul. 2024, doi: 10.2196/55757.

[15] A. Stephenson, S. M. McDonough, M. H. Murphy, C. D. Nugent, and J. L. Mair, "Using computer, mobile and wearable technology enhanced interventions to reduce sedentary behaviour: A systematic review and meta-analysis," *International Journal of Behavioral Nutrition and Physical Activity*, vol. 14, no. 1, p. 105, Aug. 2017, doi: 10.1186/s12966-017-0561-4.

[16] Y. Zhang, F. W. Ngai, Q. Yang, and Y. J. Xie, "Effectiveness of digital health interventions on sedentary behavior among patients with chronic diseases: Systematic review and meta-analysis," *Journal of Medical Internet Research mHealth and uHealth*, vol. 13, p. e59943, Jun. 2025, doi: 10.2196/59943.

[17] N. C. Barengo *et al.* , "Mobile health technology in the primary prevention of type 2 diabetes: A systematic review," *Current Diabetes Reports*, vol. 22, no. 1, pp. 1–10, Jan. 2022, doi: 10.1007/s11892-021-01445-w.

[18] T. Duong *et al.* , "Digital health interventions to prevent type 2 diabetes mellitus: Systematic review," *Journal of Medical Internet Research*, vol. 27, p. e67507, Apr. 2025, doi: 10.2196/67507.

[19] C. Gomez-Garcia, C. A. Maher, B. Sañudo, and J. M. Jurado-Castro, "Mobile health interventions for individuals with type 2 diabetes and overweight or obesity—A systematic review and meta-analysis," *Journal of Functional Morphology and Kinesiology*, vol. 10, no. 3, p. 292, Jul. 2025, doi: 10.3390/jfmk10030292.

[20] Q. He, X. Zhao, Y. Wang, Q. Xie, and L. Cheng, "Effectiveness of smartphone application-based self-management interventions in patients with type 2 diabetes: A systematic review and meta-analysis of randomized controlled trials," *Journal of Advanced Nursing*, vol. 78, no. 2, pp. 348–362, Feb. 2022, doi: 10.1111/jan.14993.

[21] D. E. Nkhoma *et al.* , "Digital interventions self-management education for type 1 and 2 diabetes: A systematic review and meta-analysis," *Computer Methods and Programs in Biomedicine*, vol. 210, p. 106370, Oct. 2021, doi: 10.1016/j.cmpb.2021.106370.

[22] X. Zhang, X. Qiao, K. Peng, S. Gao, and Y. Hao, "Digital behavior change interventions to reduce sedentary behavior and promote physical activity in adults with diabetes: A systematic review and meta-analysis of randomized controlled trials," *International Journal of Behavioral Medicine*, vol. 31, no. 6, pp. 959–973, Dec. 2024, doi: 10.1007/s12529-023-10188-9.

[23] V. Nguyen, P. Ara, D. Simmons, and U. L. Osuagwu, "The role of digital health technology interventions in the prevention of type 2 diabetes mellitus: A systematic review," *Clinical Medicine Insights: Endocrinology and Diabetes*, vol. 17, p. 11795514241246419, 2024, doi: 10.1177/11795514241246419.

[24] S. Smith, B. Salmani, J. LeSarge, K. Dillon-Rossiter, A. Morava, and H. Prapavessis, "Interventions to reduce sedentary behaviour in adults with type 2 diabetes: A systematic review and meta-analysis," *Public Library of Science ONE*, vol. 19, no. 7, p. e0306439, 2024, doi: 10.1371/journal.pone.0306439.

[25] M. J. Page *et al.* , "The PRISMA 2020 statement: An updated guideline for reporting systematic reviews," *British Medical Journal*, vol. 372, p. n71, Mar. 2021, doi: 10.1136/bmj.n71.

[26] E. Aromataris, C. Lockwood, K. Porritt, B. Pilla, and Z. Jordan, Eds., *Joanna Briggs Institute Manual for Evidence Synthesis*. JBI, 2024, doi: 10.46658/JBIMES-24-01. [Online]. Available: https://synthesismanual.jbi.global/

[27] J. P. T. Higgins *et al.* , Eds., *Cochrane Handbook for Systematic Reviews of Interventions*, 2nd ed. Chichester, U.K.: John Wiley & Sons, 2019, doi: 10.1002/9781119536604.

[28] G. H. Guyatt *et al.* , "GRADE: An emerging consensus on rating quality of evidence and strength of recommendations," *British Medical Journal*, vol. 336, no. 7650, pp. 924–926, Apr. 2008, doi: 10.1136/bmj.39489.470347.AD.

[29] Z. Xu *et al.* , "A mobile-based intervention for dietary behavior and physical activity change in individuals at high risk for type 2 diabetes mellitus: Randomized controlled trial," *Journal of Medical Internet Research mHealth and uHealth*, vol. 8, no. 11, p. e19869, Nov. 2020, doi: 10.2196/19869.

[30] M. A. Pereira *et al.* , "Efficacy of the 'Stand and Move at Work' multicomponent workplace intervention to reduce sedentary time and improve cardiometabolic risk: A group randomized clinical trial," *International Journal of Behavioral Nutrition and Physical Activity*, vol. 17, p. 133, Oct. 2020, doi: 10.1186/s12966-020-01033-3.

[31] D. P. Bailey, L. H. Mugridge, F. Dong, X. Zhang, and A. M. Chater, "Randomised controlled feasibility study of the MyHealthAvatar-Diabetes smartphone app for reducing prolonged sitting time in type 2 diabetes mellitus," *International Journal of Environmental Research and Public Health*, vol. 17, no. 12, p. 4414, Jun. 2020, doi: 10.3390/ijerph17124414.

[32] T. C. Zongpa, B. Chandrasekaran, and A. Arumugam, "Effectiveness of a smartphone directed physical activity program on cardiometabolic disease risk in desk-based office employees—A pragmatic, two-arm, parallel, cluster randomised trial," *Muscles, Ligaments and Tendons Journal*, vol. 10, no. 4, pp. 713–723, 2020, doi: 10.32098/mltj.04.2020.19.

[33] T. Sathish, "Diabetes prevention and lifestyle intervention in resource-limited settings," *The Lancet Diabetes & Endocrinology*, vol. 7, no. 3, pp. 165–167, Mar. 2019, doi: 10.1016/S2213-8587(19)30027-0.

[34] S. L. Lim *et al.* , "Effect of a smartphone app on weight change and metabolic outcomes in Asian adults with type 2 diabetes: A randomized clinical trial," *Journal of the American Medical Association Network Open*, vol. 4, no. 6, p. e2112417, Jun. 2021, doi: 10.1001/jamanetworkopen.2021.12417.

[35] D. Chen *et al.* , "Effects of an individualized mHealth-based intervention on health behavior change and cardiovascular risk among people with metabolic syndrome based on the behavior change wheel: Quasi-experimental study," *Journal of Medical Internet Research*, vol. 25, p. e49257, Nov. 2023, doi: 10.2196/49257.

[36] F. Alòs *et al.* , "Impact of a primary care-based mobile health intervention to 'sit less and move more' on HbA1c, blood pressure, and other clinical outcomes in office employees with type 2 diabetes: A randomized controlled trial," *Primary Care Diabetes*, vol. 19, no. 5, pp. 434–445, Oct. 2025, doi: 10.1016/j.pcd.2025.05.010.

[37] P. J. Highton *et al.* , "Structured group education programme and accompanying mHealth intervention to promote physical activity in women with a history of gestational diabetes (Baby Steps): 4-year follow-up of a randomised controlled trial," *Diabetes, Obesity and Metabolism*, vol. 28, no. 1, pp. 754–758, Jan. 2026, doi: 10.1111/dom.70199.

[38] Y. Mao, W. Lin, J. Wen, and G. Chen, "Impact and efficacy of mobile health intervention in the management of diabetes and hypertension: A systematic review and meta-analysis," *British Medical Journal Open Diabetes Research & Care*, vol. 8, no. 1, p. e001225, Sep. 2020, doi: 10.1136/bmjdrc-2020-001225.

[39] H. Xue *et al.* , "The effectiveness of digital health intervention on glycemic control and physical activity in patients with type 2 diabetes: A systematic review and meta-analysis," *Frontiers in Digital Health*, vol. 7, p. 1630588, Jul. 2025, doi: 10.3389/fdgth.2025.1630588.

[40] M. Kitazawa *et al.* , "Lifestyle intervention with smartphone app and isCGM for people at high risk of type 2 diabetes: Randomized trial," *The Journal of Clinical Endocrinology & Metabolism*, vol. 109, no. 4, pp. 1060–1070, Apr. 2024, doi: 10.1210/clinem/dgad639.

[41] M. L. Brierley *et al.* , "The Regulate your Sitting Time (RESIT) intervention for reducing sitting time in individuals with type 2 diabetes: findings from a randomised-controlled feasibility trial," *Diabetology & Metabolic Syndrome*, vol. 16, p. 87, Apr. 2024, doi: 10.1186/s13098-024-01336-6.

[42] R. Tarricone, F. Petracca, L. Svae, M. Cucciniello, and O. Ciani, "Which behaviour change techniques work best for diabetes self-management mobile apps? Results from a systematic review and meta-analysis of randomised controlled trials,"

eBioMedicine, vol. 103, p. 105091, May 2024, doi: 10.1016/j.ebiom.2024.105091.

[43] I. Parés-Salomón *et al.* , "Effectiveness of workplace interventions with digital elements to reduce sedentary behaviours in office employees: A systematic review and meta-analysis," *International Journal of Behavioral Nutrition and Physical Activity*, vol. 21, no. 1, p. 41, Apr. 2024, doi: 10.1186/s12966-024-01595-6.

[44] C. M. Ng, K. W. Teoh, C. W. Chong, Y. L. Ng, J. S. Bell, and S. W. H. Lee, "A digital health-supported Prediabetes Intervention, Management and Evaluation (PRIME) Program improves Healthy Eating Index score: A cluster randomized controlled trial," *Nutrition Research*, vol. 138, pp. 151–161, Jun. 2025, doi: 10.1016/j.nutres.2025.04.005.

[45] A. J. Buffey, M. P. Herring, C. K. Langley, A. E. Donnelly, and B. P. Carson, "The acute effects of interrupting prolonged sitting time in adults with standing and light-intensity walking on biomarkers of cardiometabolic health: A systematic review and meta-analysis," *Sports Medicine*, vol. 52, no. 8, pp. 1765–1787, 2022, doi: 10.1007/s40279-022-01649-4.

[46] S. M. Dsouza *et al.* , "Effect of digital health interventions on glycaemic control among type 2 diabetes individuals in low- and middle-income countries: A systematic review and meta-analysis," *BioMed Central Public Health*, vol. 26, no. 1, p. 2340, Jun. 2026, doi: 10.1186/s12889-026-27908-x.

[47] M. Alsahli, A. Abd-Alrazaq, M. Househ, S. Konstantinidis, and H. Blake, "The effectiveness of mobile phone messaging-based interventions to promote physical activity in type 2 diabetes mellitus: Systematic review and meta-analysis," *Journal of Medical Internet Research*, vol. 24, no. 3, p. e29663, Mar. 2022, doi: 10.2196/29663.

[48] K. Liu, Z. Xie, and C. K. Or, "Effectiveness of mobile app-assisted self-care interventions for improving patient outcomes in type 2 diabetes and/or hypertension: Systematic review and meta-analysis of randomized controlled trials," *Journal of Medical Internet Research mHealth and uHealth*, vol. 8, no. 8, p. e15779, Aug. 2020, doi: 10.2196/15779.

[49] S. Hangaard *et al.* , "The effectiveness of telemedicine solutions for the management of type 2 diabetes: A systematic review, meta-analysis, and meta-regression," *Journal of Diabetes Science and Technology*, vol. 17, no. 3, pp. 794–825, May 2023, doi: 10.1177/19322968211064633.

[50] N. Alfarwan, A. Hodkinson, M. Panagioti, L. Hassan, and E. Kontopantelis, "Clinical and cost-effectiveness of telemedicine among patients with type 2 diabetes in primary care: A systematic review and meta-analysis," *Diabetic Medicine*, vol. 41, no. 8, p. e15343, Aug. 2024, doi: 10.1111/dme.15343.

[51] B. M. F. M. Duvivier *et al.* , "Breaking sitting with light activities vs structured exercise: A randomised crossover study demonstrating benefits for glycaemic control and insulin sensitivity in type 2 diabetes," *Diabetologia*, vol. 60, no. 3, pp. 490–498, Mar. 2017, doi: 10.1007/s00125-016-4161-7.

[52] H. Alaslawi, I. Berrou, A. Al Hamid, D. Alhuwail, and Z. Aslanpour, "Diabetes self-management apps: Systematic review of adoption determinants and future research agenda," *Journal of Medical Internet Research Diabetes*, vol. 7, no. 3, p. e28153, Jul. 2022, doi: 10.2196/28153.

[53] E. K. Kim *et al.* , "The effect of a smartphone-based, patient-centered diabetes care system in patients with type 2 diabetes: A randomized, controlled trial for 24 weeks," *Diabetes Care*, vol. 42, no. 1, pp. 3–9, Jan. 2019, doi: 10.2337/dc17-2197.

[54] K. Yamamoto *et al.* , "Can self-monitoring mobile health apps reduce sedentary behavior? A randomized controlled trial," *Journal of Occupational Health*, vol. 62, no. 1, p. e12159, Jan. 2020, doi: 10.1002/1348-9585.12159.

[55] B. S. Gerber *et al.* , "Mobile health intervention in patients with type 2 diabetes: A randomized clinical trial," *Journal of the American Medical Association Network Open*, vol. 6, no. 9, p. e2333629, Sep. 2023, doi: 10.1001/jamanetworkopen.2023.33629.

[56] H. Oinas-Kukkonen and M. Harjumaa, "Persuasive systems design: Key issues, process model, and system features," *Communications of the Association for Information Systems*, vol. 24, no. 1, pp. 485–500, 2009, doi: 10.17705/1CAIS.02428.

[57] R. Warren, K. Carlisle, G. Mihala, and P. A. Scuffham, "Effects of telemonitoring on glycaemic control and healthcare costs in type 2 diabetes: A randomised controlled trial," *Journal of Telemedicine and Telecare*, vol. 24, no. 9, pp. 586–595, Oct. 2018, doi: 10.1177/1357633X17723943.

[58] M. J. Crowley *et al.* , "Effect of a comprehensive telehealth intervention vs telemonitoring and care coordination in patients with persistently poor type 2 diabetes control: A randomized clinical trial," *Journal of the American Medical Association Internal Medicine*, vol. 182, no. 9, pp. 943–952, Sep. 2022, doi: 10.1001/jamainternmed.2022.2947.

[59] T. L. Webb, J. Joseph, L. Yardley, and S. Michie, "Using the internet to promote health behavior change: A systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy," *Journal of Medical Internet Research*, vol. 12, no. 1, p. e4, Feb. 2010, doi: 10.2196/jmir.1376.

[60] S. Michie *et al.* , "The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions," *Annals of Behavioral Medicine*, vol. 46, no. 1, pp. 81–95, Aug. 2013, doi: 10.1007/s12160-013-9486-6.

[61] S. M. Kelders, R. N. Kok, H. C. Ossebaard, and J. E. W. C. Van Gemert-Pijnen, "Persuasive system design does matter: A systematic review of adherence to web-based interventions," *Journal of Medical Internet Research*, vol. 14, no. 6, p. e152, Nov. 2012, doi: 10.2196/jmir.2104.

[62] A. O. Alsayed, N. A. Ismail, L. Hasan, A. H. Syed, F. Embarak, and A. Da'u, "A systematic literature review for understanding the effectiveness of advanced techniques in diabetes self-care management," *Alexandria Engineering Journal*, vol. 79, pp. 274–295, Sep. 2023, doi: 10.1016/j.aej.2023.08.026.