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ประสิทธิผลของสมาร์ทโฟนแอปพลิเคชันต่อพฤติกรรมการบริโภคอาหารในผู้ป่วยโรคหลอดเลือดหัวใจ : การทบทวนวรรณกรรมอย่างเป็นระบบและการวิเคราะห์อภิมาน

Effectiveness of mHealth Application on Dietary Behaviors in Patients with Coronary Artery Disease : A Systematic Review and Meta-analysis

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บทคัดย่อ

การทบทวนอย่างเป็นระบบนี้มีวัตถุประสงค์เพื่อประเมินประสิทธิผลของสมาร์ทโฟนแอปพลิเคชันต่อพฤติกรรมการบริโภคอาหารในผู้ป่วยโรคหลอดเลือดหัวใจ การทบทวนวรรณกรรมอย่างเป็นระบบครั้งนี้ได้คัดลือกการวิจัยการทดลองแบบสุ่ม และวิจัยกึ่งทดลองที่ทดสอบผลของการใช้สมาร์ทโฟนแอปพลิเคชันต่อพฤติกรรมการบริโภคอาหารในผู้ป่วยโรคหลอดเลือดหัวใจ การศึกษาที่เผยแพร่และไม่ได้เผยแพร่ในภาษาไทยและภาษาอังกฤษ ตั้งแต่ปี 2555 ถึง 2565 การศึกษาที่ผ่านเกณฑ์การคัดเข้าได้รับการประเมินคุณภาพของการศึกษาโดยผู้ตรวจสอบสองคนโดยใช้เครื่องมือการประเมินของ JBI (Joanna Briggs Institute) หากผลลัพธ์ของข้อมูลสามารถวิเคราะห์อภิมานได้ ข้อมูลจะถูกรวบรวมเพื่อการวิเคราะห์อภิมาน ในกรณีที่ไม่สามารถวิเคราะห์ได้ ผลการวิเคราะห์จะถูกนำเสนอในรูปแบบบรรยาย (Narrative Synthesis) ผู้วิจัยใช้ระบบ GRADE ประเมินระดับคุณภาพของหลักฐานทางวิชาการ (Certainty of Evidence) หมายเลขทะเบียนโปรโตคอลของการทบทวนวรรณกรรมอย่างเป็นระบบครั้งนี้ คือ CRD42022320586 ผลการวิจัยพบว่า

จำนวนงานวิจัยที่ศึกษาทั้งหมด 934 เรื่อง มีเพียง 20 เรื่องเท่านั้นที่เข้าเกณฑ์การคัดเลือก และมีเพียง 7 เรื่องที่ผ่านเกณฑ์การคัดเข้าและผ่านเกณฑ์การประเมินคุณภาพของการศึกษา 6 เรื่องสามารถวิเคราะห์ได้โดยการวิเคราะห์อภิมานและ 1 การศึกษาสำหรับการสรุปเชิงบรรยาย พบว่าสมาร์ทโฟนแอปพลิเคชันสามารถปรับปรุงพฤติกรรมการบริโภคอาหารในผู้ป่วยโรคหลอดเลือดหัวใจมีความแตกต่างระหว่างกลุ่มทดลองและกลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ SMD 0.30, 95% *CI* 0.09 ถึง 0.51, (*p*=.006) ผู้วิจัยได้ทำการวิเคราะห์กลุ่มย่อย พบว่าพฤติกรรมการบริโภคอาหารในช่วง 3 เดือนแรกมีความแตกต่างอย่างมีนัยสำคัญทางสถิติระหว่างกลุ่มทดลองและกลุ่มควบคุม SMD 0.30, 95% *CI* -0.01 ถึง 0.53 (*p*=.059) ระดับคุณภาพของหลักฐานทางวิชาการในแต่ละผลลัพธ์มีตั้งแต่ระดับต่ำไปจนถึงระดับปานกลาง

การทบทวนอย่างเป็นระบบนี้ชี้ให้เห็นว่าสมาร์ทโฟนแอปพลิเคชันเป็นทางเลือกหนึ่งสำหรับการปรับปรุงพฤติกรรมการบริโภคอาหารในผู้ป่วยโรคหลอดเลือดหัวใจในช่วงสามเดือนแรก

คำสำคัญ: การทบทวนวรรณกรรม สมาร์ทโฟนแอปพลิเคชัน อาหาร โรคหลอดเลือดหัวใจ

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Abstract

This systematic review aimed to evaluate the effectiveness of mHealth application on dietary behaviors in patients with coronary artery disease (CAD). The randomized control trial and quasi-experimental studies, which investigated the effectiveness of mHealth application on dietary behaviors in patients with CAD, were selected for searching review materials in this study. Published and unpublished studies in Thai and English from 2012 to 2022 were included in the review. Eligible studies were critically appraised by two reviewers using the JBI critical appraisal instruments (Joanna Briggs Institute [JBI], 2017). When possible, studies were pooled using meta-analysis. Where statistical pooling was not possible, the findings were presented in narrative form. The degree of certainty of the evidence on clinical outcomes was assessed using the GRADE approach. Systematic review registration number is CRD42022320586.

While the search identified 934 potential studies, only 20 of them met the inclusion criteria and, finally seven studies passed the criteria for critical appraisal assessment. Six studies could be analyzed by meta-analysis and one study for narrative summary. The result found that the mHealth application improved dietary behavior in patients with CAD (SMD 0.30, 95% CI 0.09 to 0.51, (p=.006)). There was a statistical significance between one and three months (SMD 0.30, 95% CI -0.01 to 0.53, (p=.059)). The certainty of evidence for each outcome ranged from very low to moderate level.

This systematic review suggests that using a mHealth application is one option for improving dietary behaviors in patients with CAD for the first three months. The limitation of this review is that it was only focused on experimental studies (RCT and quasi-experimental studies). Further primary research may fill this gap or further review should clarify effectiveness of mHealth applications on dietary behaviors in patients with CAD.

Keywords: Systematic Review, mHealth Application, Diet, Coronary Artery Disease

Introduction

Coronary Artery Disease (CAD) is the leading cause of death worldwide, responsible for 16% of the world's total deaths, both in developed and developing countries (Sekhri, Kanwar, Wilfred, Chugh, Chhillar, Aggarwal, et al., 2014). Central and Eastern European countries are currently sustaining the highest prevalence (Khan, Hashim, Mustafa, Baniyas, Al Suwaidi, AlKatheeri, et al., 2020). CAD is also at the top of the leading causes of death in Thailand, responsible for 35% of the population, accounting for 24.5 million Thai people, as the mortality rate of coronary heart disease per 100,000 persons was 26.9, 27.8, 29.9, 32.3, 31.8, respectively from 2013 to 2017 (Ministry of Public Health [MOPH], 2018). CAD is a multifactorial disease with age, gender, hereditary, and behavioral risk factors. Behavioral risk factors are known to be the vital risk factors for CAD including smoking, physical inactivity, unhealthy diet, and alcohol consumption. Although diet is not the only factor of coronary artery disease, diet is a daily necessity which plays a vital role in people's lives indicating that "you are what you eat" (Banerjee, 2015). In addition, the American College of Cardiology (ACC) and American Health Association (AHA) 2019 revealed that consuming high amounts of saturated fats or trans fats, cholesterol, sodium, processed meats, refined carbohydrates (white bread, pasta, and white rice), and sweetened beverages can lead to overweight and obesity, high

blood cholesterol, high blood pressure, atherosclerosis, and plaque buildup in the heart's arteries (Arnett, Blumenthal, Albert, Buroker, Goldberger, Hahn, et al., 2019). Even though dietary guidelines have been created and shared widely, the compliance among patients changing their dietary behaviors is low (Eckardt, Buschhaus, Nickenig & Jansen, 2021). It was found that the mHealth application is the popular method in dietary management for patients with CAD (European Society of Cardiology [ESC], 2017).

The European Society of Cardiology (ESC) reported that mHealth application is vital to achieve its mission of reducing the burden of cardiovascular disease and allowing people to live longer, healthier lives (European Society of Cardiology (ESC), 2017). Nurses are the key persons to promote dietary behaviors by educating and following up patients with CAD about their diet. In addition, nurses' also play a role in assessment, nursing care plan with patients, and evaluation (Lupan, 2019). For this reason, the mHealth application is vital for nurses to educate and follow CAD patients because technology-based treatment has resulted in increased survival of patients with CAD in recent decades (Yu, Malik, & Hu, 2018).

The outcomes previous reviews were adherence of cardiac rehabilitation, exercise capacity, medication adherence, smoking cessation, mental health, and quality of life (Douma & Habibovic, 2021; Meehan, Kunniardy, Murphy, Clark, Farouque, & Yudi, 2019; Widmer, Collins, Collins, West, Lerman, & Lerman, 2015; Xu, Li, Zhou, Li, Hong, & Tong, 2019). There was no systematic review that focused on the outcome of dietary behaviors (Choi, Dhawan, Metzger, Marshall, Akbar, Jain et al., 2019; Krackhardt, Jörnten-Karlsson, Waliszewski, Knutsson, Niklasson, Appel, et al., 2022; Manzoor, Hisam, Aziz, Mashhadi, & Haq, 2021; Michelsen, Sjölin, Bäck, Gonzalez Garcia, Olsson, Sandberg, et al., 2022; Tang, Chong, Chua, Chui, Tang, & Rahmat, 2018; Varnfield, Karunanithi, Lee, Honeyman, Arnold, Ding et al., 2014; Widmer, Allison, Lennon, Lopez-Jimenez, Lerman, & Lerman, 2017) The knowledge gained is thus scattered, unclear, and inconsistent.This makes it difficult to apply research findings to nursing practice. Therefore, the researcher would like to gather nursing research about mHealth application on dietary behaviors in patients with CAD in order to analyze and synthesize data for reaching clear conclusions and can be referenced.This study will begin to bridge the gap in the literature by systematically reviewing on all available studies on mHealth application on dietary behaviors in patients with CAD by following JBI systematic review.

Objective

To evaluate the effectiveness of mHealth application versus standard of care on dietary behaviors in patients with coronary artery disease.

Conceptual Framework

This systematic review is to assess the effectiveness of the mHealth application versus standard of care on dietary behaviors in patients with CAD, based on a systematic review process proposed by the Joanna Briggs Institute (Aromataris, 2014), consisting of nine steps: 1) formulate review question; 2) define inclusion and exclusion criteria; 3) locate studies; 4) select studies; 5) assess study quality; 6) extract data; 7) analysis data; 8) present results; and 9) interpret findings

and recommendations to guide nursing practice by specifying the qualifications of the research on mHealth application on dietary behaviors in patients with CAD.

Methods

A systematic review and meta-analysis were used to investigate the effectiveness of a mHealth application on dietary behaviors in patients with CAD. This review followed JBI guidelines (Aromataris, 2014) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page, McKenzie, Bossuyt, Boutron, Hoffmann, Mulrow, et al., 2021) for systematic reviews. This protocol has been registered with PROSPERO (CRD42022320586).

Population and Sample

Population in this systematic review consisted of the research that investigated about the mHealth application on dietary behaviors in patients with CAD. The sample comprised research about mHealth application on dietary behaviors in patients with CAD which have inclusion and exclusion criteria base on the PICO format: population (P), intervention (I), comparison (C), outcome (O), study design (S) as presented in Table 1:

Table 1 Inclusion and exclusion criteria of sample based on the PICO format

P: Population	Patients aged 18 years or older diagnosed with CAD. There were no restrictions regarding participants setting, participants may be admitted to an in-patient unit or out-patient unit or long-term care at home. Patients who were diagnosed with CAD and cognitive impairment or psychiatric disease were excluded.
I: Intervention	MHealth application used for improving dietary behaviors. The MHealth application may be used for any duration, frequency, and intensity designed to improve dietary behaviors. For this review, interventions included mHealth applications that use mHealth, tablet, and computer or software installed on mobile electronic devices which can deliver health services and information using the internet and related technologies, such as self-monitoring by taking a picture of their food or putting a check mark in a checklist for recording their behaviors, motivating patient by automatic message reminders about healthy habits, and supporting patients. The interventions that include only telephone follow-up or text messaging (SMS message) were excluded.
C: Comparator	Standard of care was the common type of care services regarding dietary behaviors for patients with CAD which are provided by nurses or cardiologist such as educating patient about lifestyle modification and following up patients without mHealth education.
O: Outcomes	The primary outcome of this review was dietary behaviors. This outcome was measured by questionnaires such as diet scores that calculated the summation of intake of fat, fiber, sodium, alcohol, daily servings of fruits, vegetables, whole grains, lean proteins, sweets, seafood beans white meat, nuts, olive oil, red meat and sausage, butter and cream, soda, and juices. This study investigated secondary outcomes, including changes in body mass index (BMI), LDL-cholesterol level, total cholesterol, and blood pressure. These outcomes were measured by using the standard laboratory test for CAD patients.
S: Study design	Experimental studies were included (RCT and Quasi-experimental design studies) comparing mHealth application to standard of care that evaluate a primary outcome of change in dietary behaviors. Therefore, any descriptive study designs were excluded.
T: Time	The published and unpublished research in English or Thai from 2012 to 2022 were included.

Research Instrument

1. The inclusion criteria form is a tool developed by the researcher following the PICO criteria according to the inclusion criteria.

2. The critical appraisal form is a tool used to assess the research methodology of the research selected for systematic review. The researcher used the JBI critical appraisal checklists for randomized controlled (13 items) and nonrandomized trials (9 items) (Joanna Briggs Institute, 2017).

3. The data extraction form is a tool used to record data from selected studies for systematic review. The researchers used the JBI data extraction form for review for systematic reviews and research syntheses developed by the Joanna Briggs Institute (Joanna Briggs Institute, 2020). Details regarding the study included the participants, settings, the interventions, the comparators, the outcome measures, study design, statistical analysis, and results.

Data Collection

To collect data, the researcher performed the following tasks:

1. Formulate a review question based on the PICO format: population (P), intervention (I), comparison (C), outcome (O), study design (S), and time (T).

2. Define inclusion and exclusion criteria.

3. Search studies in databases including Pubmed, MEDLINE, CINAHL Complete, Cochrane Libraly, Proquest, Clinicalkey nursing, Thaijo, Sciencedirect, Scopus, Embase, Oxford Academic, Springer, BMJ Journals, Wiley online library. Sources of unpublished studies/ gray literature to be searched include Cochrane central register of controlled trials, OVID, Google scholar, Thailist (a Thai literature for theses), and ProQuest Dissertations and Theses.

4. Select studies from all identified studies screened for title and abstract against inclusion criteria following the PICO principle by using Zetero and the duplicated studies were removed. The full text was screened by the researcher and major advisor for assessment against the inclusion criteria for the review. Potentially relevant studies were retrieved in full, and their citation details imported into the JBI System for the Unified Management, Assessment and Review of Information (JBI SUMARI) (Munn, Aromataris, Tufanaru, Stern, Porritt, Farrow et al., 2019). Reasons for exclusion were recorded and reported in the systematic review. No disagreement arose between the reviewers in the selection process. The process of study selection was presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram.

5. Risk of bias was assessed independently between the two reviewers using the JBI critical tools in JBI SUMARI. The tools that were used in this review are the JBI critical appraisal checklists for randomized controlled (13 items) and nonrandomized trials (9 items)(Joanna Briggs Institute, 2017). When there was a difference between reviewers regarding their answers, the first and second reviewer discussed it and finally came to a consensus. It was therefore not sent to a third reviewer. Reviewers discussed the criteria for inclusion and decided the total number of “yes” answers should be more than 7 out of 9 for quasi-experimental study and more than 8 out of 13 in RCT; and

6. Data were extracted from included studies by the researcher and major advisor using JBI SUMARI which followed JBI Data Extraction Form (Joanna Briggs Institute, 2020). Data extracted consisted of the study characteristics and results data.

Data Analysis

1. Characteristics of included studies used narrative synthesis.

2. To establish the effectiveness of mHealth application on dietary behaviors in patients with CAD and other secondary outcomes the researchers used narrative synthesis and meta-analysis.

Data from included trials were pooled in a statistical meta- analysis model using JBI SUMARI software (Munn, Aromataris, Tufanaru, Stern, Porritt, Farrow, et al., 2019). For the primary outcome, dietary behaviors were continuous data, and statistical analyses used the fixed effects model because the number of studies was less than five studies and there was no methodological heterogeneity. Similarly, for the secondary outcomes including systolic blood pressure, BMI, LDL-cholesterol, and total cholesterol the researcher also used the fixed effect model. Additionally, the reviewer did the sub-group analysis for dietary behaviors outcome dividing them into two groups (one to three months and six to twelve months) because the outcome measurement was different among included studies. Statistical heterogeneity was assessed in the meta-analysis using I^2 and x^2 statistics. One proposed suggestion was to consider ratings of low, moderate, and high heterogeneity for I2 values of 25%, 50%, and 75% (Aromataris & Mun, 2020). Additionally, heterogeneity was considered substantial if I2 was >50% and p value <0.10 in the x2 test. Sensitivity was considered in this review for examining the impact of decisions made during the review process. Funnel plot for analyzing publication bias was not performed because less than 10 studies were included.

Ethical Consideration

In this review, reviewers used the exemption ethic according to the consideration obtained from the ethical committee of the faculty of nursing, Prince of Songkla University.

Results

The PRISMA flow diagram details the results of the search (Figure 1). The results from included studies were first collected into extract table data (table 2).

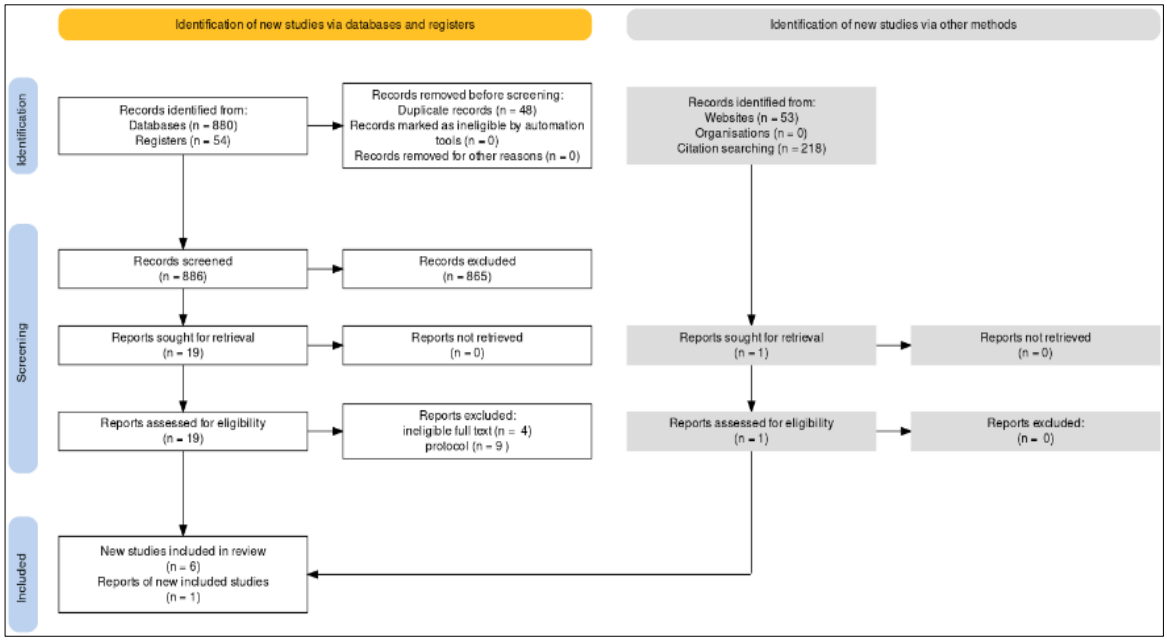


Figure 1 Prisma flow diagram

1. Characteristic of included studies including six RCTs, and one quasi-experimental study design. Two studies were conducted in the USA (Choi, Dhawan, Metzger, Marshall, Akbar, Jain,

et al., 2019; Widmer, Allison, Lennon, Lopez-Jimenez, Lerman, & Lerman, 2017), and five studies were from Pakistan (Manzoor, Hisam, Aziz , Mashhadi, & Haq, 2021), Sweden (Michelsen, Sjölin, Bäck, Gonzalez Garcia, Olsson, Sandberg, et al., 2022), Malaysia (Tang, Chong, Chua, Chui, Tang, & Rahmat, 2018), Germany (Krackhardt, Jörnten-Karlsson, Waliszewski, Knutsson, Niklasson, Appel et al., 2022), Australia (Varnfield, Karunanithi, Lee, Honeyman, Arnold, Ding, et al., 2014). The participants in all the studies were diagnosed with coronary artery disease. The number of participants in the studies ranged from 80 to 672. The distribution of male and female participants in the trials had male predominance. The mean age of participants in the trials ranged from 52.67 to 63.6. The duration of intervention for most cases was 4-24 weeks, 2 trials were 48-56 weeks.

2. Methodological Quality was carried out by two independent reviews for the six studies. This review included randomized and quasi-experimental study designs. There were six randomized studies and one quasi-experimental study included in this review. The results of the critical appraisal are shown in tables 2 and 3. The first and second authors determined that seven of the studies met the criteria of methodological quality and were appropriate for analysis.

Table 2: Extract data table

First author, year and country	Intervention(I) Comparison(C) study design and duration	Component of application	Included outcomes and instruments	Result	Critical Appraisal score
Choi 2019 USA	I: 51 smartphone app C: 49 s standards of CR without mHealth RCT 6months	Monitoring dietary behaviors, monitoring clinical assessments, taking picture of food by patients, and face-to-face counseling mentors	Mediterranean Diet Score (MDS) -Mediterranean Diet questionnaire (MDQ) Height, weight, blood pressure (BP), and laboratory biomarkers -Standard laboratory blood test	Adherence to the Mediterranean diet increased significantly over time for both groups (P<.001), but there was no significant difference between groups (P=.69). There were no significant differences between EXP and SOC with regard to BP, lipid parameters, hemoglobin A1c, or C-reactive protein (CRP). Participants in EXP achieved a significantly greater weight loss on average of 3.3 pounds versus 3.1 pounds for participants in SOC, p=.04.	10/13
Krackhardt 2022 Germany	I: 342 smartphone app C: 334 standards of CR without mHealth RCT 12months	Monitoring dietary behaviors, monitoring clinical assessments, educational material messages, and individualized feedback	Adherence to a healthy diet -Lifestyle Change Questionnaire (LSQ) BP and BMI by -standard physical exam.	Agreed or partially agreed to a healthy diet EXP1=85.7 % EXP2=91.9 % SOC1=89.2 % SOC2=82.2 % Visit 1: p* = 0.243 Visit 2: p* = 0.027 There were no significant differences in blood pressure and BMI between visits.	9/13

First author, year and country	Intervention(I) Comparison(C) study design and duration	Component of application	Included outcomes and instruments	Result	Critical Appraisal score
Varnfield 2014 Australia	I: 60 the CAP-CR platform used a smartphone C: 60 standards of CR without mHealth RCT 1.5 month	Monitoring dietary behaviors, monitoring clinical assessments, educational material messages, and individualized feedback	Diet scores -Dietary Habits Questionnaire (DHQ) BP, BMI and lipid profile. -Laboratory test	Diet scores showed no difference between the smartphone-based group and the traditional group. Weight loss was not much difference between groups. Fat loss was not much difference between two groups.	10/13
Manzoor 2021 Pakistan	I: 80 the CAP-CR platform used a smartphone C: 80 standards of CR without mHealth RCT 6 months	Motivational messages, and individualized counselling	Diet scores -Healthy eating assessment questionnaire (HEQ)	Diet counselling increased adherence to proper diet, as shown by the increase in HEQ scores at 12 and 24 weeks follow-up. Subjective assessment of healthy diet preference also showed marked improvement.	10/13
Michelsen 2022 Sweden	I: 101 smartphone application C: 49 standards of CR without mHealth education RCT 14 months	Monitoring dietary behaviors, monitoring clinical assessments, educational material messages, and individualized feedback	Diet scores -Dietary question-naire	A healthy diet index score improved significantly more between baseline and the 2-week follow-up in the intervention group (+2.3 vs +1.4 points; P=.05), mostly owing to an increase in the consumption of fish and fruit	11/13
Widmer 2017 USA	I: 34 smartphone-based CR program C: 37 standards of CR without mHealth education RCT 3 months	Monitoring dietary behaviors, monitoring clinical assessments, educational material messages, and individualized feedback	Diet scores -Dietary question-naire	Diet scores presented significant increase at 3 months (p=.03) Our data show an augmented significantly reduction in risk factors including weight loss, BMI, Total cholesterol, LDL shown a non-significant reduction at 3 months	12/13
Tang 2018 Malaysia	I: 47 smartphone application C: 47 standards of CR without	WhatsApp (Group discussion chat), and educational	Diet scores Questionnaire of adherence to a healthy lifestyle.	The results show that for patients' adherence to a healthy lifestyle, the pretest and posttest mean scores for the intervention group were 42.89 and 63.55,	9/9

First author, year and country	Intervention(I) Comparison(C) study design and duration	Component of application	Included outcomes and instruments	Result	Critical Appraisal score
	mHealth education Quasi-study 1 month	material messages		which means that there was an increase of 20.66.	

Note. ACS= acute coronary syndrome, BMI = body mass index, BP= blood pressure, C= control group, CAP= Care Assessment Platform, CR= cardiac rehabilitation, CV= cardiovascular, EXP=experimental group, I= intervention group, LDL= low density lipid, Mcard= mobile health augmented cardiac rehabilitation, RCT=randomized control trial, SOC = standard of care group

Table 3 Critical appraisal results (randomized controlled trials)

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	scores
Choi et al., 2019	Y	U	Y	Y	U	N	Y	Y	Y	Y	Y	Y	Y	10/13
Krackhardt et al., 2022	Y	U	Y	U	U	U	Y	Y	Y	Y	Y	Y	Y	9/13
Manzoor et al. 2021	Y	Y	Y	U	U	U	Y	Y	Y	Y	Y	Y	Y	10/13
Michelsen et al., 2022	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	11/13
Varnfield et al., 2014	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	10/13
Widmer et al., 2017	Y	Y	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	Y	12/13
%	100	67	100	17	17	33	100	100	100	100	100	100	100	

Note. Y=yes, N= no, U= unclear, Q1-Q13 are questions followed JBI Critical Appraisal Checklist for RCT

Table 4 Critical appraisal results (quasi-experimental study)

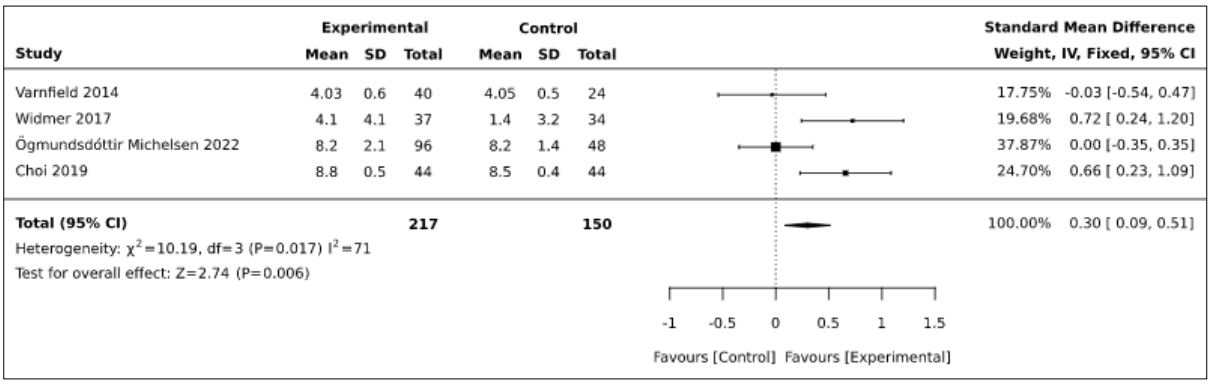
citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	scores
Tang et al., 2018	Y	Y	Y	Y	Y	Y	Y	Y	Y	9/9
%	100	100	100	100	100	100	100	100	100	

Note. Y=yes, N= no, U= unclear, Q1-Q9 are questions followed JBI Critical Appraisal Checklist for quasi-study

3. Review findings

3.1 Dietary behaviors (primary outcomes), pool data from four RCTs (Choi, Dhawan, Metzger, Marshall, Akbar, Jain, et al., 2019; Michelsen, Sjölin, Bäck, Gonzalez Garcia, Olsson, Sandberg, et al., 2022; Varnfield, Karunanithi, Lee, Honeyman, Arnold, Ding, et al., 2014; Widmer, Allison, Lennon, Lopez-Jimenez, Lerman, & Lerman, 2017) showed a significant difference between two groups, SMD 0.30, 95% CI 0.09 to 0.51, (p=.006). Moreover, there was a high heterogeneity (I2= 71, p >0.01) (figure 2).

Figure 2 The effectiveness of mobile health application on dietary behavior outcome in patients with CAD



Two RCTs (Krackhardt, Jörnten-Karlsson, Waliszewski, Knutsson, Niklasson, Appel, et al., 2022; Manzoor, Hisam, Aziz, Mashhadi, & Haq, 2021) and one quasi-experimental study (Tang, Chong, Chua, Chui, Tang, & Rahmat, 2018) could not be analyzed by meta-analysis because these studies had a difference of dietary behavior outcome measurement. The result showed that the mobile health application increased adherence to a proper diet by the increase in HEQ scores at 12 and 24 weeks follow-up and agreeing or partially agreeing to a healthy diet showed a significant increase from 85.7% to 91.9% in 48 weeks (Widmer, Allison, Lennon, Lopez-Jimenez, Lerman, & Lerman, 2017). In addition, Tang, Chong, Chua, Chui, Tang, & Rahmat (2018) revealed that the intervention group using WhatsApp as an information sharing tool had a significant development of adherence to healthy lifestyles (included dietary behavior) from a mean of 42.89 to 63.55 (p=0) (Tang, Chong, Chua, Chui, Tang, & Rahmat, 2018). For Dietary Behaviors at 1-3 months, pool data from two RCTs (Varnfield, Karunanithi, Lee, Honeyman, Arnold, Ding, et al., 2014; Widmer, Allison, Lennon, Lopez-Jimenez, Lerman, & Lerman, 2017) showed a significant difference between two groups, SMD 0.36, 95% CI 0.01 to 0.71, p=.041. For Dietary Behaviors at 6-12 months, pool data from two RCTs (Choi, Dhawan, Metzger, Marshall, Akbar, Jain et al., 2019; Michelsen, Sjölin, Bäck, Gonzalez Garcia, Olsson, Sandberg et al., 2022) showed no significant difference between two groups, SMD 0.26, 95% CI -0.01 to 0.53, p=.059.

3.2 Secondary outcomes: systolic and diastolic BP, pool data from four RCTs (Krackhardt, Jörnten-Karlsson, Waliszewski, Knutsson, Niklasson, Appel, et al., 2022; Michelsen, Sjölin, Bäck, Gonzalez Garcia, Olsson, Sandberg, et al., 2022; Varnfield, Karunanithi, Lee, Honeyman, Arnold, Ding, et al., 2014; Widmer, Allison, Lennon, Lopez-Jimenez, Lerman, & Lerman, 2017) showed no significant difference between two groups, WMD 0.80 (95% CI -1.14 to 2.74) (p = .419) and WMD 0.94 (95% CI -0.26 to 2.13) (p = 0.123). For BMI, pool data from two RCTs (Krackhardt, Jörnten-Karlsson, Waliszewski, Knutsson, Niklasson, Appel et al., 2022; Widmer, Allison, Lennon, Lopez-Jimenez, Lerman, & Lerman, 2017) showed no significant difference between the two groups, WMD -0.17 (95% CI -0.71 to 0.37) (p = .545). For LDL-cholesterol and total cholesterol, pool data from three RCTs (Michelsen, Sjölin, Bäck, Gonzalez Garcia, Olsson, Sandberg, et al., 2022; Varnfield, Karunanithi, Lee, Honeyman, Arnold, Ding, et al., 2014; Widmer, Allison, Lennon, Lopez-Jimenez, Lerman, & Lerman, 2017) showed

no significant difference between two groups, SMD 0.14 (95% CI -0.10 to 0.38) (p=.25) and SMD 0.14 (95% CI -0.11 to 0.40) (p=.268).

In conclusion, reviewers followed JBI which applied the GRADEpro software (McMaster University and Evidence Prime, 2022) approach to create summary of findings tables of the primary outcomes in reviews on the effectiveness of interventions as shown in figure 3.

Figure 3 Summary of findings tables of the primary outcomes in reviews on the effectiveness of mobile health application

Mobile health application on dietary behaviors compared to standard of care in patients with coronary artery disease

Patient or population: patients with coronary artery disease
Setting:
Intervention: mobile health application on dietary behaviors
Comparison: standard of care

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects	
				Risk with standard of care	Risk difference with mobile health application on dietary behaviors
Dietary behaviors assessed with: Self-reported questionnaire follow-up: range 1 months to 14 months	367 (4 RCTs)	⨁◯◯◯ Low[a,b,c]	-	-	SMD **0.3 SD more** (0.09 more to 0.51 more)
dietary behavior between 1-3 months assessed with: self-reported questionnaire	135 (2 RCTs)	⨁◯◯◯ Low[a,b,c]	-	-	SMD **0.36 SD more** (0.01 more to 0.71 more)
dietary behaviors more than 3 months assessed with: self-reported questionnaire	232 (2 RCTs)	⨁◯◯◯ Low[a,b,c]	-	-	SMD **0.26 SD more** (0.01 fewer to 0.53 more)

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval; **SMD:** standardised mean difference **WMD:** weighted mean difference

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Explanations

a. concerning the risk of bias on blinding
b. concerning heterogeneity of included studies
c. small number of study

Discussion

The results showed that the use of an mHealth application on dietary behavior in patients with CAD had a significant difference between mHealth application and the standard of care group. However, there was a high heterogeneity; this may be because there were differences of duration of outcome measurement. The researchers did the subgroup-analysis of dietary behaviors between one to three months and six to twelve months, it found that the mHealth application on dietary behaviors between one to three months had a significant difference between mHealth application and standard of care group, but still showed a high heterogeneity; this may be because they gave the summation of diet scores from different food; for example, Varnfield, Karunanithi, Lee, Honeyman, Arnold, Ding, et al. (2014) measured diet scores calculated by the summation of intake of fat, fiber, sodium, and alcohol whereas Widmer, Allison, Lennon, Lopez-Jimenez, Lerman, & Lerman (2017) measured diet scores calculated by summation of daily servings of fruits, vegetables, whole grains, and lean proteins, with points taken away for daily serving of saturated fats and sweets. Meanwhile, dietary behaviors between six to twelve months had a non-significant difference between the two groups. As a result, using the mHealth application within first three months enhanced patients' adherence to a healthy diet in patients with CAD more than six to twelve months. It may be that this was because they had become familiar with application, and for this reason, the patient's attention was reduced in the latter which is consistent with a study by

Michelsen, Sjölin, Bäck, Gonzalez Garcia, Olsson, Sandberg, et al.(2022) that revealed healthy diet scores improved significantly at two weeks in the intervention group. Additionally, the study of Widmer, Allison, Lennon, Lopez-Jimenez, Lerman, & Lerman (2017) showed diet scores increasing significantly at three months in the intervention group.

Implication of the Results

This review recommended that mHealth application is one option for improving dietary behaviors in patients with CAD, especially during the 1st to 3rd months of intervention. The certainty of evidence for each outcome in this review was ranging from very low to moderate level because there were concerns regarding the risk of bias on blinding, concerning heterogeneity of included studies. Moreover, the outcomes were surrogate outcomes (i.e., BP, BMI, LDL and total cholesterol), and some studies had a small number of events. The limitation of this review is that the reviewer focused on only experimental studies **(**RCT and quasi**-**experimental studies**)**; therefore, it may affect the certainty of the evidence**.**

Recommendation for Further Study

Further study should include descriptive studies to increase the certainty of the evidence. Moreover, future research may focus more deeply on application activity patterns, as there are likely to be more applications for CAD patients in the future.

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