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Systematic Review

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Potential of Mobile Applications in Prevention and Management of Cardio-Metabolic Diseases

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ABSTRACT

Background: The pervasive use of mobile computing and communication technologies in healthcare and public health is expanding even in low and middle income countries. Among all types of mobile phones, smartphones are a more recent development, with features such as computing capability, capacious memories, large screens and open operating systems. Besides delivering interventions and education programs, smart phone applications (apps) are also being used to monitor progress and act as knowledge database. This review explored the current evidence of smart phone technology in prevention and management of cardio-metabolic diseases.
Methods: A systematic search was done using the keywords [‘mobile Applications’ OR ‘telemedicine’ OR ‘smartphone’] and [OR ‘cardiovascular’ OR ‘obes*’OR ‘metabolic syndrome’ OR diabetes OR dyslipid* OR hypertensi*], with limitation to ‘reviews’, English publications and the last 5 years. Databases searched include OVID MEDLINE, PUBMED, COCHRANE, CINAHL, SCOPUS and PROQUEST. The shortlisted reviews including meta-analysis, narrative and systematic reviews were qualitatively evaluated and findings were compared.
Results: Twenty-six articles (n=26) comprised of apps inventory, narrative and systematic reviews were included in the following areas: nutrition (n=3), physical activity (n=4), tobacco smoking (n=1) and cardiovascular (n=1), type 2 diabetes (n=8) and obesity/weight loss (n=9).
Conclusion: Although there is limited evidence, we can now see a shift towards development and investigation of existing and new apps in prevention and management of cardio-metabolic diseases. Future studies could explore the feasibility and long-term effectiveness of theory-supported apps that were developed with newest evidence.

KEY WORDS: Smartphone; Mobile technology; Cardio-metabolic diseases.

ABBRIVATIONS: CMD: Cardio-Metabolic Diseases; PDA: Personal Digital Assistant; iOS: iPhone Operating System; MMS: Multimedia Messaging Service; SMS: Short Message Services; SCT: Social Cognitive Theory; CDM: Chronic Diseases Management; BMI: Body Mass Index.

INTRODUCTION

Cardio-metabolic diseases (CMD), primarily cardiovascular diseases and diabetes are the leading cause of death worldwide.[1] Kruashaar and Krämer[1] proposed that first line of defence against CMD to be prudent health behaviours, but the current model of disease incidence reduction seems to be ineffective mainly due to lack of individualisation and consumerisation. Fresh and innovative method of cost-effective strategy aimed at high-risk individuals is necessary to address this issue. New treatment strategies for CMD include moderate physical activity, weight reduction, blood pressure control, and correction of dyslipidaemia and glycaemic control.[2] Recent researches have started to incorporate mobile technology as one of the modalities in intervention program for people with CMD.

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Viewed to be "*handheld computers*", rather than just phones, smartphones are now increasingly common in mobile health (mHealth) research, especially with growing number of easy-to-use and downloadable applications (apps). This emerging application area of mHealth has made various health interventions possible. For example, interaction between users and healthcare agencies using Wi-Fi and cellular networks to report whether the pills were taken, tracking of people with asthma with the use of mobile devices, Bluetooth radio to assist when they needed help breathing, assistance for weight-loss app and blood sugar self-monitoring system for people with diabetes.

Smartphones typically offer very easy-to-use interfaces and opportunities for the end-user to download new functionality in terms of mobile apps. Smartphones have made it easier to get organized in a large geographical area and to be always connected to family, peers, communities and most importantly, to share information.[3] In terms of healthcare, smartphone technologies are now used in the diagnosis of diseases, acute and chronic treatment and rehabilitation, and education and training of healthcare practitioners.[4] Besides, the elements of smartphones are now being utilised in the disease prevention or wellness sector.

A recent study by Miller and colleagues,[5] suggested most members of public had favourable perceptions of mobile technology and acknowledge physicians, use of smartphone or personal digital assistant (PDA) in practice. Furthermore, sharing of information obtained from these technologies with patients was welcomed. This should be of no surprise as communication between healthcare professionals and patients forms the essence of effective prevention and management of chronic diseases. However, the current traditional face-to-face system is rather strained with irregular consultations and long gap between encounters.[6] While the key role of traditional face-to-face consultations cannot be denied, inclusion of mobile technologies in the existing system will help to fill the so-called gap in care between encounters. Fortney et al[6] suggested four virtual healthcare utilisation that should be considered in additional to traditional face-to-face encounters - (i) synchronous and (ii) asynchronous (iii) digital patient to provider encounters; digital peer to peer communications and (iv) synchronous digital interactions between patients and computer health apps.

A review of a large pool of mHealth research-related articles (n=117) revealed a majority of the research work was on basic mobile phone features (e.g. SMS) and only 8% of the studies reported the use of smartphone apps.[7] However, the review noted the studies on apps to be relatively newer and there is a shift from assessment of mobile technology to assessment of its impact. Majority of the articles addressed health promotion, self-monitoring and communication and an impressive 60% of the studies reported positive impact of mobile technology-based interventions. Recent evidence of smartphone technology in prevention and management of CMD is explored in this article.

METHODOLOGY

Keywords ("mobile Applications" or "telemedicine" or "smartphone") AND (or "cardiovascular" or "obes*" or "metabolic syndrome" or diabetes or dyslipid* or hypertensi*), with limitation to "reviews", English publications and the last 5 years. Databases searched include OVID MEDLINE, PUBMED, COCHRANE, CINAHL, SCOPUS and PROQUEST. Additional reviews were obtained *via* cross-referencing. The shortlisted reviews including meta-analysis, narrative and systematic reviews were qualitatively evaluated and findings were compared. Reviews that reported solely on other mobile technology such as web-based interventions, phone call follow-ups or text messages, and animal studies were excluded.

Articles that were included in this review (n=26) comprised of apps inventory, narrative and systematic reviews. Of these reviews, 3 reported on nutrition, 4 on physical activity, 1 each on tobacco smoking and cardiovascular, 8 on type 2 diabetes (T2D) and 9 on obesity/weight loss. Manual method and electronic sheets were used to extract the data from these articles. For each study, the citation, type of article, aim, number of studies or apps reviewed, and major findings and conclusion were abstracted. All information was obtained from the published reviews.

SMARTPHONES IN PREVENTION OF CARDIO-METABOLIC DISEASES

Mobile technology has since attempted to address few health behaviours towards prevention of chronic diseases. Twenty-six of 59 trials on mobile technologies were focused on modification of health behaviours.[8] Nutrition, physical activity and tobacco smoking were the health behaviours that have been the focal points in recent years.

Physical Activity

Table 1 summarises reviews and inventories on mobile apps in the area of physical activity. Although the numbers of research using apps are limited,[9] the interest showed in this area of technology is encouraging. Native software developed by King and colleagues[10] in 2008 for PDA was an excellent example of early development of theory and evidence-based apps to encourage participants to be physically active. Participants of this intervention took part on a short survey twice daily to assess the types and context of physical activity, as well as behavioural or motivational factors relevant to them. Social Cognitive Theory (SCT), assessment of barriers and enablers, self-management and goal-setting approach were embedded in the program, and based on these principles, graphical or textual feedback was developed.

An apps inventory by Higgins[11] and Knight et al,[12] found a typical fitness App to be more effective when behaviour change techniques are incorporated, though very few of the apps

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Authors	Type of review	Aim	n	Main findings	Conclusion/Future recommendations
Matthews et al[13]	Article	To review the current state of mobile apps for health behavioural change related to physical activity.	20 articles	• Features of persuasive systems design: ○ Moderate support of tasks, dialogue and social aspects. ○ System credibility support was found to be low.	• Persuasive mobile technology design principles are best used in apps to improve the well being of people.
Higgins[11]	Apps inventory	(1) To investigate if mobile apps can assist patients to reach health and fitness goals; (2) To discuss apps; (3) To give a synopsis of common apps in health and fitness.	131 apps	• Inclusion of evidence-based behaviour change techniques in apps development can improve its effectiveness. • Recommended apps are: ○ Intense cardio – Strava running & cycling, Nike+Running, RunKeeper & Runtastic. ○ Tracking & Analysis – Fitocracy, Map My Fitness, Map My Run& Fitbit. • Data summaries provided by apps able to give valuable information on patients' activities.	• Mobile apps can assist general public with diet, exercise, weight control, sleep monitoring and stress relief. • Fitness apps has the potential in public health, preventive, clinical and rehabilitation settings. • Future research could examine the effectiveness of these apps in changing patients' behaviours and improving their well being.
Knight et al[12]	Apps inventory	(1) To identify evidence-based physical activity apps; (2) To identify technological features in physical activity apps that could improve health outcomes.	379 apps	• 7 apps implemented evidence-based recommendations for resistance training. • Technological features of apps: social networking (n=207); pairing with a peripheral health device (n=61); measuring additional health parameters (n=139). • Only 1 App that referenced physical activity guidelines (150 mins/week of exercise).	• No apps found to adhere to evidence-based recommendations for aerobic physical activity. • There is a lack of evidence-based physical activity apps, which could be an opportunity for future studies.
Bert et al[15]	Article	To explore mobile apps in health promotion (physical activity).	10 articles	• Majority of the apps proposed a range of exercises (gender-specific), assess sports statistics (distance, speed, calories), act as pedometer.	

Table 1: Summary of reviews on smartphone applications in the area of physical activity.

included this element in the design. Social networking, pairing with health device and additional health parameters were some of the common technological features.[12] Despite the potential, there is an acute shortage of evidence-based physical activity apps with importance in persuasive technology design,[13] which could form a basis for future studies.

The applicability and generalisability of the findings are limited as the existing interventions differed according to interfaces, type and frequency of messages, mode of delivery, and use of theoretical background. Although inclusion of other components such as pedometer and accelerometer with smartphone[9] might hold promise for more accurately delivered intervention, there is still no clear evidence if such interventions may work better compared to stand alone interventions.

Nutrition

Literature suggest majority of the nutrition or diet mobile apps to be calorie counters and/or food diaries.[14,15] Self-monitoring apps were found to result in better self-monitoring adherence in addition to dietary and anthropometric changes.[14] An inventory of 91 apps by Martin et al[16] found the apps to suit both public and health professionals use. However, most of the apps were of low quality. The reviews and inventory are summarized in Table 2.

Tobacco Smoking

Although there were plenty of studies investigated the effectiveness of short message services (SMS) as intervention medium, there is a lack of evidence supporting the use of mobile apps in tobacco smoking cessation. A single review[17] on mobile intervention for pregnant smokers highlighted the issues of low enrolment (Table 2). Common tools or feature of these apps include quit date setting, smoking status tracking, cravings management support, quitline referral and tailored components. Heminger and colleagues stressed that the usefulness of the tools and low enrollment issues have to be addressed before the apps' effectiveness can be studied.

Future studies that are aiming to utilise mobile technologies such as apps in prevention of CMD could be more specific in terms of components and aspects of the technology that are useful. More studies should be focused on the native apps or existing apps on its effectiveness on tackling various health behaviours using different mechanism. Cost-effectiveness analysis

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Authors	Type of review	Aim	n	Main findings	Conclusion/Future recommendations
Lieffers et al[14]	Article	To discuss research on mobile apps that records dietary intake.	18 Studies	• 9 studies reported application categories – food database and food photography. • 8 studies evaluated dietary self-monitoring using apps. • One study has tested features of application and self-monitoring.	• Assessments of energy and nutrient intake in food database and food photography apps were correlated with conventional methods. • Self-monitoring apps resulted in improved self-monitoring adherence, anthropometry and/or dietary intake. • Nutrition mobile apps have great potentials in dietetic practice.
Bert et al[15]	Article	To explore mobile apps in health promotion (nutrition).	9 Studies	• Noted the majority of the nutrition apps to be calorie counters and food diaries.	
Martin et al[16]	Apps inventory	(1) To review mobile apps; (2) to make a diagnosis of the quality and validity and (3) review studies witch incorporating apps as part of the methodology.	95 apps	• The use of apps was a good strategy for prevention and management of diseases related to nutrition and lifestyle. • Apps to be used by individuals and/or professionals. • 51.6% of the apps were classified to be of low quality.	• Improved apps (with regards to usefulness and safety) will be useful tools in the healthcare system.
Heminger et al[17]	Article	To summarise mHealth cessation programs for smoking pregnant mothers.	2 Articles	• Lack of evidence to back the use of apps in pregnant mothers. • Common tools - quit date setting, smoking status tracking, cravings management support, quitline referral and tailored components. • The theories used varied. • About half of the apps included content on smoking cessation and pregnancy. • Issue include low enrolment.	• Few apps are available for smoking pregnant mothers. • Prospective studies should examine the usefulness of the apps, and improve enrolment strategies.

Table 2: Summary of reviews on smartphone applications in the area of nutrition and tobacco smoking.

should also be included in future study designs, as the current interventions are severely lacking in area. There is also a gap in evidence in other demographical groups such as children, elderly people and those from lower income groups, which can be addressed in the future research.

SMARTPHONES IN MANAGEMENT OF CARDIO-METABOLIC DISEASES

Mosa et al[18] review on healthcare apps found 15 apps for patients' disease management, which include 7 apps for general healthcare and 6 apps for chronic diseases management. Majority of these apps were available in iPhone Operating System (iOS) platform. There are a considerable number of studies in the management of CMD which investigated the effectiveness and feasibility of smartphone apps in improving clinical outcomes of CMD that requires long-term continuous care.

Cardiovascular Diseases

According to Park and colleagues[19] (Table 3), 6 studies have used apps as primary or at least a part of the intervention program to promote cardiovascular disease-related self-management. The use of multiple modes including SMS, e-mail and apps, and inclusion of behavioural theory may result in better outcomes. Theories that can be considered include Health Belief Model (HBM), or a combination of few behavioural change theories.

Type 2 Diabetes

Type 2 diabetes (T2D) is one of the most popular areas of interest when it comes to apps-based interventions (Table 3). Most interventions using mobile apps showed positive outcomes especially on primary end points such as glycated haemoglobin (HbA1c).[20,21] Interventions that allow interaction between patients and providers were more likely to be effective,[20] while the visual reinforcement was identified as motivational.[22] Blood glucose recording and activity logs were the most common features of commercially available mobile apps for diabetes.[23] Majority (71%) of the mobile phone-based interventions for T2D[24] used study-specific apps with more features than simple SMS. These features (diary/log, reminders, and information/education) varied according to study requirement and many studies had multiple functions. Diary or log was the most common feature (81%) used in the interventions, mainly to empower the participants to self-record data such as blood glucose, calorie/carbohydrate

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Authors	Type of review	Aim	n	Main findings	Conclusion
Park et al[19]	Article	To review studies that have used mobile phone interventions to promote CVD-related self-management.	28 articles	• 12 studies applied smartphone technology – data acquisition/transmission in tele-monitoring programs (n=7); App as part of intervention (n=6) and as primary intervention (n=5). • 7 studies used multiple modalities (SMS, apps, Internet, e-mail) in intervention delivery. • 3 studies using apps were observational, 3 were trials and 2 of the trials combined apps with other modalities. • Use of multiple modalities (i.e. SMS, mobile apps) may provide better outcomes.	• Behavioural change principles to promote and sustain healthy lifestyle habits in people with CVD may result in a better clinical outcomes. • Theories that can be considered include SCT, HBM or a combination of few behavioural change theories. • Qualitative research methods will improve the design, implementation and adherence to intervention.
McMillan et al[22]	Article	To identify the mobile apps that have been used to promote active living in people with T2DM.	9 studies	• 6 studies used mobile apps in the intervention. • The visual reinforcement was identified as motivational. • No studies on effectiveness of the apps in monitoring health behaviours or behaviour change. • No studies focused on decreasing the participants' sedentary behaviour. • The viability and appropriateness of this technology to sustain lifestyle change have not been investigated.	• Individually tailored technology including visual feedback of glucose and activity data increase motivation toward self-management. • Integration of behavioural theories with technology may be more effective.
David et al[21]	Article	To systematically review the recent clinical studies using mobile apps for diabetes management.	21 studies	• 11 studies on used apps – RCT or cohorts with duration of study from 12 weeks to 12 months. • 76% of the studies reported +ve outcomes after mobile apps-based interventions. • "User-friendliness" of an app affected the compliance and outcomes. • Use of diabetes diary apps for self-titration of insulin dose led to significant reduction in HbA1c.	• Apps have an advantage for patient education, care and behavioural modifications. • Apps and tele-consultations fared better than SMS in improving the clinical outcomes.
Garabedian et al[20]	Article	(1) To review the effectiveness of mobile technologies; (2) To explore interaction between people with diabetes, payers and providers with such technology.	20 studies	• Primary endpoints e.g. HbA1c improved in majority of the interventions. • Interventions were likely to be effective if interaction between patients and providers were allowed. • No studies explored regulatory or payer reimbursements.	• Limited evidence on effectiveness of frequent use, use by healthcare provider and the long-term effectiveness. • Future research should focus on valid study design and longer follow-up.
Williams & Schroeder[23]	Apps inventory	To identify common features of popular diabetes apps and recognise improvements to meet the needs of Latinos.	20 apps	• 1/3 of apps available in local language. • Blood glucose recording and activity logs were the most common features. • 10% of apps connected directly with a glucometer. • 30% of apps had medication or blood glucose checking reminder service to prompt patients.	• Diabetes education, reminder service, use of local language (Spanish) and glucometer connectivity are some basic features that can be incorporated in future apps for Latinos with diabetes.
Fijacko et al[26]	Apps inventory	To conduct a review of T2DM risk estimation mobile apps focusing on functionality and availability of information of the risk calculators.	31 apps	• Only 9 apps disclosed the name of T2D diabetes risk calculators. • No apps disclosed users' data being used to improve performance of risk calculator or offer summary descriptive statistics of all users.	• Risk calculation are advised to be upgraded to include information on blood sugar level. • Apps have future potential but developers are not keen on furnishing the methodology used to estimate the risk.

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Huckvale et al[28]	Apps inventory	To conduct systematic review of rapid/ short-acting insulin dose calculator apps.	46 apps	• Calculators used simple mathematical procedures using planned carbohydrate intake and recent blood glucose level. • The setbacks: majority of the apps lacked numeric input validation, did not document formula, recommended in appropriate dose, allowed missing values and used ambiguous terminology. • Only one iOS App was found to be issue-free.	• Lack of appropriate dose recommendation measures, putting users at risk of overdose or suboptimal glucose control. • Recommendation of unregulated dose calculator apps are to be done with caution. • Clinical input during App design stage is vital. • Coordinated surveillance by regulators, health agencies and App stores is required.
Eng & Lee[27]	Apps inventory	To conduct a review of medical apps focused on endocrine diseases	n/a	• More iOS apps instead of Android apps • 33% of iOS apps on diabetes focused on health tracking such as blood sugar and insulin doses, which need manual data entry. • 2 apps were attached to glucometer. • 22% were teaching/ training diabetes apps. • Insulin dose calculators found without any evidence for FDA-approval.	• Great potential for apps in this field. • Challenges faced by the apps include: lack of clinical evidence on effectiveness, lack of integration with healthcare system; lack of scientific evaluation; organised search and potential risk.
El-Gayar et al[29]	Apps inventory and article	To review commercial mobile apps on diabetes self-management.	71 apps 16 Articles	• Self-management tasks involved: exercise, insulin/medication dosage; blood glucose testing and diet. • Support tasks: decision making, notifications, tagging and integration with social media. • Apps usage is associated with improved self management attitudes. • Limitations: lack of personalised feedback, usability, data entry and integration with existing records.	• Future research should explore user-centred and sociotechnical designs to improve usability, usefulness and adoption. • Holistic approach that takes patients 'expectations and providers' needs will result in apps proliferation and efficacy.

Table 3: Summary of reviews on smartphone applications in the area of cardiovascular diseases and type 2 diabetes.

consumption or physical activity. Reminder message was the next popular feature, though only 6 studies used the functions to educate the participants.

Extensive description on one of the apps, Diabeo system has been published.[25] The system helps diabetic patients by calculating and adjusting dosage of insulin required based on carbohydrate intake, pre-meal blood glucose, and anticipated physical activity reported, and automatically adjusts carbohydrate ratio and basal insulin. Further, tele-consultation was given based on the data transferred to healthcare professional. The system has been reported to reduce the cost of care and improves metabolic control for diabetes patients.

There is also a serious lack of evidence-based diabetes risk calculator apps, none of the 9 apps revealed the name or source of the risk calculator.[23,26] Reviews have also caution the use of dose calculator apps, and future apps design to take clinical input into consideration.[27,28] Diabetes education, user-centred and socio-technical system design, reminder service, use of local language and glucometer connectivity are some basic features that can be incorporated in future apps.[23,29]

Obesity

Obesity and/or weight loss is another popular area of interest (Table 4). Mobile apps have been postulated to be useful for self-regulatory strategies for weight loss.[30] However, there is no significant difference in amount of weight lost when use of apps was compared to other self-monitoring methods. Popular apps on health and fitness (n=23) have overall moderate quality, good functionality but low information quality.[31] Common techniques used in existing apps include tracking of food intake and calorie counting to achieve energy deficit.[32]

Stephens and Allen[33] in their review, highlighted a study by Lee and colleagues[34] that used a mobile apps in their game-based weight reduction intervention program for obese adults. The apps provided the intervention participants with diet and exercise games with an avatar that changed according to the current weight of the participants. Despite the small sample size and non-randomised study design, statistically significant decreases in fat mass, weight and body mass index (BMI), and positive user satisfaction was reported.

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Authors	Type of review	Aim	n	Main findings	Conclusion
Semper et al[30]	Article	To systematically review mobile apps that use self-management strategies for weight loss.	29 studies	• Apps maybe useful for self-managing diet for weight loss in overweight or obese adults. • However, there is no significant difference in amount of weight lost when use of apps compared to other conventional self-monitoring methods. • Limitation: variability in study designs and comparator groups.	• Future research should incorporate standard but more rigorous methodology, as well as inclusion of measures of eating behaviour change in addition to weight and BMI measurements.
Bardus et al[31]	Apps inventory	To comprehensively analyse features of popular apps on health and fitness.	23 apps	• 16 apps were free to use. • 19 apps tracked behaviour. • 15 apps addressed combined issues of weight control, physical activity and diet. • Apps had average quality, good functionality but low information quality. • Frequent techniques include goal setting and self-monitoring. • App quality was correlated with technical features and number of techniques. • Apps with tracking used significantly more techniques and scored significantly higher in engagement, appearance and general quality. • Apps that used techniques associated with effectiveness such as goal-setting were rated to have better information quality.	• Despite inclusion of behavioural tracking and behavioural change-related features, most apps assessed have an average quality. • Attention needs to be paid to development of apps with evidence-based content to improve information quality.
Quelly et al[38]	Article	To examine the impact of mobile apps on anthropometry, psycho-social and behavioural outcomes in children and adolescents.	9 studies	• The available evidence is limited and mixed.	• Findings supports further study of the impact on childhood obesity-related outcomes. • Future studies to have on the impact of apps use on motivation and goal-setting behaviour.
Zhang et al[37]	Apps inventory	To evaluate information quality of current bariatric and obesity apps.	39 apps	• Limitation: Lack of appropriate references, disclose of sponsorship and apps modifications.	
Gilmore et al[32]	Apps inventory	To review components of effective weight management technology.	22 apps	• Most of the apps are either free or low-cost – readily available to general public. • Common technique: Self-monitoring done via capturing information on food consumed, calorie counting to achieve energy deficit. • Advantages: inexpensive, ease in delivery and wider dissemination. • Disadvantages: Underestimation of actual energy intake due to self-report. • New studies used apps to objectively assess dietary intake eg. using camera function to capture the food images that are used to estimate calorie and nutrient information.	• Lack of evidence-based apps. • New studies that compares the effectiveness and usability of apps head-to-head with other methods are needed. • Validating assessments of energy intake and expenditure against gold standards could determine the accuracy and relevance of an App. • Future programs should be customised to individual users, partnering with devices that are able to assess weight, activity data and food wireless, besides delivering data-driven feedback to users.
Azar et al[39]	Apps inventory	To evaluate use of features related to theories of behaviour change in diet and anthropometric tracking apps.	23 apps	• *Lose It!* was the top-rated app in behavioural theory and persuasive technology categories. • All apps had poor inclusion of strategies based on behavioural theories.	• Components behavioural theories can be added to apps in the future to enhance the apps' effectiveness. • Expectation of an effective App include: long-term support of behaviour change, triggers and responsiveness to input and increased incentives. • Future studies need to formally identify and evaluate most effective apps features.

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Pagoto et al[35]	Apps inventory	To determine inclusion of commercial weight-loss iOS and Android apps in evidence-based weight loss interventions.	30 apps	• Quality of apps varied. MyNetDiary was the App with highest proportion of evidence-based strategies. • Common features: goal-setting (93%), diet (90%), calorie balance (87%), food item barcode scanner (57%), social media connection (47%), reminders when tracking lapsed (20%). • Only 20% of mobile apps gave users a specific weekly physical activity goals and 3.3% included automated physical activity tracker. • 10% of apps allowed users to record reflections, but no feedback given.	• Behavioural strategies that could improve motivation, reduce stress, social support, eating behaviour, time management and problem-solving were missing in the apps. • Future research should determine the efficacy of these apps with advice and monitoring of healthcare providers.
Stephens & Allen[33]	Article	To systematically review user satisfaction and effectiveness of mobile apps interventions to promote weight loss.	7 studies	• Weight change was the most frequency features (57%). • 71% of the studies reported significant changes in at least one of the following outcomes: of weight loss, physical activity, dietary intake, decreased body mass index, decreased waist circumference, sugar-sweetened beverage intake, screen time, and satisfaction or acceptability outcomes. • Apps interventions were supported by education or additional interventions.	• Future trials should focus on the parts of technology that are effective.
Stevens et al[36]	Apps inventory	(1) To review available mobile apps related to weight-loss surgery and (2) To assess the involvement of healthcare professionals in apps design.	28 apps	• 26 apps were designed for patients' use. • Common features: patient information (10 apps), patient support forums and patient record tools (6 each). • Healthcare professionals were only involved in 12 apps design.	• Apps could provide accurate and reliable information. • Approval from an established bariatric surgical body could improve user confidence.

Table 4: Summary of reviews on smartphone applications in the area of obesity or weight loss.

Goal-setting is the most common feature of commercial weight loss apps, though the quality of existing apps varied.[35] Healthcare professionals were only involved in development of 12 apps.[36] Another inventory on bariatric surgery apps (n=39) found most apps lacked of references, and disclosures of sponsorship among other information.[37] The available evidence on the impact of mobile apps on anthropometry, psychosocial and behavioural outcomes related to obesity is rather limited and mixed.[38] Similar to other conditions, many components of behavioural theories and long-term engagement with users have been suggested to be added to apps in the future to enhance the apps effectiveness.[39]

Other technologies and supporting equipment are also used together with these apps to achieve better clinical outcomes and user satisfactions. Very often, a tailored website is used with the mobile apps for physicians or healthcare provider to follow the patients trends in terms of blood glucose level, blood pressure and physical changes, and then send them personalised recommendations when necessary.[40,41] Low-cost unobtrusive wireless sensors including pedometers and accelerometers, and Bluetooth-enabled glucometers have begun to fulfil the need for better monitoring tools. Continuous data from ankle triaxial accelerometers or Bluetooth-enabled glucometer for example, can be transmitted from the device to smartphone and then to a remote data analysis server.[42] This will allow for quality real-time feedback from the healthcare provider to patients, and such consistent communication has been demonstrated to be of critical importance. WellDoc™ was a successful system which provided real-time feedback on patients blood glucose levels, banking on both Bluetooth-enabled glucometer and mobile apps.[43]

CONCLUSION

The available evidence though limited in number, is pointing towards a new approach in prevention and management of CMD. While the use of traditional mHealth features such as SMS is still prevalent, we can now see a shift towards development and investigation of existing and new apps in preventive and curative care.

There is a growing but limited evidence in support of emerging evidence-based mobile technology for management of CMD. In future, researchers can focus on studies related to on the feasibility and effectiveness of apps on improving self-efficacy of patients with CMD. As most of the reported studies are short-term in nature, long-term effects of apps-driven, evidence-supported and theory-backed intervention with significant sample size that are needed. Acceptability and generalisability of such apps to wider communities, as well as the costs and risks of such interventions should also be studied.

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Accuracy in information given through publicly available apps is important to ensure the users receive well-grounded and established evidence. Incorrect or outdated information from healthcare apps may lead to complications or undesired consequences. Future studies on existing apps should study the structure and features of these apps before adopting it for intervention purpose to avoid such issues. Guidelines on how these apps can be reviewed before used in healthcare setting could also be drafted. In addition to available apps, apps that have been developed for research could be made available for larger population after the effectiveness has been established.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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