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SYSTEMATIC REVIEW OPEN ACCESS

The Integrated Nutrition Education on eHealth Intervention and Its Effectiveness on Improvement of Anthropometric Status and Behavioural Outcomes of Obese Adults: A Systematic Review

Intervention eHealth Terintegrasi Pendidikan Gizi and Efektivitasnya terhadap Perbaikan Status Antropometri and Outcome Perilaku Dewasa Gemuk : Tinjauan Sistematis

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Obesity, Nutrition Education, eHealth, BCT, Behaviour Change Theory

ABSTRACT

Background: The problem of overnutrition has become an epidemic issue at the global level. As one of the effective ways to prevent and overcome obesity, nutrition education is growing by utilizing eHealth media as a message delivery channel.
Objectives: To identify studies that integrate nutrition education with eHealth-based technology in the prevention and control of obesity, behavioral theory and BCT (Behaviour Change Technique), their effectiveness in improving the anthropometric status and behavioral outcomes in obese adults.
Discussion: Article searches were conducted using PubMed, Science Direct, ProQuest, and using manual search Google Scholar in reputable journals in the last ten years, and 17 English articles were obtained. Two forms of communication channels and activities were used to deliver nutrition education messages, namely interpersonal channels and internet-based mass media with or without assistance. Mobile applications were the most widely used as a messaging tool. The most frequently used theory was Social Cognitive Theory, and the majority of BCT were self-monitoring, goal setting, and feedback. The eHealth method (online) gave the same results on anthropometric status, physical activity, and treatment adherence compared to face-to-face (offline) by providing the same BCT-based obesity management intervention.
Conclusions: Integrating nutrition education into eHealth media channels that emphasizes modification of eating behavior and physical activity has a significant effect on improving anthropometric status but was inconsistent on eating behavior and physical activity outcomes in adults with short-term intervention (≤3.5 months/ 14 weeks). This effect will give benefit the outcomes if followed by personal or group mentoring accompanied by well-design BCT.

ABSTRAK

Latar Belakang: *Masalah gizi lebih telah menjadi isu epidemik tingkat global. Pendidikan gizi, sebagai salah satu cara yang efektif diterapkan dalam Intervention pencegahan dan penanggulangan obesitas semakin berkembang dengan memanfaatkan media eHealth sebagai saluran penyampaian pesan.*
Tujuan: *Mengidentifikasi studi yang mengintegrasikan pendidikan gizi dengan teknologi eHealth dalam pencegahan dan penanggulangan obesitas serta bentuk teori perilaku dan teknik perubahan perilaku (Behaviour Change Technique/ BCT) serta efektivitasnya terhadap perbaikan status antropometri and outcome perilaku pada usia dewasa gemuk.*
Ulasan: *Pencarian artikel dilakukan menggunakan data base online PubMed, Science Direct, ProQuest, and pencarian manual menggunakan Google Scholar pada jurnal bereputasi sepuluh years terakhir dan diperoleh 17 artikel berbahasa Inggris. Terdapat dua bentuk saluran komunikasi dan aktivitas yang digunakan untuk penyampaian pesan pendidikan gizi, yaitu saluran interpersonal dan media massa berbasis internet dengan pendampingan dan atau tanpa pendampingan. Aplikasi seluler merupakan media eHealth yang paling banyak digunakan sebagai alat penyampaian pesan. Teori yang paling sering*

digunakan adalah Teori Kognitif Sosial dan mayoritas BCT yaitu self monitoring, goal setting dan umpan balik. Metode eHealth (online) memberikan hasil yang sama efektifnya pada outcome status antropometri, aktivitas fisik dan kepatuhan perlakuan dibandingkan tatap muka (offline) dengan pemberian intervensi manajemen obesitas berbasis BCT yang sama.
Kesimpulan: *Integrasi pendidikan gizi ke dalam saluran media eHealth yang menekankan modifikasi perilaku makan dan aktivitas fisik, diikuti pendampingan baik personal ataupun kelompok disertai BCT memberikan pengaruh signifikan terhadap perbaikan status antropometri dan hasil inkonsisten pada outcome perilaku makan dan aktivitas fisik pada orang dewasa gemuk dalam jangka pendek (≤3,5 bulan/14 minggu).*

Kata kunci: *Obesitas, Pendidikan Gizi, eHealth, BCT, Theory Perubahan Perilaku*

INTRODUCTION

Obesity is a nutritional status condition with a Body Mass Index (BMI) score of >25 kg / m2 which is categorized into overweight (more weight) and obesity[1]. The World Health Organization (WHO) suggests that obesity has become an epidemic issue at the global level as it has continued to triple in prevalence from 1975 to 2016. The trend of increasing the nutritional status of fat in adult individuals aged >18 years also occurred in Indonesia. The prevalence of overweight has almost doubled from 2007 (8.6%) to 2018 (13.6%) and cases of obesity also doubled from 2007 (10.5%) to 2018 (21.8%)[2].

The results of studies from several countries mentioned an increase in BMI scores in individuals during the covid-19 pandemic. On the other hand, the severity of covid-19 was further exacerbated by the presence of obesity [3,4], especially in the younger age group[5], so currently, the implementation of intervention programs related to the prevention and prevention of obesity during the covid-19 pandemic needs to be a concern. In addition to BMI, measurement of the anthropometric status of waist circumference and body composition (example: decreased fat mass) should be considered in helping evaluate the effectiveness of nutritional intervention programs. This is because BMI cannot describe body composition. After all, it is not able to distinguish between muscle mass and fat mass and cannot distinguish the distribution of fat in the body which is an important factor of obesity-related diseases[6–8].

The main factor of obesity is mainly an unhealthy diet and lifestyle. If these two lifestyles are not treated immediately will cause an increased risk of non-communicable diseases (NCD) including type 2 diabetes mellitus, cardiovascular disease, some cancer events, and even premature death[9]. Lifestyle change interventions through improved eating behavior and physical activity are effective approaches to addressing the incidence of obesity and improving health outcomes[10,11]. It takes an approach to be able to increase individual knowledge and awareness of the risk factors of disease events accompanied by ways to realize behavioral changes by the desired goal through nutrition education. The scope of the subject matter in nutrition education is very broad, covering issues around food, food safety, nutrition, and physical activity that encourage a person to live more actively with a healthy diet[12]. In several studies, nutrition education interventions in adults with obesity improve eating habits as well as blood serum markers and body anthropometry[13].

Nowadays, nutrition education media is currently growing, ranging from face-to-face methods to the use of eHealth as a message delivery channel. EHealth is defined as health services and information delivered through the internet and information technology that make a health intervention more accessible. The current condition of the covid-19 pandemic forces every health program planner, especially in the field of nutrition education to adapt to technology to minimize barriers related to distance[15]. Therefore, this systematic review study aimed to answer the following research questions: (1) what were the characteristics of studies that integrate nutrition education in eHealth media? (2) What were the nutritional education materials, use of behavioral change theories, and techniques used in the study? (3) Could integrate nutrition education in eHealth-based intervention media provide the improved anthropometric status (BMI, waist circumference, and percent body fat), changes in eating behavior, and physical activity?

METHODS

This systematic review used three electronic databases: PubMed/Medline, Science Direct, and ProQuest. Keywords used in article searches were a combination of the words nutrition education, eHealth, adult, obesity, body mass index, body composition, and weight loss by using boolean operators "AND" and "OR" to provide narrower and more productive searches conducted in the period April 1st-June 15th, 2021. Manual searches for relevant studies were also performed from the article reference list in Google Scholar. The selected article was an English-language article in the last ten years (2011-2021) and was fully accessible and published from a reputable journal indexed Scopus based on Scimago journal rank (SJR). The reason for the selection of the last ten years was to consider that the results of this library review were expected to be recommendations for further studies related to eHealth-based nutrition education services in Indonesia with the pace of technological development that can be implemented by Indonesia as a developing country.

The inclusion criteria used in this literature review were: (1) include nutritional education interventions in the form of eHealth in experimental studies of obesity prevention and/or management; (2) the age of participants ≥18 years which was an adult age category[16]; (3) studies reporting one or all of the measurements of anthropometric parameters (body weight, BMI, waist circumference and body fat percentage); eating behaviors (consumption of vegetables and fruits, sugary drinks and diet quality);

and/or physical activity. The exclusion criteria in the article search were experimental studies with respondents who had degenerative diseases such as cardiovascular disease, endocrine gland, and neoplasmic disorders as well as bariatric postoperative patients. E-Health intervention studies that did not integrate nutrition education as a major intervention component or part of the study were also excluded from this review. Based on our definition in this systematic review study, eHealth-based nutrition education interventions cover all types of technology channels used as nutritional education messaging media, aimed at assisting respondents in weight loss and anthropometric parameter improvement, supporting a healthy diet, and increased physical activity. Nutritional education interventions delivered using eHealth media may be stand-alone or be part of other multicompetital interventions. This literature study only conducts systematic literature reviews and did not combine data in a meta-analysis.

RESULTS

Study Selection

Based on search results from electronic databases and the manual references the addition, obtained as many as 670 articles relevant to keywords. After eliminating duplication articles, 587 articles were obtained which were then screened to see the suitability of the title and abstract with the purpose of this study and obtained a total of 116 relevant articles. The next stage was to conduct the selection of articles that could be accessed in full as well as a further review of the content of the article based on the criteria of inclusion and obtained the final results of 17 relevant articles. Figure 1. shows a flowchart of one study selection process.

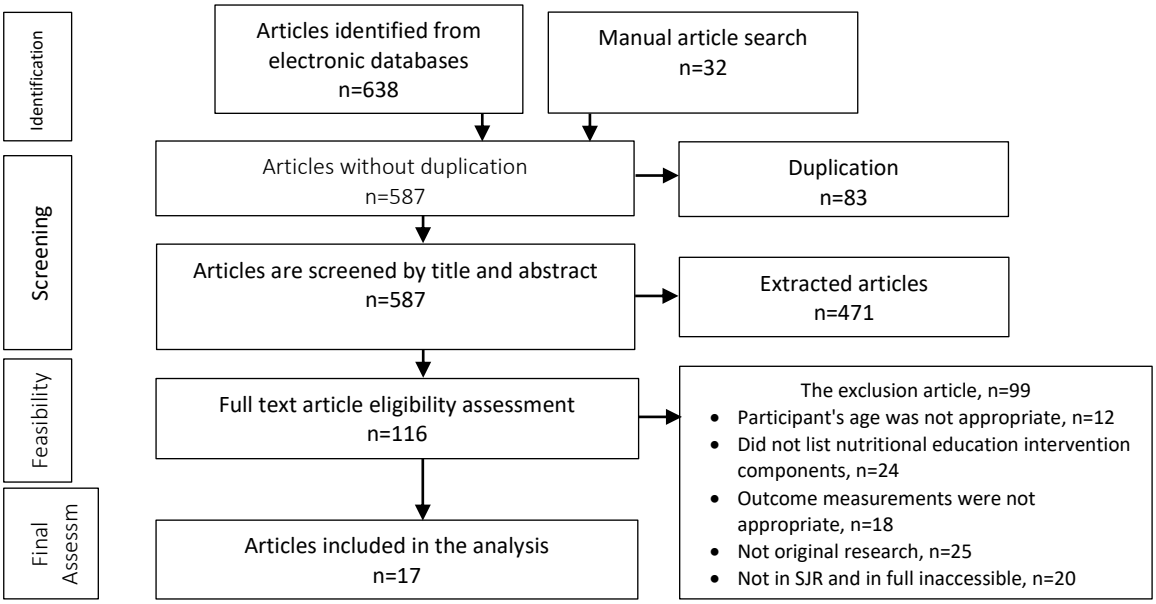

Figure 1. Flowchart of the study selection procedure

Table 1. The general characteristics of the study based on references, participants, treatment and duration control, educational media and outcome)

No	Study References	Characteristics of Participants	Treatment and Duration Control	Educational Media	Outcome
1	Harvey-Berino et al, 2012, US[17]	• Male and female (n=336) • 18–35 years • BMI<18,5; 18,5-25,0; and ≥25 kg/m^2	1 quasi-experimental pre-post study group; 12 weeks	website	Bodyweight, BMI
2	Svetkey et al, 2015, US[18]	• Male and female (n=365) • 18–35 years • BMI ≥25 kg/m^2	3 RCT groups. 6, 12, and 24 months	The mobile app, phone	Weight, diet quality, physical activity
3	Naimark et al, 2015, Israel[29]	• Male and female (n=99) • ≥18 years • Average BMI 25-26 kg/m^2	1 RCT group. 14 weeks	website	Weight, waist circumference, nutritional knowledge, diet quality, physical activity

No	Study References	Characteristics of Participants	Treatment and Duration Control	Educational Media	Outcome
4	Martin et al, 2015, US[19]	• Male and female (n=40) • 18–65 years • BMI 25-35 kg/m^2	2 RCT groups. 12 weeks	mobile apps, text messaging, email, phone	Weight, waist circumference
5	Oh et al, 2015, Korea[30]	• Male and female (n=334) • ≥20 years • BMI ≥25 kg/m^2	2 RCT groups. 24 weeks	The mobile app, phone	Weight, BMI, % body fat, eating habits
6	Allman-Farinelli et al, 2016, Australia[31]	• Male and female (n=354) • 18-35 years • BMI 23-31.9 kg/m2	2 RCT groups. 12 weeks	The mobile app, phone, text message, email, booklet, website	Weight, physical activity, eating behavior
7	Alencar et al, 2017, US[20]	• Male and female (n=25) • 18-65 years • BMI ≥30 kg/m^2	2 RCT groups. 12 weeks	video conferencing, mobile app, website	Weight, % body fat
8	Gomez-Marcos et al, 2018, Spanyol[21]	• Male and female (n=833) • 18-70 years • Average BMI 27-28 kg/m^2	2 RCT groups. 3 and 12 months	The mobile app, a printed brochure	BMI, waist circumference, % body fat
9	Taetzsch et al, 2019, US[22]	• Male and female (n=43) • ≥18 years • BMI ≥25 kg/m^2	2 groups quasi-experimental study. 12 weeks	video conferencing	Bodyweight
10	Thomas et al, 2019, US[23]	• Male and female (n=270) • 18-70 years • BMI 25-45 kg/m^2	3 RCT groups. 18 months	mobile apps, printed modules, face-to-face	Bodyweight, BMI
11	Lison et al, 2020, Spanyol[24]	• Male and female (n=105) • 18-70 years • BMI 24.9-35 kg/m^2	2 Randomized wait-list controlled trial groups. 3 and 9 months	website	BMI, physical activity
12	Duncan et al, 2020, Australia[32]	• Male and female (n=116) • 18-65 years • BMI 25-40 kg/m^2	3 RCT groups. 6 and 12 months	mobile apps, email, SMS, printed modules, face-to-face	Weight, waist circumference, physical activity, energy intake
13	Das et al, 2017, US[25]	• Male and female (n=644) • ≥18 years • BMI <25; 25-39,9; and ≥40 kg/m^2	4 pre-post study group 11 weeks	video conferencing, face-to-face, website	Weight
14	Haas et al, 2019, Swiss[15]	• Male and female (n=116) • ≥18 years • BMI 26-33 kg/m^2	1 pre-post pilot study group. 3 and 12 months	mobile app	Weight, BMI, waist circumference, % body fat
15	Huber et al, 2015, US[26]	• Male and female (n=116) • 18-55 years • BMI ≥25 and ≤39,9 kg/m^2	2 RCT groups. 12 and 24 weeks	telephone	Weight, BMI, waist circumference
16	Vadheim et al, 2017, US[27]	• Male and female (n=894) • ≥18 years • BMI ≥24.0 kg/m^2	2 pre-post study groups. 16 weeks	video conferencing, face-to-face	Weight, BMI, physical activity
17	Whitelock et al, 2019, UK[28]	• Male and female (n=107) • 18-65 years • BMI ≥25.0 kg/m^2	2 RCT groups. 8 weeks	The mobile app, print booklet	Weight, % body fat, energy intake

Study Characteristics

The general characteristics of the research included in this systematic review study can be seen in table 1. A total of 13 studies came from countries in the European region[15,17-28] and the rest (n=4) came from countries in the Asia Pacific region[29-32]. The population group that was a study participants were all men and women who specifically targeted the criteria of BMI ≥23 kg/m^2 (n = 16), the rest conducted a general selection of participants who were then classified in the BMI category in a certain rangef[17,29,21,25]. The majority of studies used

randomized controlled trial (RCT) designs in three groups (n=3) [18,23,32] and two groups (n=10) [19-21,24-26,28-29,30-31,]. Four studies using quasi-experimental designs were conducted pre-post on one group (n=2) [17,15] and two groups (n=2) [22,27]. The duration of the intervention varied from the range of 8 weeks to 24 months. Although there was a repetition of outcome measurements at a certain time, the majority of outcome measurement evaluations were conducted in the short term ≤3.5 months / 14 weeks (n = 12) [15,17,19-22,24-26,28-29,31].

Some studies used 2 to 3 media as channels of communication and activity in the delivery of nutrition education messages and behavioral changes in one intervention period, either given mentoring or independent tasks that must be done by participants in the intervention group. The use of a combination of interpersonal nutrition education methods through telephone/face-to-face personal counseling/group discussion/email with websites/mobile apps/print modules was found in five studies[18, -23,30-31]; a combination of video conferencing with mobile application/website/ mail/printed module in three studies[20,25,22]; and a combination of websites and emails in one study[24]. Two studies used≥4 educational media, namely a combination of mobile applications/print media (booklets, leaflets, modules)/email/text messages/counseling by phone or face-to-face[19,31,32]. There were six studies that used only one eHealth medium in its intervention group, namely mobile apps (n=1) [15]; phone (n=1)[26]; website (n=3) [17,24,29] and video conferencing (n=1) [27]. Overall, the most widely used media in the intervention group was mobile apps (n=10) [15,18–21,23,28,30–32].

Nutrition Education Materials

Nutrition-related materials provided to participants in this systematic review study generally included study materials related to basic nutrition science principles, modification of food consumption patterns, and other recommendations related to obesity management, including calorie deficit material and low-calorie food selection (n=7)[17-18,20,24-26,28]; types of nutrients and nutritional value of foodstuffs (n =8) [15, 27,29-30,20,22,24-25]; control and portion size of meals (n=4)[19,25,15,27]; additional education related to hunger management, stress and psychological variables (n=7) [15,19-20,25, 27-28,32]; how to calculate the calories of food (n = 2)[23,29]; energy density (n=2)[15,31]; restriction of fatty and/or sweetened foods (n=5) [17,19, 23,28,31]; the importance of vegetable and fruit consumption (n=3)[17,28,31]; read the food label (n=1)[20]; meal timing (n=1)[15]; and compiled a grocery shopping list (n=2)[15,28]. There were five studies that provide recommendations for food consumption based on applicable guidelines, consisting of dietary approaches to stop hypertension/DASH Diet[18], Dietary Guidelines for Americans 2010[29], American Heart Association's[19], Mediterannean Diet[21], and Australian Dietary Guidelines32.

The entire study in this systematic review provides educational materials related to physical activity and sports. Common materials provided in these 17 studies were information on the importance of physical activity, activity recommendations and/or strategies without setting daily and/or weekly (n=10) [15,17,20,22,24-25,28-30,32], calorie increases, neat calorie increases (n=1)[20], how to measure exercise intensity (n=2)[20,24] and recommendations for resistance training (n=1)[32]. Seven other studies added information in the form of recommendations for physical activity time of 60 minutes/day (n=1)[31]; moderate to high intensity exercise in four studies with a time of >180 minutes/week (n =1)[18] and 150 minutes/week (n=3)[21,26-27]and high intensity 60 minutes/week (n=1)[21]; 10,000 steps/day (n=2)[19,21]; as well as physical activity 5x/week without old recommendations and intensity of exercise (n=1)[24]. Some of the topics of nutrition education and physical activity materials in these 17 studies were further used as goals and became a tool for self-monitoring of participants through recording food consumption behavior and physical activity. In addition, obesity management methods based on behavior change techniques with the addition of sleep quality regulation interventions did not provide significant results compared to standard methods that emphasized only dietary regulation and physical activity[32]. A comprehensive review of the study can be seen in table 2.

Integration of Theories and Techniques of Behavior Change

Six studies used the theory of behavior change, which uses the integration of two theories (n=2)[18,32], and four other studies used only one type of theory in their intervention[17,19,29,31] (Table 2). All of these theory-based studies had used a combination of nutritional education and physical activity materials with behavior change techniques and overall had positive results for improvements in anthropometric status (weight loss, % body fat, waist circumference) and eating behavior (diet quality, eating habits) and physical activity (increased exercise time and activity) with assistance (n =5) or independent (n=1)[29]. Studies that did not explicitly report behavioral change theories were 11 studies, with results varying against several outcomes of anthropometric and behavioral status improvements, i.e. significantly positive (n=5)[15,20,24,26,30] and insignificant (n=6) [21-23,25,27-28].

The whole study used behavior change technique (BCT) strategies in their implementation, but the most widely used in this review were self-monitoring (n=17), goal setting (n=13), and feedback (n=12) through automatic behavioral recording into a mobile application integrated with a weighing tool or pedometer (n=2)[19,21]or manual recording using a notebook/journal (n=2)[26,23]. Other methods of recording behavior were using websites or emails (n=4)[17,22,25,27] and other studies did not explicitly mention recommendations or the use of media for behavioral recording. Variables recorded as self-monitoring mater for all participants in the majority were weight, type, length of physical activity, and daily food consumption.

Table 2. Comprehensive review of studies

No.	Study References	Theories and Techniques of Behavior Change	Nutrition Education Materials	Form of Mentoring	Result
1	Harvey-Berino et al, 2012, US[17]	Theory: • Social Cognitive Theory Technique: • Self-monitoring, stimulus control, problem-solving, goal setting, relapse prevention, assertiveness training	Via website • The basics of obesity management, • Modification of diet and exercise • The basis of behavior modification includes how to shape behavior, provide feedback and help students achieve goals.	• Education classes/groups directly/offline on 15-20 people every week for 12 weeks face-to-face • Bulletin boards on websites as a media of group communication	• Obtained weight loss average of 2.3±2.7 kg (range of -13.1 to +3.2 kg) • Students'ts with BMI of 25-29.9 kg/m2 lost weight and 2.7% and BMI of>30 kg/m2 lost weight and 3.0% of the initial body weight.
2	Svetkey et al, 2015, US[18]	Theory: • Social Cognitive Theory and Transtheoretical Model Technique: • Goal setting, self-monitoring, social support, feedback	General education in the Cell Phone (CP) and Personal Coaching (PC) intervention group deficit calory • Healthy Diet (DASH Diet) • Create behavioral targets: >180 minutes/week of physical activity, monitoring the weight, food consumption, and physical activity. CP intervention: mobile app • Based on usage guidelines in the app and create behavioral targets. PC intervention: phone • Guide to targeting behavior over the phone Control: Handout	CP intervention • Self-learning using features available within the app PC intervention • Group education sessions every week (1x/week) for 6 weeks • Counseling by phone 1x/month • Recording of in-app behavior as directed by the counselor during a telephone assistance session *Control* • Receive 3 handouts without being asked to do self-monitoring	• There was a reduction in weight in the CP intervention group at each time of measurement (-0.87, -1.48, and -0.99 at 6, 12, and 24 months) and this hail was no different from the control group. • The PC intervention group experienced greater weight loss (-3.07, -3.58, and -2.45 at 6, 12, and 24 months) and these results differed significantly from controls at 6 months (p<0.001) and 12 months (p=0.0025). • There was no significant difference in average weight loss, diet quality score (HEI), and physical activity in the 24th month in each group.
3	Naimark et al, 2015, Israel[29]	Theory: • Control System Theory of Self Regulation Technique: self-monitoring, feedback,	Direct general education (offline) • Healthy lifestyle • Nutritional recommendations for health • Clinical benefits of weekly physical activity. Intervention: website • Collection of articles "Healthy Nutrition" in application: the importance of nutrients and food sources • Calculation of calories of food and energy expenditure from physical activity Control: Not accepting any intervention	Intervention group participants conducted direct self-learning by accessing unaccompanied application features	• There was a significant difference in the intervention's weekly physical activity time (63 minutes) versus control (-30 minutes) (p=0.02). • There was a significant difference in weight change in the intervention group (-1.44kg) versus the control (-0.128kg) (p=0.03). • Knowledge scores (76 to 79; p=0.04) and dietary quality (67 to 71; p<0001) improved significantly in the intervention group
4	Martin et al, 2015, US[19]	Theory: • Learning theory	Primary education Intervention: mobile apps, phone, email, text messaging	Intervention	• There was a significant difference in waist circumference reduction in week 12

No.	Study References	Theories and Techniques of Behavior Change	Nutrition Education Materials	Form of Mentoring	Result
		Technique: feedback, goal-setting, self-monitoring, strengthening	• How to do weight weighing and read weight charts • Instructions to increase physical activity • American Heart Association's diet Additional Education Intervention • Portion control reduced eating out, consumption of sugary beverage foods, Delivery of food photos • Physical activity (10,000 steps) Control: text message and email • Stress management, healthy eating patterns in general, exercise, and sleep quality	• Recommendations 1 time/week based on heavy graph data by email, text message, or phone • If the development of participants is not by the recommended graph, then additional assistance is provided Control: • There's no mentoring. The number of text messages and emails received was the same as during the intervention.	between the intervention and control group (p<0.05) with a value of -6.9 cm in the intervention and 1.7cm in the control • There was a significant difference in the weight loss in the 12th week (p<001) with a value of -9.4 Kg in the intervention and -0.6 Kg in the control • In the intervention group, 80% of participants experienced a decrease in weight >5% and 50% of participants >10%. In the control group, no one >5%.
5	Oh et al, 2015, Korea[30]	Theory: • - Technique: feedback, goal-setting, self-monitoring	Intervention: mobile app, phone • Disease management, health education, sports recommendations, treatment, nutritional sciences (proper nutrition) Control • Basic information about physical activity • Control of eating habits	Both groups received direct/individual counseling four times over 24 weeks. The intervention group was given additional counseling by phone/individual according to the participants' wishes.	•Weight loss of 2.21 kg (SD 3.60) at intervention and 0.77 kg (SD 2.77) in control in the 24th week •There were significant differences in intervention and control in BMI (p<001), body fat p=0.001, waist circumference (p<0001), and eating habits (p=0.012) in the 24th week with a larger intervention group
6	Allman-Farinelli et al, 2016, Australia[31]	Theory: • Transtheoretical Model Technique: • Self-monitoring, social networking	Interventions: mobile apps, phones, text messages, emails, booklets, websites • Core foodstuffs, energy density, recommended amount of vegetable and fruit consumption, high-fat and high energy foods, sugary beverages, and eating out rules • Importance of physical activity 60 minutes/day Controls: text message, website, phone	Intervention • Intensive phase: 8 SMS/week, 18 handouts, 1 email/week, coaching calls in weeks 2, 5, 8, and 11. • Maintenance phase: 1 SMS, 1 email/month, booster calls 5th month & 8th month Control • Intensive phase: 4 SMS/week, 2 handouts, phone at the beginning with no advanced mentoring phone • Maintenance phase: -	• There was a significant change in weight loss in the intervention compared to the 12th-week controls (model β=−3.7, 95% CI −6.1 to −1.3) and after the 9th month (β=−4.3, 95% CI − 6.9 to − 1.8). • Interventions were more likely to meet the recommendations of fruit consumption (OR 3.83, 95% CI 2.10-6.99) and vegetables (OR 2.42, 95% CI 1.32-4.44). There was no significant difference in physical activity between the groups.
7	Alencar et al, 2017, US[20]	Theory: • - Technique: Self-monitoring, goal setting, feedback	General Education • Calorie deficit diet, Daily calorie recommendations, Physical activity instructions	Intervention • Receive mentoring and feedback 1 time/week. Control • No weekly assistance	• There was a significant difference in weight loss with the intervention group greater (7.3±4.4 kg) than the control (1.5±4.1 kg) (p<0.05).

No.	Study References	Theories and Techniques of Behavior Change	Nutrition Education Materials	Form of Mentoring	Result
			• Interventions: video conferencing, website, mobile app • Read labels, eat intuitively, fiber, hydration, macronutrients and calorie calculations, physical activity instructions, NEAT calories, problem-solving, measuring exercise intensity and nutrition • Gain support, overcome obstacles, goal setting, and stress management Controls: mobile app, video conferencing at the beginning only.		• There was a significant difference in body fat percent reduction with the intervention group experiencing a greater average decrease (-9.0±8.3%) than the control (1.3±7.7%) (p<0.05). • There was a significant difference in the number of weekly steps with the intervention group higher (30,163.8±30,117.6) versus the controls (-5,972.0±22,286) (p<0.05).
8	Gomez-Marcos et al, 2018, Spanyol[21]	Theory: • - Technique: goal setting, self-monitoring, feedback	Personal general education: 30-minute face-to-face counseling • Physical activity and the Mediterranean diet • Daily physical activity: 30 minutes of moderate activity 5 hr mg; 20 minutes of high activity 3 hr/mg or 10,000 steps/day. Intervention: mobile app, a printed brochure Control: printed brochure	Intervention • Application use training assistance at the beginning • visits 1 week after use to ensure there are no difficulties in use. Control • No assistance	• In the 3rd month, only a significant female BMI score on Intervention (p<0.05) with a decrease of 0.7% (95% CI: −0.27 to −0.04) • BMI score increased by 0.7% on Control (95% CI: 0.01-0.29) month 12 • There was a significant reduction in waist circumference of -0.72 cm (95% CI: -1,888 to -0.160) and body fat of -0.35 (95% CI: -0.923 to -0.075) only in females subjects in the Intervention group.
9	Taetzsch et al, 2019, US[22]	Theory: • - Technique: • Goal setting • Self-monitoring	Intervention: video conference, email • Nutrition education (example: nutritional content of foodstuffs), physical activity, and behavior • Additional visuals (example: choosemyplate.gov) Control: Written journal, email • Nutrition education, physical activity, and behavior are the same as the intervention	Intervention •Weekly feedback and recommendations via email from online record keeping. Consultation is not time-limited. Control • Feedback during weekly sessions through written recommendations in participant monitoring journals and weekly emails	• Both groups had significant weight loss percentages in week 12 (p<0001) • There was no significant difference between the weight (6.2±3.2% and 5.3±3.4%) of the offline group and the online in the 12th week (p=0.60) • Online methods with effective video conferencing are feasible for use in healthy weight management
10	Thomas et al, 2019, US[23]	Theory: • - Technique: • Self-monitoring, goal setting, stimulus control, feedback	Group-based intervention (GROUP): face-to-face • Content from the Diabetes Prevention Program (DPP) and Look Ahead Trials • Low-fat diet (<30% of calories from fat), menu planning, calorie and fat calculation of foodstuffs and recorded in self-	GROUP • Group discussion sessions of 15-20 people 1x sessions/week for 6 months, followed by the second 6 months every 1x sessions / 2 weeks and the last 6 months 1x session/month. Led by dietitian and	• The weight loss in the SMART group (5.5 kg (95% CI, 3.9 to 7.0) was no different from GROUP (from 5.9kg (95% CI, 4.5 to 7.4kg). Contrary to expectations, Control experienced a considerable weight loss (from 6.4kg (95% CI, 3.7 to 9.2kg) which was no different from the SMART group.

No.	Study References	Theories and Techniques of Behavior Change	Nutrition Education Materials	Form of Mentoring	Result
			monitoring books • Building the ability to behave: physical activity, problem-solving, restriction of fried foods Smartphone-based intervention (SMART): a mobile app • General education is the same as GROUP with different methods (video skill training and recording on MyFitnessPal) Control • Print out educational materials: benefits of weight loss, healthy eating patterns, and routine physical activity habits	exercise experts. • Feedback on recommendations from record-keeping results SMART • video skill training duration of 5 minutes for 3x/week in the first 6 months, then 2x/week in the second 6 months, and 1x/week in the third month. • Feedback in the form of recommendations • 10-minute/month consultation session. Control • 10-minute/month education sessions to evaluate progress goals	There was no significant difference between the three groups. • Online weight loss management methods provide results that were as good as conventional methods according to standard gold.
11	Lison et al, 2020, Spanyol[24]	Theory: - Technique: Self-monitoring, self-instruction, behavioral recording, stimulus control, self-reinforcement, problem-solving homework, homework	General Education •Risk of cardiovascular disease • Healthy lifestyle recommendations, salt restrictions, food recommendations, low-calorie diets, 5x/week physical activity recommendations, and maximum heart rate recommendations during exercise. Intervention: website •9 modules: obesity and hypertension materials, building healthy eating habits, and increasing physical activity •Psychoeducation about healthy lifestyle and behavior change techniques, documents, and videos. •Control: not giving additional education	Intervention • No special assistance, only technical assistance of research with online module delivery with the first 5 modules 1x/week and modules 6-9 given every 2 weeks. • Email notifications of each module have been sent • The team contacted participants only if they stopped using the module >2 weeks after the module was delivered and followed up on the technical difficulties of the study after 3 weeks of delivery	• Significant reduction in BMI, and body fat mass at 3 months in the Intervention group. Effect size BMI and moderate to high body fat mass. These results were maintained and improved in T-2 and showed significant changes in BMI (mean difference −0.4, 95% CI −0.1 to −0.6; P=.005), body fat mass (mean difference −2.4, 95% CI −1.1 to −3.6; P<.001),
12	Duncan et al, 2020, Australia[32]	Theory: • Social cognitive theory and Self-regulation theory Technique: • education, goal-setting, self-monitoring, feedback	Enhanced & Traditional: mobile apps, email, text messaging, modules, counseling sessions • Handbook: instructions for goal setting, action planning, stress management, healthy eating advice, and resistance training	• Email 1x/week summary of goals-related behavior that has been included in the application • 1x/week SMS text messages about weight loss facts • Participants who stop accessing the application (≥4/7 days/week)	• No significant difference in weight Intervention (enhanced & traditional) with Control (difference -0.92. 95% CI (-3.33, 1.48)) in the 6th and 12th months (difference 0.00, 95%CI (-2.62, 2.62)) • Compared to Control, the Intervention group significantly increased resistance

No.	Study References	Theories and Techniques of Behavior Change	Nutrition Education Materials	Form of Mentoring	Result
			• Personal counseling: Australian Dietary Guidelines and Australian Guide to Healthy Eating recommendations Additional education for *Enhanced* • Sleep quality, bedtime feedback, relaxation techniques, stress management	will be sent an SMS for compliance reminders	training (OR=7.83 (95% CI 1.08, 56.63)) and decreased energy intake in the 6th month (-1073.03 (-2028.84, -45.22))
13	Das et al, 2017, US[25]	Theory: - Technique: • Self-monitoring, goal setting, strengthening	• Principles of nutrition and weight management: calorie deficits, macro, and micronutrients • Healthy and unhealthy foods • Management of hunger and food cravings • Portion control • Consistency of behavior	• 1-hour/week group meeting in-person/video conference/community/workplace • Communication via message boards on the website with group leaders or other participants	• The percentage of weight loss was significantly higher at the age of ≥30 than <30 years (+2.2%, p<0.001) • Participants at work had a higher weight loss (+1.2%, p<0,001). • There was no significant relationship between the types of program implementation methods (video conference VS face-to-face)
14	Haas et al, 2019, Swiss[15]	Theory: - Technique: • Self-monitoring, goal setting, stimulus control, alternative strategies, feedback, positive reinforcement, consistency	• Negative energy balance • Dinner plate model (Swiss version) • Portion sizes • Eating rhythm • The density of food energy • Quality of carbohydrates, fats, carbohydrate modification diet • Sufficient source of protein • Understanding the situation within yourself (emotional eating, celebrations, holidays, strong eating cues) • Food shopping • Physical activity	Initiation Phase (weeks -2-0) Phase 1: Transition (months 1-3) • service via application 5x/ week • nutritional feedback and physical activity, determination of 1-2 goals for 2 weeks, evaluation of goals and adaptation, information and educational materials according to goals • 1x skype call Phase 2: Stabilization (months 4-6) • 3-week application services behind nutrition and physical activity, strengthening new behaviors, setting goals, evaluation, and educational materials • 1x Skype call, communication with group friends (guided coach) • Phase 3: Maintenance (months 7-12) • service via application per 2 weeks • nutritional feedback and physical activity communication with group	• There was a significant difference in the weight change of the 12th week with a median of -3.8 kg (-15 to 2.4, p<0.001) and week 52 -4.9 kg (-21.9 to 7.5, p<00.001). • There was a significant difference in median BMI change (1.4 kg/m2, range of -4.5 to 1.1, p<0.001); waist circumference (-3.5 cm, range -23 to 5, p<0.001); %body fat (-2.3kg, range -7.6 to 2.5, p<001) at week 12 and also seen in week 52. • There was a significant difference in eating habits to be healthier (fruit and vegetable consumption, breakfast, reduction of alcohol and sugary drinks and fatty foods) in the 12th week (p<001) and 52nd (p<0.001). There was no significant association of changes in physical activity between baseline and weeks 12 and 52.

No.	Study References	Theories and Techniques of Behavior Change	Nutrition Education Materials	Form of Mentoring	Result
				friends, educational materials via web-based	
15	Huber et al, 2015, US[26]	Theory: • - Technique: • Self-monitoring, goal setting, feedback,	Intervention: telephone • Calorie deficit • Motivational interviews focus on improving healthier lifestyles, identifying barriers, problem-solving, goal setting • Strategies to achieve deficit calorie and exercise targets Control: Pamphlet	• Telephone counseling 1x/ 2 weeks for 3 months making a total of 7x phone calls • Average phone duration of 20 minutes • Monitoring the progress of participants to the targets that have been made and the determination of planning for the next 2 weeks.	• There was a significant difference in the reduction in BMI Intervention score (-0.4kg/m2, p=0.038) 3rd month versus Control. However, this result is not significant in the 6th month. • In women, Intervention treatment was significantly associated with a reduction in the weight of baand (-1.6kg, p=0.016) and BMI (-0.6kg/m2, p=0.020) in the 3rd and 6th months (-2.3kg, p=0.013 and -0.8kg/m2, p=0.025).
16	Vadheim et al, 2017, US[27]	Theory: • Technique: • Goal-setting, self-monitoring, strengthening	General material Core Topic • The fat content of food, Foods rich in nutrients, regulation of portions of food • Physical activity and exercise • Stress management and problem-solving Additional Topic (Choice) • How to cook healthy, Understand cardiometabolic risks, Mindless eating • Intervention: video conference Control: Face-to-face	Core Curriculum • Group assistance for offline sessions for b3-25 people and online sessions for 8-12 people, for 16 sessions/week Additional Curriculum • Mentoring 6 sessions for 6 months with topics according to the needs of participants in the group. Supervision of physical activity for at least 2 sessions/week	• There was no significant difference in the number of attending sessions of participants, weight loss, and BMI score between the group and offline and online methods. • There was no significant difference in the number of participants with a weight loss of ≥5% between the group with offline (56%) and online (57%) or ≥7% (38% vs. 41%) methods.
17	Whitelock et al, 2019, UK[28]	Theory: • - Technique: • reminder messages, self-monitoring, reinforcement	Nutrition Education Print Booklet (British Heart Foundation) • Balanced nutritional diet, calorie deficit, and low-calorie selection, Consumption of vegetables and fruits, Avoiding high-sugar and fat beverage foods • Make a shopping list, Rules on eating out, Importance of physical activity • attentive eating Intervention: booklet, voice, and text messaging, a mobile app with the addition of attentive eating material Control: booklets, text messages, mobile apps without attentive eating materials	• No assistance	• There was no significant difference in weight loss Intervention and Control (p=0.89) in week 8. • There was no significant difference in energy intake (p=0.67) and percent body fat (p=0.81) between the Intervention and Control group • Intervention-based attentive eating using mobile apps did not have a significant effect on the greater reduction in energy intake and weight at week 8 than the general standard diet recommendations.

Effectiveness of Study Interventions with Short-Term Duration (≤3.5 months / 14 weeks)

Of the 13 studies that had a short-term duration of intervention, 10 studies reported variable weight as anthropometric outcome status with six studies explaining weight loss values ranging from -1.2 kg to -9.4 kg[15,17,19-20,28-29] and others only explaining the % of significant weight loss without explaining how much the reduction in kilograms (kg) (n=3)[22,25,31]. A total of 5 studies reported BMI outcomes and overall showed significant score reductions in the range of -0.16 to -1.4 kg/m^2 [15,17,21,24,31]; significant waist circumference variables in the three studies[15,19,21] and insignificant in the two studies[26,29] with decreases in the range of -1.4 to -6.9 cm; and variable % body fat was significant in three studies[15,20,21] and not significantly in one study[28] with a decrease in the range of -0.24 to -9.0%. Eating behavior variables were only reported in four studies, related to fruit and vegetable consumption which reported more significantly met the recommendations in the intervention group (n=2)[15,31]and consumption of fat and sweetened beverage foods significantly decreased (n=1)[15], and there was no significant difference in energy intake (n=1)[28]. Physical activity variables were only reported in two studies with no significant changes in both the intervention group and control[24,31] but still saw an increase in moderate-intensity physical activity of 12 minutes/day in the intervention group versus control[31]. Nutrition education interventions delivered single-handedly using one eHealth medium provided results as well as multicomponent eHealth media interventions to improve anthropometric outcome variables with different magnitudes of decline in each study with short-term duration.

Effectiveness of Study Interventions with Long-Term Duration (≥4 months / 16 weeks)

There were 10 studies that evaluated outcomes at several points in the long-term duration category with measurement times at 4 months (n=1)[27], 6 months (n=4)[18,26,30,32], 9 months (n=2)[24,31], 12 months (n=4)[15,18,21,32], 18 months (n=1)[23], and 24 months (n=1)[18]. In this long-term study, the use of two nutritional education media in the intervention group (phone application and mentoring) (n=2)[18,30] provided significant

EHealth media used as a communication channel for delivery of nutritional education messages in some studies was stand-alone or multicomponent with the most widely used medium in intervention groups being mobile applications. Nutrition education materials containing the topic of the nutritional value of foodstuffs accompanied by daily calorie restriction as well as information on the importance of physical activity and recommendations for physical activity/exercise accompanied by BCT with or without daily targets were the most widely used as nutritional education materials in eHealth-based interventions in this review. Calorie deficits with increased physical activity were a topic recommended by the AHA/ACC/TOS (2013) as a dietary intervention material that can be given to people with more weight and obesity because it has provided strong evidence of successful weight loss[41].

results on variable weight loss with an average reduction of ±-3.16 kg in the 6th month and -3.58 kg in the 12th month. But by the 24th month, the difference became insignificant in the average weight loss, diet quality, and physical activity between the intervention group and the control[18]. Interventions with multi-component nutrition education media with ≥3 media (mobile apps, websites, print handouts, and telephone mentoring) also had a significant effect on weight loss outcomes in the 9th month[31]. A study that only used one medium, which was mobile applications[15] and telecoaching via telephone[26] gave significant results on weight loss with values of -4.9 kg and -2.3 kg. Interestingly, inconsistent results were seen in other studies in either the use of one medium or multicomponent. Studies with the use of mobile apps alone without assistance did not have a significant effect on the 12th month[21] and studies with the use of ≥1 media also did not have a significant influence on weight loss variables in the intervention group compared to controls in months 6 and 12[32].

DISCUSSION

The purpose of interventions that integrate nutritional education materials using eHealth media in this overall review was related to weight management to improve the anthropometric status, changes in eating behavior, and physical activity. The nutritional education methods delivered using eHealth media almost entirely involve modifying behavior changes to facilitate behavior sustainably. By definition of nutrition education itself, it aims to help patients gain the knowledge and skills needed to make changes. Nutrition education and changes in eating habits can have beneficial impacts in many ways including disease control, improved health status, improved quality of life, and decreased health costs[40].

The results of this study showed that there were two forms of communication channels and activities that are commonly used for the delivery of nutrition education messages in this review, namely interpersonal channels through group discussions and private counseling and mass media channels through the use of the internet (email, websites, applications, video conferences).

Delivery of nutritional education materials using eHealth media online provided equally effective results compared to offline direct intervention with the provision of methods based on behavior change techniques and the same duration. This was evident from the three studies in this study showing no significant results on the outcome of anthropometric status (weight loss, BMI), physical activity, and treatment compliance in studies compared eHealth-based methods (online) with face-to-face (offline) which both received obesity management intervention methods accompanied by behavior change techniques in each group (n =4)[22-23,25,27]. In this review, it was also seen that studies using behavior change theory and BCT showed more improvement in expected outcomes rather than studies that did not integrate the theory. In the design of a mHealth-based intervention application, the theory and the BCT selected must be appropriate and interrelated. The ineffectiveness

of an intervention could be due to the theory used not providing a sufficient basis for designing interventions for behavior change that was targeted[42].

Overall, the most commonly used theory in the study was Social Cognitive Theory (SCT). The SCT theory is a new naming of Learning Theory also developed by Bandura[43] and is a theory for understanding how individuals can translate attitudes and intentions into long-term behavioral changes[12]. In SCT theory, goal setting and self-monitoring are forms of BCT that have been shown to increase self-efficacy and facilitate behavioral change[44]. Another theory of behavior change used in the study was the Transtheoretical Model (TTM) mentioned in two studies[18,31]. TTM theory emphasizes behavioral changes based on five stages that occur sequentially in a short time, ranging from no intention to take action to the continuous stage of behavioral maintenance[45]. Therefore, studies using TTM theory are generally studies with a long duration of time depending on which stage to take as a focus by the researcher.

The integration of nutrition education into eHealth media channels with the provision of nutritional science materials that emphasize modification of eating behavior and physical activity and followed by mentoring both personally and in groups accompanied by BCT that has been designed can have a significant influence on the improvement of anthropometric status and inconsistent results in the outcome of eating behavior and physical activity in obese adults in the short term (≤3.5 months/14 weeks). The use of technology for weight management interventions and healthy lifestyles was less effective on some anthropometric and behavioral status variables if performed in the long term. This was reinforced by previous studies that mentioned that technology-based weight management interventions accompanied by behavioral change engineering components can provide positive results in the short term (3-6 months), but in the long term still provide inconsistent results[46]. Systematic review studies and meta-analyses also showed significantly higher weight loss in interventions combined with dietary modifications and physical activity in behavior-based weight management in obese adults[10].

Only 1 study[29] reported measuring increased knowledge scores as an outcome variable. Therefore, looking at the definition and scope of nutrition education that was broad[12], it can be seen from the results of this review that the impact of eHealth media interventions integrated nutrition education was not seen only as limited to the increase in knowledge scores that were short-term but were expected to have more impact on changes in health behaviors. With the interaction between participants and eHealth media used, participants indirectly gained nutritional knowledge through routine learning when using eHealth media. The role of nutrition education in this eHealth-based intervention was to provide nutrition and health information as well as techniques on how to achieve the expected healthy behaviors. The main content in nutrition education was certainly related to individual health, among others, the balance between food consumption and physical activity to the prevention and management of chronic diseases, such as obesity. This will be more effective if it was focused on clearly defined behaviors, practices, or problems. But behavior change itself certainly takes time and must be maintained by overcoming the obstacles[12,47-48]. It is necessary to design eHealth media that are by the targets so that the effectiveness of interventions can better provide results to expected outcome variables by also involving relevant stakeholders, such as Information Technology/IT developers, health workers in technology planning that can be adjusted to the level of education and socioeconomic and how appropriate methods can be given to prospective users[49].

The study was a narrow review that specializes only in the assessment of eHealth media that integrates nutrition education in experimental design-based obesity management interventions, not conducting quantitative analysis (meta-analysis) on outcome variables, so the broader discussion may be limited. Apart from this, this study can provide an overview of the recommendations of forms of nutrition education integrated into eHealth media as one form of technology-based intervention on behavior-based obesity management.

CONCLUSION

The integration of nutrition education into eHealth media channels with nutritional science materials that emphasize modification of eating behavior and physical activity, followed by personal or group assistance accompanied by BCT has a significant influence on improving the anthropometric status and inconsistent results in the outcome of eating behavior and physical activity in obese adults in the short term (≤3.5 months/14 weeks). The use of behavioral change theory was designed eHealth-based studies with BCT were more effective at providing significant results toward improvements in several variable outcomes of anthropometric status, eating behavior, and physical activity in short- and long-term studies.

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