

Effectiveness of mobile health interventions on management of patients with hypertension: a systematic review of systematic reviews[†]



Review

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Abstract: **Objective:** To systematically evaluate the effectiveness of mobile health (mHealth) interventions on self-management and blood pressure (BP) control in patients with hypertension and to provide recommendations for the clinic and future research.
Methods: Databases including Embase, Cochrane Library, CINAHL, CNKI, SinoMed, Wanfang, and Weipu were searched to collect systematic reviews (SRs) and meta-analyses on mHealth interventions for hypertension management. Two researchers independently screened the articles and extracted data, and the Assessment of Multiple Systematic Reviews (AMSTAR 2) was used to evaluate the methodological quality of the included reviews.
Results: A total of 11 SRs were included: 1 review was rated as high quality, 3 as low quality, and 7 as critically low quality. The mobile phone was the most common intervention type, followed by the internet. Seven reviews performed meta-analyses and showed that mHealth was associated with a significant reduction in systolic blood pressure (SBP), from 2.28 mmHg (95%CI -3.90 to -0.66; $I^2 = 40\%$) to 14.77 mmHg (95%CI 11.76–17.77; $I^2 = 89.7\%$), and diastolic blood pressure (DBP), from 1.50 mmHg (95%CI -2.20 to -0.08; $I^2 = 62\%$) to 8.17 mmHg (95%CI 5.67–10.67; $I^2 = 86\%$). Self-management behaviors included medication adherence (MA), diet, smoking, alcohol drinking, physical activity, and BP monitoring. There were inconsistent results on the effectiveness of mHealth interventions.
Conclusions: mHealth interventions can improve BP control, MA, diet, and smoking in patients with hypertension, but the evidence for the efficacy of mHealth on physical activity and alcohol drinking improvement is limited. The methodological quality of existing SRs on the management of BP in patients with hypertension was relatively low, and more well-designed SRs or meta-analyses were needed to provide more evidence. mHealth interventions are useful for improving BP control of patients with hypertension.

Keywords: blood pressure • hypertension • mobile health • self-management • smartphone • systematic review

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1. Introduction

Hypertension is the most common chronic disease, with a prevalence of 31.1% among adults globally.¹ Its main complications, including stroke, myocardial infarction, heart failure, and chronic kidney disease, are not only disabling but also associated with high mortality rates, placing a significant burden on families and society.^{2,3} The annual worldwide economic cost of hypertension is estimated at US \$370 billion.³ Hypertension has already become a global public health problem. Evidence has shown that hypertension can be prevented and controlled.⁴ However, blood pressure (BP) control in hypertensive patients is not suboptimal.⁵ Hypertension affects 31.1% of adults in the world, with 28% achieving control in high-income countries and 8% in low-and middle-income countries.¹ Effective BP control depends on the patient's good self-management.⁶ Self-management was defined as the capability of individuals to manage their health conditions, with or without the support of a health care provider.⁷ The scope of self-management includes education for patients, self-monitoring of clinical data and behaviors (diet, exercise, smoking, and drinking), self-titration of medical management, and support for medication adherence (MA) as prescribed regimes.⁸ Evidence showed that effective interactions between healthcare providers and patients can improve patients' awareness of BP control and self-management.⁹ In recent years, with the rapid development of wireless communication technology and the popularization of mobile phones, mobile health (mHealth) has provided a powerful platform for healthcare providers and patients to implement personalized medical services and convenient communication.¹⁰ Mobile health refers to medical and public healthcare practices supported by mobile devices, such as mobile phones and smartphones, client-monitoring devices, personal digital assistants (PDAs), and tablets.¹¹ In recent years, mHealth has provided healthcare providers and patients with tools to improve the self-management of hypertension, such as health information networks, electronic health records, remote medical services, and wearable devices for BP monitoring.¹² Mobile health employs various features, such as text messages, emails, phone calls, and mobile phone applications.¹³ Over the past decade, the family remote BP self-measurement has shown a good effect in the management of hypertension.^{14–16} With advancements in internet technology, some studies have reported the effectiveness of wireless network real-time data transmission, mobile phones, and web applications to provide decision support for self-management of hypertensive patients.^{17–19} Some previous systematic reviews (SRs) evaluated the effectiveness of mobile health on hypertension management; however, different SRs differed in intervention

measures, outcome indicators, and effects.^{6,20–22} Two SRs conducted meta-analysis and found that mHealth reduced BP.^{6,20} As for self-management, 1 study reported positive effects on both physical activity and diet,⁶ while another SR showed no difference between mHealth and conventional interventions.²² There were inconsistent findings on the effectiveness of mHealth. Therefore, it is necessary to conduct a SR of SRs to determine the effects of mHealth interventions on hypertension and to provide decision support for clinical practice.

2. Methods

2.1. Search strategy

Embase, Cochrane Library, China National Knowledge Infrastructure (CNKI), SinoMed, Wanfang, and Weipu databases were searched from inception to 9 November 2020. The search was restricted to studies in humans and publication language (English and Chinese). A keyword search was carried out using the terms “hypertension”; “mobile health” or “mobile” or “tele*” or “app*” or “smartphone” or “short message service”; “systematic review” or “meta-analysis.” Reference lists of included SRs were searched to ensure the comprehensiveness of the search.

2.2. Inclusion and exclusion criteria

Inclusion criteria were (1) a systematic review and/or meta-analysis published in English or Chinese; (2) a SR based on randomized controlled trials (RCTs) or quasi-experimental research design; (3) studies that included adult hypertensive patients; (4) studies focusing on the effect of mHealth interventions on the management of hypertension; and (5) studies where the main outcomes included BP and self-management behaviors.

Exclusion criteria were (1) SR plans, (2) repeated publications, and (3) meeting abstracts or documents for which the full text cannot be obtained.

2.3. Study selection and data extraction

Two researchers independently screened the title, abstract, and full text according to the inclusion and exclusion criteria and independently extracted data from the included studies using a unified table. The following data were extracted: the first author, publication year, journal, databases searched, study design, number of studies and patients, intervention measures of the intervention group and control group, target function of intervention delivery by mHealth, duration of follow-up, outcomes, main results, conclusions, and limitations. If there was a disagreement during study selection and

data extraction, a third researcher was involved to discuss the dispatcher to reach an agreement.

2.4. Quality assessment

Two researchers independently used the Assessment of Multiple Systematic Reviews (AMSTAR 2) checklist²³ to evaluate the methodological quality of the included SRs. AMSTAR 2 is not intended to generate an overall score. Seven critical domains were considered when grading the quality of the SR (Q2, Q4, Q7, Q9, Q11, Q13, and Q15). The quality of included SRs was classified as high quality (no or one non-critical weakness), moderate quality (more than one non-critical weakness), low quality (one critical flaw with or without non-critical

weaknesses), or critically low quality (more than one critical flaw with or without non-critical weaknesses).²³

3. Results

3.1. Study selection

A total of 268 articles were obtained in the first search, and 207 articles remained after excluding duplicates. Of these, 173 articles that were inconsistent with the study theme were excluded by screening title and abstract. The full text of 34 eligible articles was reviewed. Of these, 23 were excluded for not meeting the criteria, and 11 were included in our study, with 1 study identified from the reference list (Figure 1).

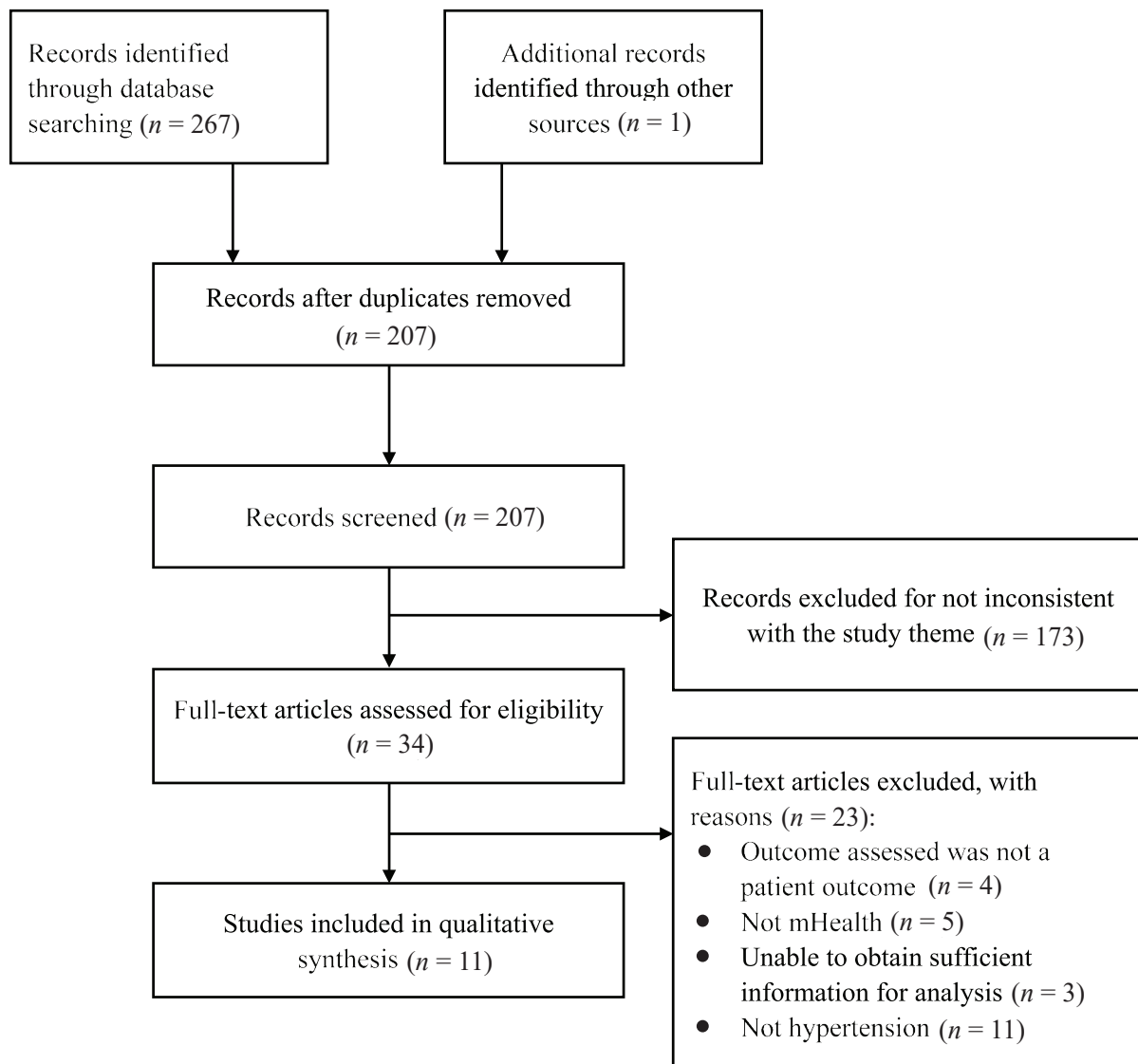


Figure 1. Flowchart of searching and selection process.

3.2. Main characteristics of included reviews

The characteristics of the included 11 reviews are summarized in Table 1. All reviews were published between 2011 and 2020. Eight reviews were published in English and 3 in Chinese. As for the study design, 8 reviews were based on RCTs, and 3 were based on RCT and quasi-experimental trials. The mHealth interventions mainly focused on the use of mobile phones and the internet to assist disease self-management by monitoring BP, transmitting information, and counseling. The mobile phone was the most common intervention type (9 reviews), followed by the internet (5 reviews). Regarding the main target function of the mHealth intervention, self-management of hypertension was the most common (9 reviews), followed by BP monitoring (2 reviews), MA (2 reviews), BP control (1 review), feedback (1 review), and counseling (1 review). All reviews reported BP as the main outcome indicator. Six reviews evaluated MA, and 4 assessed self-management behaviors. Regarding the methodological quality assessment for primary studies, 6 reviews used the Cochrane Collaboration's tool for assessing the risk of bias (RoB), 1 used the Jadad scale, and 5 did not conduct a quality assessment. Due to the heterogeneity in original studies, only 7 reviews conducted a meta-analysis.

3.3. Quality of included reviews

Based on AMSTAR 2 criteria, 1 SRs was rated as high quality, 3 as low quality, and 7 as critically low quality (Table 2).

3.4. Effects of mHealth on the management of hypertension

Results of the 11 reviews on the effects of mHealth are summarized in Table 3.

3.4.1. BP

All 11 reviews reported BP. Ten reviews reported systolic blood pressure (SBP) and diastolic blood pressure (DBP). Four SRs conducted a qualitative synthesis due to heterogeneity: 3 reviews showed large improvements (more than half of the included studies)^{21,26,27} and 1 review showed low improvements (less than half of the included studies).²⁹ Seven reviews performed meta-analysis.^{7,21,23–25,30,31} The results of these 7 reviews have consistently showed that mHealth was associated with a significant reduction in SBP, from 2.28 mmHg (95%CI -3.90 to -0.66; $I^2 = 40\%$)²² to 14.77 mmHg (95%CI 11.76–17.77; $I^2 = 89.7\%$),²⁵ and DBP, from 1.50 mmHg (95%CI -2.20 to -0.80; $I^2 = 62\%$)²⁴ to 8.17 mmHg (95%CI 5.67–10.67; $I^2 = 86\%$).²⁵ One of the

studies showed that although BP can be lowered, remote BP monitoring was not superior to conventional care in avoiding cardiovascular events.²⁰

3.4.2. Self-management behaviors

MA

Five reviews assessed the effects of mHealth intervention on MA and reported inconsistent results. One Chinese study conducted a meta-analysis and showed that internet-based education improved MA (RD = 0.29, 95%CI [0.24–0.34]; $I^2 = 82\%$).²⁸ Xu et al.²² found that MA demonstrated a significant effect in favor of the intervention group (SMD = 0.38, 95%CI [0.26–0.50]; $I^2 = 0\%$). Li et al.⁶ showed that more than half of the studies improved the MA. Jamshidnezhad et al.²¹ showed that 3 of the 4 studies reported improvements in MA, whereas only one study showed significant effects. Xiong et al.²⁷ showed that 12 of the 21 studies found significant improvements in the level of MA, while 10 of the 12 studies were not statistically significant.

Diet

Two reviews explored the effects of mobile phone and internet-based interventions on patients' diet management, and both showed positive effects.^{6,28} A meta-analysis showed that internet-based education was superior to regular health education in diet management (RD = 0.32, 95%CI [0.26–0.38], $P < 0.01$; $I^2 = 79\%$).²⁸

Smoking and drinking

One review showed that mobile applications had a significant effect on reducing smoking, while there was no statistically significant effect on patients' alcohol consumption.²¹

Exercise

Two reviews studied the effects of mobile phone and internet-based interventions on patients' exercise status, and both showed a positive effect.^{6,28} A meta-analysis showed that internet-based education was better than regular health education in regular exercise with high heterogeneity (RD = 0.29, 95%CI [0.22–0.36], $P < 0.01$; $I^2 = 84\%$).²⁸ While another study did not show a statistically significant effect of the intervention (SMD = 0.13, 95%CI (-0.11 to 0.37).²²

BP monitoring

One review showed that internet-based education was better than regular health education in BP

First author (year)	Journal	Country	Databases	Type of study included	No. of included studies	Range of year of publication	No. of patients	Intervention (target function)	Duration (months)	Outcomes measures	Meta-analysis	Quality assessment
Xu and Long (2020) ²²	JMIR mHealth Uhealth	N/A	MEDLINE, Embase, PubMed, Cochrane Library databases	RCT	8	2012–2020	1657	Mobile phone apps (self-management)	1.5–18	SBP, DBP, MA, physical activity	Y (mHealth favors)	RoB
Li et al. (2020) ¹⁸	JMIR mHealth Uhealth	USA (11), Canada (3), Spain (1), Iran (1), UK (3), Honduras and Mexico (1), Korea (1), China (1), South Africa (1), Chile (1)	PubMed, Embase, Web of Science, Cochrane, Google Scholar	RCT	24	2010–2019	8933	App-based tools that are accessible via mobile phone or tablet (self-management)	1.5–18	SBP, DBP, MA, self-management behavior, cost	Y (mHealth favors)	RoB
Choi et al. (2020) ²⁰	Telemed J E Health	USA (14), Italy (2), Spain (1), Denmark (2), UK (1), South Korea (3), Canada (1), Germany (1), Argentina, Guatemala, Peru (1), Finland (1)	Embase, EBSCOhost, the Cochrane Library, ProQuest, Medline	RCT	27	1996–2017	9435	Telephone, internet, mobile phones, and letters (remote monitoring of BP)	3–13	SBP, DBP, the target BP achievement rate	Y (mHealth favors)	RoB
Jamshidnezhad et al. (2019) ²¹	Acta Inform Med	USA (3), Sweden (1), Vietnam (1), Spain (1)	The Scopus, PubMed	RCT, Before and after clinical trial	6	2015–2019	N/A	Mobile phone apps (self-care)	2–9	BP, MA, high-risk behaviors	N	N/A
Wang et al. (2019) ²⁴	Journal of Cardiovascular and Pulmonary Diseases	USA (7), UK (2), Argentina (1), Canada (1), Spain (1)	PubMed, Cochrane library, CNKI, Wanfang database	RCT	12	2008–2017	4015	Internet (self-management)	1.5–12	SBP, DBP	Y (mHealth favors)	RoB
Yu et al. (2019) ²⁵	Journal of Preventive Medicine	China (11)	PubMed, Cochrane Library, CNKI, Wanfang database, VIP	RCT	11	2015–2018	1174	Smartphone app (self-management)	3–12	SBP, DBP	Y (mHealth favors)	RoB

(Continued)

First author (year)	Journal	Country	Databases	Type of study included	No. of included studies	Range of year of publication	No. of patients	Intervention (target function)	Duration (months)	Outcomes measures	Meta-analysis	Quality assessment
Alessa et al. (2018) ²⁶	JMIR mHealth Uhealth	Spain (2), South Korea (1), USA (9), China (1), South Sweden (2), Sweden (1), Canada (2), France (1), Italy (1)	MEDLINE (OVID), Embase (OVID), PsycINFO (OVID), CINAHL, the Cochrane Central Register of Controlled Trials (CENTRAL, The Cochrane Library), IEEE Xplore ASSIAN, Google Scholar and the main Arabic databases Al Manhal, AskZad, Mandumah	All quantitative, qualitative, and mixed-method studies	21	2012–2017	3112	Mobile phone or a tablet app (monitor, feedback, counseling, self-management)	3–13	SBP, DBP	N	RoB
Xiong et al. (2018) ²⁷	CurrHypertens Rep	UAE (1), Sweden (1), South Africa (1), Austria (1), USA (1), Iran (2), Pakistan (1), South Korea (1), Malaysia (1), Bolivia (1), Chile (1), England (1)	PubMed, Embase, Web of Science	RCT, CCT, Before and after study	21	2012–2017	N/A	Smart phone, text message, application (MA)	1–12	SBP, DBP, MA	N	N/A
Fei et al. (2018) ²⁸	Chinese Journal of Cardiovascular Medicine	China (33)	CNKI, Wanfang database, VIP	RCT	33	2008–2017	8959	Internet (self-management)	N/A	SBP, DBP, MA, lifestyle changes	Y (mHealth favors)	Jadad
Chandak and Joshi (2015) ²⁹	Technol Health Care	N/A	PubMed	RCT	12	2009–2013	N/A	Internet, computer and cell phone (self-management)	6–24	SBP, DBP, MA	N	N/A
Verberk et al. (2011) ³⁰	Blood Press Monit	N/A	PubMed, Medline, Embase, the Cochrane databases	RCT	9	1996–2010	N/A	Telephone, internet, or mail (self-management)	2–12	SBP, DBP	Y (mHealth favors)	N/A

Note: BP, blood pressure; DBP, diastolic blood pressure; MA, medication adherence; N/A, not available; RCT, randomized controlled trials; CCT, clinical control trial; RoB, risk of bias; SBP, systolic blood pressure.

Table 1. Characteristics of included studies.

Reference	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
Xu and Long (2020) ²²	Y	Y	NA	Y	Y	N	Y	Y	Y	NA	Y	NA	Y	Y	N	Y
Li et al. (2020) ⁶	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Choi et al. (2020) ²⁰	Y	Y	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	NA	Y
Jamshidnezhad et al. (2019) ²¹	Y	NA	N	Y	Y	Y	Y	Y	N	Y	NA	NA	N	N	NA	Y
Wang et al. (2019) ²⁴	Y	NA	N	Y	NA	NA	Y	Y	Y	N	Y	N	N	N	N	NA
Yu et al. (2019) ²⁵	Y	NA	Y	Y	Y	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Alessa et al. (2018) ²⁶	Y	NA	NA	Y	Y	Y	Y	N	Y	Y	NA	NA	Y	Y	NA	Y
Xiong et al. (2018) ²⁷	Y	NA	NA	Y	Y	Y	Y	Y	NA	NA	NA	NA	Y	Y	NA	Y
Fei et al. (2018) ²⁸	Y	NA	Y	Y	NA	NA	N	Y	Y	N	Y	Y	N	Y	N	NA
Chandak and Joshi (2015) ²⁹	Y	NA	NA	Y	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Verberk et al. (2011) ³⁰	Y	NA	NA	Y	NA	NA	Y	Y	Y	NA	Y	Y	N	N	Y	Y

Note:

Q1: Did the research questions and inclusion criteria for the review include the components of PICO?

Q2: Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review, and did the report justify any significant deviations from the protocol?

Q3: Did the review authors explain their selection of the study designs for inclusion in the review?

Q4: Did the review authors use a comprehensive literature search strategy?

Q5: Did the review authors perform study selection in duplicate?

Q6: Did the review authors perform data extraction in duplicate?

Q7: Did the review authors provide a list of excluded studies and justify the exclusions?

Q8: Did the review authors describe the included studies in adequate detail?

Q9: Did the review authors use a satisfactory technique for assessing the RoB in individual studies that were included in the review?

Q10: Did the review authors report on the sources of funding for the studies included in the review?

Q11: If meta-analysis was performed, did the review authors use appropriate methods for statistical combination of results?

Q12: If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?

Q13: Did the review authors account for RoB in individual studies when interpreting/discussing the results of the review?

Q14: Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?

Q15: If they performed quantitative synthesis, did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?

Q16: Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

Abbreviations: AMSTAR 2, assessment of multiple systematic reviews; N, no; NA, not available; RoB, risk of bias; Y, yes.

Table 2. Methodological quality of 11 studies based on AMSTAR 2 criteria.

self-monitoring (RD = 0.30, 95%CI [0.21–0.39], $P < 0.01$; $I^2 = 85\%$).²⁸

3.4.3. Cost

One review analyzed the cost-benefits of mHealth intervention in patients with hypertension.⁶ Six of 24 articles measured the cost of mHealth, and there were no unified conclusions. mHealth interventions may cause costs from monitoring, mobile phone use, connection charges, and the cost of nurse support.

4. Discussion

To our knowledge, this is the first SR of SRs that focuses on the effects of mHealth interventions on the management of hypertensive patients. This study included 11 wSRs.^{6,20–22,26–30} The results showed that most of the mHealth interventions included health education for

patients, BP monitoring, medical consultations, and medication reminders, which were conducted via mobile phones and the internet. Compared with conventional hypertensive management, the mHealth interventions provided a more convenient platform for personalized medical services and real-time communication for patients and healthcare providers, so that patients can monitor BP more regularly and receive more information about disease management and medical feedback in a timely manner.^{6,10} Compared with conventional care, most of the reviews showed that mHealth interventions can help control BP and improve MA and patients' lifestyle.

Evidence has shown that effective self-management is essential to BP control and reducing complications in patients with hypertension.⁴ BP reduction is the most important outcome indicator for judging BP control in patients with hypertension. A reduction in SBP of 2 mmHg, as observed in mHealth interventions, is

Study	Outcomes and main results				Conclusions	Limitations
	SBP reduction	DBP reduction	BP normalization rate	MA	Self-management behaviors	
Xu and Long (2020) ²²	-2.28 mmHg (95%CI: -3.90 to -0.66; $I^2 = 40\%$)	-1.84 mmHg (95%CI: -3.49 to -0.19; $I^2 = 54\%$)	N/A	SMD = 0.38 (95%CI: 0.26-0.50; $I^2 = 0\%$)	No difference between groups was demonstrated with respect to physical activity. One study showed a significant effect of reducing smoking and one study showed a significant effect of confidence in controlling BP	Few studies included in this meta-analysis, included trials were mainly conducted in North America and East Asia
Li et al. (2020) ⁶	SBP: -3.78 mmHg ($P < 0.001$; 95%CI -4.67 to -2.89)	DBP: -1.57 mmHg ($P < 0.001$; 95%CI -2.28 to -0.86)	N/A	7 articles reported statistically significant improvement in intervention groups	Of the 9 articles that focused on the behavioral change of self-management, all reported positive effects either through physical activities or through a healthier diet	Observed heterogeneities, only recruited RCTs, restricted to English
Choi et al. (2020) ²⁰	SBP: -3.482 mmHg ($P < 0.001$; 95%CI 2.459-4.505)	DBP: -1.638 mmHg ($P < 0.001$; 95%CI 1.084-2.192)	The RBPM group showed a significantly larger improvement (45.05% vs. 38.42%)	N/A	N/A	No detail analysis of marginalized areas, not generalizing the achievement rates of target, BP strategy is not perfect
Jamshidnezhad et al. (2019) ²¹	N/A	N/A	3 of 6 studies confirmed the effect of using mobile applications on lowering BP	1 of 6 studies reported significant effect	1 study showed a significant effect on reducing smoking	The low number of studies, meta-analysis was not possible, non-English studies were not included
Wang et al. (2019) ²⁴	-3.41 mmHg (95%CI: -3.49 mmHg to -3.32 mmHg; $I^2 = 100\%$, $P < 0.001$)	-1.5 mmHg (95%CI: -2.2 mmHg to -0.8 mmHg; $I^2 = 62\%$, $P < 0.001$)	N/A	N/A	N/A	Included only English studies
Yu et al. (2019) ²⁵	14.77 mmHg (95%CI: 11.76-17.77 mmHg; $I^2 = 89.7\%$, $P < 0.001$)	8.17 mmHg (95%CI: 5.67-10.67 mmHg; $I^2 = 85.6\%$, $P < 0.001$)	N/A	N/A	N/A	Only include Chinese literatures, quality of the included literature is low heterogeneity
Alessa et al. (2018) ²⁶	6 of 9 studies demonstrated positive effects showed a significant decrease in SBP from 8.7 mmHg to 34.8 mmHg	Significant decreases in DBP were reported in 2/6 studies, ranging from 4.9 mmHg to 12 mmHg	N/A	N/A	N/A	Restricted to English, meta-analysis was not possible, the inclusion of controlled and non-controlled studies might yield inconclusive results

(Continued)

Study	Outcomes and main results					Conclusions	Limitations
	SBP reduction	DBP reduction	BP normalization rate	MA	Self-management behaviors		
Xiong et al. (2018) ²⁷	SBP reduction from 2.06 mmHg to 47.2 mmHg	DBP reduction from 1.28 mmHg to 19.91 mmHg	12 of 16 studies reported significantly better BP reduction in the intervention groups	All 21 studies included in the review indicated a higher level of MA after the intervention, and 12 studies were able to report significantly better MA outcomes for their mHealth intervention groups	N/A	mHealth interventions improved MA and BP control	Included only published trials, included only English studies, meta-analysis was not possible
Fei et al. (2018) ²⁸	-12.73 mmHg (95%CI: -15.80 mmHg to -9.66 mmHg; $P < 0.01$)	-8.05 mmHg (95%CI: -10.51 mmHg to -5.59 mmHg; $P < 0.01$)	N/A	RD = 0.29 (95%CI: 0.24–0.34, $P < 0.01$)	Regular exercise (RD = 0.29, 95%CI: 0.22–0.36, $P < 0.01$), Regular monitoring (RD = 0.30, 95%CI: 0.21–0.39, $P < 0.01$), Better diet (RD = 0.32, 95%CI: 0.26–0.38, $P < 0.01$)	Mobile network-based health education can effectively improve BP levels and lifestyles	Observed heterogeneities, the methodology quality of the included studies is low
Chandak and Joshi (2015) ²⁹	Two telemonitoring interventions showed significant reductions in mean SBP for the intervention group	One telemonitoring study showed significant reduction in mean DBP for the intervention group	N/A	N/A	N/A	N/A	Included only English studies, strategy is not perfect
Verbeek et al. (2011) ³⁰	SBP: 5.2 ± 1.5 mmHg; $P < 0.001$	BP: 2.1 ± 0.8 mmHg; $P < 0.01$	N/A	N/A	N/A	TC led to a greater decrease in SBP and DBP than UC	

Note: BP = blood pressure; DBP= diastolic blood pressure; MA, medication adherence; N/A, = not available; RCTs, randomized controlled trials; SBP = systolic blood pressure; monitoring; TC, telecare; UC, usual care; CI, confidence interval; RD, risk difference; SMD, standardized mean difference.

Table 3. Summary of results of the 11 reviews on the effectiveness of mHealth for hypertension management.

expected to be associated with a 10% reduction in stroke mortality and a 7% reduction in mortality from coronary heart diseases.³¹ A total of 10 meta-analyses showed that mHealth interventions can reduce BP in patients with hypertension. The range of BP reduction fluctuates greatly, with SBP from 2.28 mmHg to 14.77 mmHg and DBP from 1.50 mmHg to 8.17 mmHg. This may be related to the different study populations, regions, and mHealth interventions. The reason mHealth interventions can reduce blood pressure (BP) may be they enable healthcare providers to monitor dynamic BP data in real-time via mobile medical products. This allows for timely modifications to treatment plans. Additionally, patients can receive health education on BP control and obtain feedback from doctors regarding medication adherence and lifestyle adjustments.^{6,24,25,28}

In terms of MA, there were 5 SRs, 2 of which carried out a meta-analysis. The results showed that mHealth interventions based on the internet and applications can improve patients' eMA. Li et al.⁶ and Xiong et al.²⁷ found that the automated sending of daily medicine reminders or weekly educational or motivational information may have contributed to the effectiveness of MA. Ciara et al.³² explored the experience of patients with hypertension using a smartphone APP for improving self-management and MA and demonstrated that smartphone APP was helpful and highlighted the need for personalized functions, especially in terms of MA reminder strategy.

The outcome indicators of self-management behaviors in patients with hypertension included diet, smoking and alcohol drinking, physical activity, and BP monitoring. This study confirmed that mHealth interventions were effective in improving diet management, smoking status, and BP monitoring, while evidence of the impact of mHealth on physical activity and alcohol drinking was insufficient.

In addition, mHealth interventions can improve the convenience of self-monitoring and communication between patients and healthcare providers. Patients can complete BP data transmission, consultation, and follow-up at home, which may reduce the cost of medical treatment.³³ However, only one review analyzed the cost-benefit of mHealth interventions for patients with hypertension and has not drawn a confirmed conclusion.⁶ Future research should pay attention to the cost-benefit analysis of mHealth on patients with hypertension.

Some SRs did not evaluate the methodological quality of the original studies.^{22,26,27,29,30} Due to the diversity of mHealth interventions, there was high heterogeneity between studies. In the meta-analysis, the number of included studies was small, and the follow-up period was short. It failed to further evaluate the influence of mHealth interventions on the long-term outcomes of hypertension patients, such as cardiovascular events.

There were some limitations in this study. First, there were obvious heterogeneities in the included studies due to the diversity of mHealth interventions, so the effects remained to be determined. Second, there was no quantitative synthesis of the included studies. Third, only Chinese and English publications were included, and not all common online databases were searched, so there may be selection bias. Fourth, the methodological quality of existing SRs on the management of BP in patients with hypertension was relatively low. In this study, AMSTAR 2 was used to evaluate the methodological quality of the 11 SRs, 10 of which were rated low or critically low quality, so more well-designed SRs or meta-analyses are needed to provide more evidence.

5. Conclusions

The mHealth interventions can improve BP control, MA, diet, and smoking in patients with hypertension, but the evidence for the efficacy of mHealth on physical activity and alcohol drinking improvement is limited. It is recommended to use mHealth interventions to assist hypertensive patients with BP control and disease management such as MA, diet, and smoking. However, the methodological quality of included SRs is rated relatively low. The long-term effects and cost-benefit analysis need to be further explored and verified. Further well-designed RCTs with longer follow-up are required to confirm the efficacy of the mHealth.

Practice implications

Future research should explore how to further improve the effects of mHealth interventions on patients with hypertension, including mHealth intervention based on behavior change theory or behavior intervention strategies. The age and economic situation of patients with hypertension should be fully considered to evaluate the applicability of mHealth. It is recommended to design different functions for patients with different levels of hypertension, such as lifestyle intervention and MA intervention. Additionally, there was no meta-analysis of self-management and its dimensions; therefore, future studies may conduct primary SRs and SRs on SRs of meta-analysis of self-management.

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Ethical approval

Ethical issues are not involved in this paper.

Conflicts of interest

All contributing authors declare no conflicts of interest.

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