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Masters Program in Public Health, Universitas Sebelas Maret

Meta-Analysis

Meta-analysis: The Effectiveness of mHealth Mobile Application Use to Promote Physical Activity and Ideal Body Weight in Adult with Overweight

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ABSTRACT

Background: Globally, overweight and obesity are significant contributors to morbidity and mortality, which in turn can reduce productivity and increase the burden of healthcare costs. Interventions to treat obesity include a comprehensive lifestyle approach (diet, physical activity, and behavioral therapy) to achieve and maintain weight loss. One method for monitoring weight loss program interventions is the use of a mobile health application (mHealth). This study aims to analyze the effectiveness of using mHealth on increasing physical activity and losing weight.
Subjects and Method: This research is a meta-analysis study using PRISMA flowchart guidelines. The article search process was carried out between 2011 and 2021 using databases from PubMed, Google Scholar and ScienceDirect. Based on the database, there were 15 articles that met the inclusion criteria. The analysis was carried out using the RevMan 5.3 . software.
Results: Meta-analysis of 9 randomized controlled trial articles showed that overall mHealth increased physical activity by 0.19 compared to controls (SMD= 0.19; 95% CI= 0.06 to 0.32; p = 0.004). Higher intervention outcomes were obtained from interventions for more than 3 months (SMD= 0.31; 95% CI= 0.13 to 0.49; p<0.001). Short-term effects for 3 months did not show significant results. A meta-analysis of 15 randomized controlled trial articles concluded that the use of mHealth overall was able to reduce body weight by 0.34 compared with no use of the mHealth application (SMD= -0.34; 95% CI= -0.52 to -0.17; p< 0.001). Higher intervention outcomes were obtained from the 6-month intervention (SMD= -0.52; 95% CI= -0.82 to -0.22; p < 0.001). Short-term effects for 3 months did not show significant results.
Conclusion: Long-term use of the mHealth app is effective for increasing physical activity and losing weight in overweight adults. However, the effect of short-term intervention for 3 months has not shown significant result..

Keywords: mHealth, weight loss, physical activity.

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BACKGROUND

Globally, overweight and obesity are significant contributors to morbidity and mortality (Jensen et al., 2014a), which in turn can reduce productivity and increase health care costs. Obesity can increase the risk of stroke (Kalinda, 2020), ischemic stroke (Strazzullo et al., 2010), knee osteoarthritis (Zheng & Chen, 2015), type 2 diabetes and coronary artery disease (Riaz et al., 2018).

In 2016, more than 1.9 billion adults aged 18 years and over were overweight (39%), of which more than 650 million adults were obese (13%) (WHO, 2021).

The prevalence of obesity in Indonesia has also increased from year to year. The prevalence of general obesity in adults (>18 years old) nationally in 2007 was 19.1% (8.8% overweight and 10.3% obese), in 2010 was 21.7% (10.0% overweight and 11.7% obese), in 2013 was 32.9% (13.5% overweight and 15.4% obese) (Balitbangkes, 2013), in 2018 it was 35.4% (13.6% overweight and 21.8% obese) (Balitbangkes, 2019). Riskesdas data also shows the disparity of obesity prevalence from the national prevalence value in several provinces in Indonesia. The increase in obesity will have an impact on increasing health financing.

The underlying cause of overweight and obesity is an energy imbalance between calories consumed and calories expended (WHO, 2021). Some other causes of obesity are lack of physical activity (Chau et al., 2012; Coll et al., 2015; Sudikno et al., 2015, 2020), lack of fiber consumption (Ruhee & Suzuki, 2018), high consumption of fatty foods and alcohol (Jeon et al., 2011).

Interventions to treat obesity include a comprehensive lifestyle approach (diet, physical activity, and behavioral therapy) to achieve and maintain weight loss (Jensen et al., 2014).

One of the methods for monitoring weight loss program interventions is the use of mobile health (mHealth) applications. Currently mHealth is one of the supporting elements that can contribute to improving health monitoring by helping people adopt a healthier lifestyle. The mHealth intervention has been widely reported to achieve greater weight loss than other approaches (Allen et al., 2013; Fenton et al., 2021; Hernández-Reyes et al., 2020). This app is considered satisfactory, easy to use, and helpful in achieving weight loss goals by patients. The potential of this application in facilitating weight loss lies in its ability to improve medication adherence through self-monitoring strategies (Douvani and Tsoumani, 2019).

Research conducted by (Nakata et al., 2019) revealed that the intervention using mHealth in the form of activity monitoring for 27 months could increase moderate to severe physical activity by 28.9 minutes/day (95% CI= 21.7 to 36.2; p<0.001) . A study conducted on overweight adults by Turner-McGrievy et al. (2017) also stated that the use of mobile applications for 6 months can reduce body weight by −6.8 ± 0.8 kg (p<0.001) and increase total metabolic equivalents/MET by +2015.4 ± 684.6 minutes/week (p= 0.02).

The results of another study conducted by Fenton et al. (2021) showed the opposite of the results from previous studies which stated that there was an increase in physical activity but it was not significant (62.7 minutes/week (95% CI= −98.2 to 223.6; p= 0.445). Another study conducted by (Godino et al., 2016) stated that there was no significant weight loss after 24 months of intervention (−0.79 kg, (95%CI= −2.02 to 0.43; p= 0.204) and 18 months (−0.67 kg, (95%CI= −1.69 to 0.35; p=0.200). Social and mobile technologies do not facilitate sustained weight loss among young adults, although these approaches may facilitate limited short-term weight loss.

Various studies have been conducted to see the effectiveness of using the mHealth application on increasing physical activity and weight loss, but the results of the research still show inconsistent results. Further analysis is needed to reach a convincing conclusion.

Therefore, researchers are interested in examining the effectiveness of using the mHealth application on increasing physical

activity and losing weight. Researchers used a systematic review approach to relevant studies by conducting a meta-analysis to clearly identify the effectiveness of using the mHealth application on increasing physical activity and losing weight.

SUBJECTS AND METHOD

1. Study Design

This research was conducted using a meta-analysis research design with PRISMA flow chart guidelines. Article searches were performed using the following databases: PubMed, Google Scholar and ScienceDirect. Some of the keywords used are: "mobile application and physical activity in overweight adult and randomized controlled trial", "mobile application and weight loss in overweight adult and randomized controlled trial" and "m-health or mobile applica-tion or mobile healthcare" and "physical activity or physical exercise or aerobic exercise" and "weight loss or body weight or overweight or obesity".

2. Inclusion Criteria

The inclusion criteria for this research article are articles using English, full paper articles, relevant to the title, using a Randomized Controlled Trial (RCT) study design, research subjects are adults aged 18-64 years with BMI≥25, mHealth intervention, results of increased physical activity and weight loss.

3. Exclusion Criteria

The exclusion criteria for this research article were the results did not include the number of respondents, the mean or standard deviation (SD) and the research subjects were pregnant or postpartum women.

4. Operational Definition of Variables

The articles included in this study were PICO-adjusted. The search for articles was carried out by considering the eligibility criteria determined using the following PICO model: Population= adults (18-64 years) with a BMI 25, Intervention= using the mHealth application, Comparison= not using the mHealth application, Outcome= increased physical activity and weight loss.

Being overweight is an excessive accumulation of fat due to an imbalance between energy intake and energy expenditure for a long time with a BMI 25 kg/m2 and obesity with a BMI 30 kg/m2. Overweight was measured by BMI on a continuous measurement scale.

mHealth is a health intervention using cellular communication and network technology as a medical and public health practice supported by cellular phones or smartphones, personal digital assistants (PDAs), tablets, smart watches and other wireless devices. mHealth was measured using a questionnaire and categorized into using mHealth and not using mHealth.

Physical activity is any body movement caused by the work of skeletal muscles and increases the expenditure of energy, energy, respiratory rate and heart rate. Continuous measurement scale

5. Instruments

The research was guided by the PRISMA flowchart and assessment of the quality of research articles using the Critical Appraisal Skills Program (CASP, 2020). The 11 questions used are as follows.

The 11 randomized controlled trial study questions used are as follows:

1. Does this study clearly answer the research question?
2. Was the intervention given to the respondents by randomization?
3. Were all respondents included in the study properly taken into account in the conclusions?
4. Are the respondents, researchers, and people assessing/analyzing blinded?
5. Were the study groups similar at the start of the study?

6. Outside of the interventions studied, were the study groups treated equally?
7. Were the effects of the intervention reported comprehensively?
8. Is the accuracy of the estimated effect of the intervention reported?
9. Do the benefits provided by the intervention outweigh the costs and disadvantages?
10. Are the results applicable to the context of practice or local populations?
11. Are the results applicable to the context of practice or local populations?

6. Data Analysis

Research data were analyzed using the RevMan 5.3 application, to calculate the effect size and heterogeneity of the study. The results of data processing are presented in the form of forest plots and funnel plots.

RESULTS

Process of searching article wascarried out by searching several journal databases PubMed, Sciencedirect, and Googlescholar. it can be seen using the PRISMA FLOW flowchart shown in Figure 1.

The primary research that met the criteria consisted of 15 articles from 8 articles from the Americas, 3 articles from the Asian continent, 3 articles from the Australian continent and 1 article from the European continent.

Table 1 shows the research quality assessment of 15 articles using the Critical Appraisal Skills Program Randomized Controlled Trial. Table 2 shows a summary of the articles of randomized control trials that were included in the meta-analysis.

Table 1. Assessment of the Quality Studies by Joanna Briggs Institute

Primary Study	Criteria											Total
	1	2	3	4	5	6	7	8	9	10	11	
Turner-McGrievy *et al.* (2011)	2	2	2	2	2	2	2	2	2	2	2	22
Collins *et al.* (2012)	2	2	2	2	2	2	2	2	2	2	2	22
Morgan *et al.* (2013)	2	2	2	2	2	2	2	2	2	2	2	22
Hebden *et al.* (2013)	2	2	2	2	2	2	2	2	2	2	2	22
Turner-McGrivey *et al.* (2013)	2	2	2	2	2	2	2	1	2	2	2	21
Fukuoka *et al.* (2015)	2	2	2	2	2	2	2	2	2	2	2	22
Kim *et al.* (2015)	2	2	2	2	2	2	2	2	2	2	2	22
Oh *et al.* (2015)	2	2	2	2	2	2	2	2	2	2	2	22
Svetkey *et al.* (2015)	2	2	2	2	2	2	2	2	2	2	2	22
Godino *et al.* (2016)	2	2	2	2	2	2	2	2	2	2	2	22
Little *et al.* (2016)	2	2	2	2	2	2	2	2	2	2	2	22
Spring *et al.* (2017)	2	2	2	2	2	2	2	2	2	2	2	22
Stephens *et al.* (2017)	2	2	2	2	2	2	2	1	2	2	2	21
Lee *et al.* (2018)	2	2	2	2	2	2	2	2	2	2	2	22
Zhang *et al.* (2019)												

Note: Answer: Yes=2, No =1, Can't tell=0

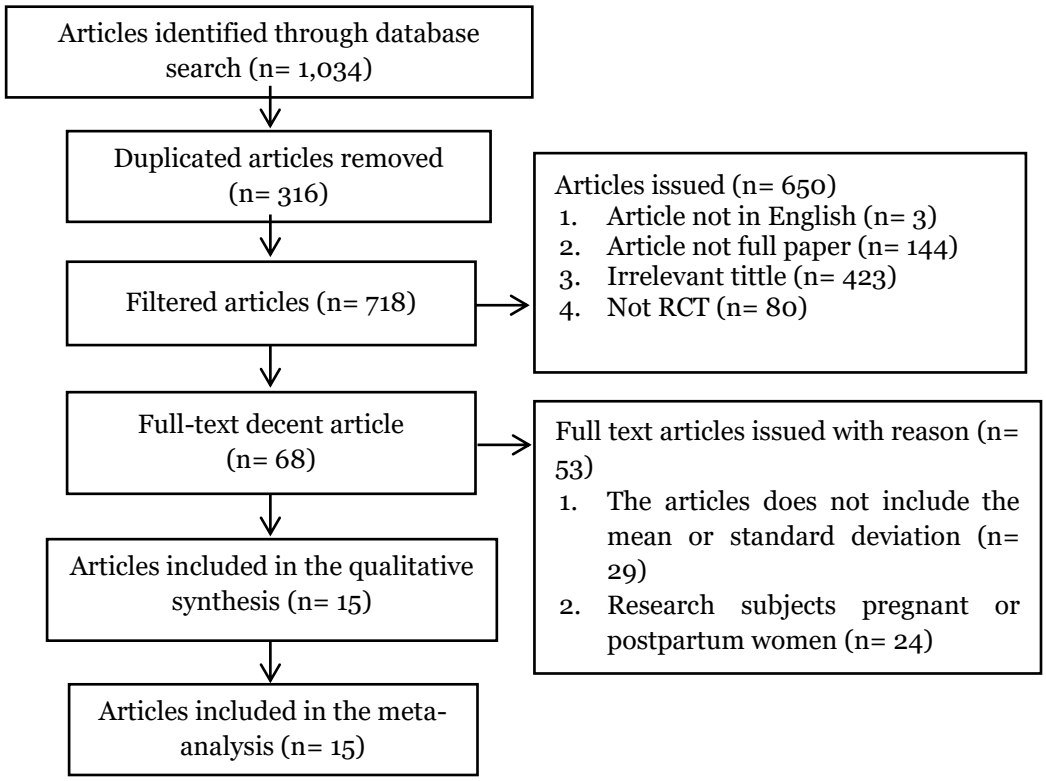

Figure 1. Results of Prisma Flow Diagrams

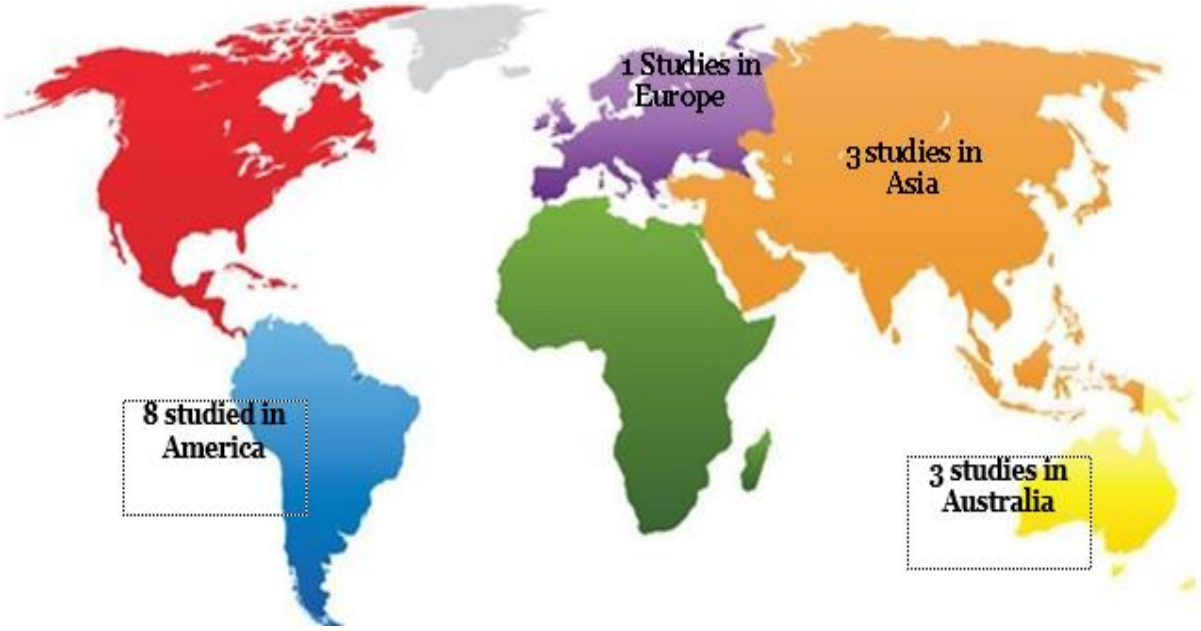

Figure 2. Resarch Distribution Map

Table 2. Description of Primary Research included in the Meta-Analysis

Author (Year)	Country	Study Design	P	I	C	O	Mean		SD	
							IG	CG	IG	CG
Turner-McGrievy & Tate (2011)	North Carolina	RCT	The study subjects were 18-60 years old, BMI 25-45 kg/m2, not pregnant or breastfeeding.	Using Podcasts (2x/week) plus mobile media intervention (twitter) and diet and physical activity monitoring application.	Only using podcast (2x/weeks)	Body weight, physical activity, calorie and fat intake, eating behavior.	94.5	82.7	130.2	153.2
Collins et al. (2012)	New South Wales	RCT	Research subjects aged 18-60 years, BMI 25-40 kg/m2, did not follow a weight loss program, had a computer with email access and internet services.	1. Given free access to basic commer-cially available websites; 2. Provided free access to the enhanced version of the website. 1&2 + online diary at least 4x/week to record food intake, physical activity, weekly weight.	Was not granted access to the weight loss program website and asked not to participate in any other weight loss program for 12 weeks.	Body weight, BMI, Waist circumference, Blood pressure, Cholesterol, LDL, HDL, blood sugar, calorie intake, physical activity.	491.6	341.8	2.60	3.11
Morgan et al. (2013)	New South Wales	RCT	The research subjects are men with a BMI of 25-40 years, have a mobile phone and a computer with email and internet facilities	1. SHED-IT (Self-Help, Exercise and Diet) Resources program dengan DVD, buku dan pedometer; 2. Self-Help, Exercise and Diet using Internet Technology) Online program.	Without intervention	Body weight, BMI, waist circumference, body compo-sition, blood pressure, calorie intake, physical acivity.	1.57	42.0	25.8	38.6

Author (Year)	Country	Study Design	P	I	C	O	Mean		SD	
							IG	CG	IG	CG
Turner-McGrievy et al. (2013)	North Carolina	RCT	Research subjects aged 18-60 years, BMI 25-45 kg/m2, have a mobile phone that is connected to the internet	Weight loss intervention using audio podcasts coupled with a mobile diet and physical activity monitoring app and social support using Twitter.	Weight loss intervention using audio podcast 2 times per week.	Weight loss intervention using audio podcast 2 times per week.	196.4	100.9	318.0	100.9
Kim et al. (2015)	Republic of Korea	RCT	The study subjects were male aged 20-60 years, BMI > 25 kg/m2, did not receive treatment that could increase their weight, had a mobile phone, and used SMS.	Using an SMS-based application that is sent 3 times per week in the morning containing “goal setting and behavior change”, “diet education and tips” and “physical activity and exercise”.	Messages are given through printed sheets.	Body weight, body fat percentage, physical activity.	2.26	1.88	2.55	2.71
Oh et al. (2015)	Republic of Korea	RCT	Men and women aged 20 years, BMI 25 kg/m2, had at least 3 metabolic syndromes.	Using the Mobile phone application to monitor body composition (InBody IH-U070B) and a pedometer transmitted via Bluetooth.	Not use health applications on mobile phones. Monitoring of body weight and physical activity is reported during a doctor's	Body weight and body mass index.	-2.29	3.62	-0.86	2.84

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Author (Year)	Country	Study Design	P	I	C	O	Mean		SD	
							IG	CG	IG	CG
					consultation.					
Svetkey et al. (2015)	North Carolina	RCT	Research subjects aged 18-35 years, BMI 25 kg/m2, using a mobile phone.	1. Using interactive smartphone applications on mobile phones (CP); 2. Self-monitoring by smartphone (PC).	Not using a smartphone	Body weight	-3.58	-2.25	1.99	9.40
Fukuoka et al. (2015)	California	RCT	Research subjects aged 35 years, BMI 25 (BMI 23 for Asia Pacific), at risk of diabetes, lack of physical activity, use a mobile phone every day.	Using a Mobile Phone–Based Diabetes Prevention Program (mDPP). An electronic diary for monitoring weight, activity and calorie intake, with daily reminders.	Get standard medical care and brochures. Do not use health applications on mobile phones.	Body weight, BMI, physical activity, hip circumference, blood pressure, lipid profile, blood sugar, calorie and fat intake.	-6.20	0.30	5.90	2.70
Godino et al. (2016)	California	RCT	Research subjects are 18-35 years old, BMI 25-34.9 kg/m2, have a computer and a mobile phone, use SMS.	SMART intervention: facebook, 3 types of mobile applications, SMS, email, website with blog post, technology for mediation with health workers.	No intervention	Body weight, BM, waist circumference, arm circumference, blood pressure.	28.1	28.6	3.60	3.60
Little et al. (2016)	English	RCT	The study subjects were 18 years old, BMI 30 kg/m2 (or 28 kg/m2 with hypertension,	1. Web-based intervention and face-to-face nurse support (POWeR+Face-to-	Diet counseling and follow-up care for 6 months.	Body weight.	98.56	101.0	15.95	19.57

Author (Year)	Country	Study Design	P	I	C	O	Mean		SD	
							IG	CG	IG	CG
			hypercholesterolemia or diabetes), not pregnant or breastfeeding.	face); 2. Web-based intervention and remote support (POWeR+Remote).						
Spring et al. (2017)	Illinois	RCT	Research subjects aged 18-60 years, BMI 30-40 kg/m2, did not increase or decrease in weight more than 11.3 kg during the last 6 months, not pregnant and breastfeeding.	Using the Engaged App and accelerometer, the application monitors food intake, weight and physical activity.	Not using the app.	Body weight, self-monitoring compliance (diet, physical activity, body weight).	-5.60	-2.70	8.59	23.29
Stephens et al. (2017)	United States of America	RCT	Age 18-25 years, BMI 25-40 kg/m2, have a Mobile phone iPhone or Android	Using smartphone applications and counseling sessions with health workers	Counseling with health workers	Body weight, BMI, waist circumference, and physical activity.	-2.70	1.50	5.47	27.09
Zhang et al. (2019)	Pennsylvania	RCT	Age 18-35 years, BMI 25, using an android smartphone, living in Philadelphia and not participating in any other physical activity study in the past 12 months	Using the PennFit App based on social cognitive theory, social support and support integrated with research	Self-monitoring without social support or connecting with other participants.	Physical activity, BMI, daily number of steps	-0.07	0.15	9.32	6.81

Author (Year)	Country	Study Design	P	I	C	O	Mean		SD	
							IG	CG	IG	CG
Lee et al. (2018)	Republic of Korea	RCT	The study subjects were 20 years old, BMI 25 kg/m2, had at least 3 metabolic syndromes	Using SmartCare App and Bioimpedance Analyzer via Bluetooth Smartphone	Not using a smartphone	Body weight, BMI, Waist circumference, body fat percentage, SBP, DBP, blood biochemistry	-2.6	-1.50	3.91	3.12

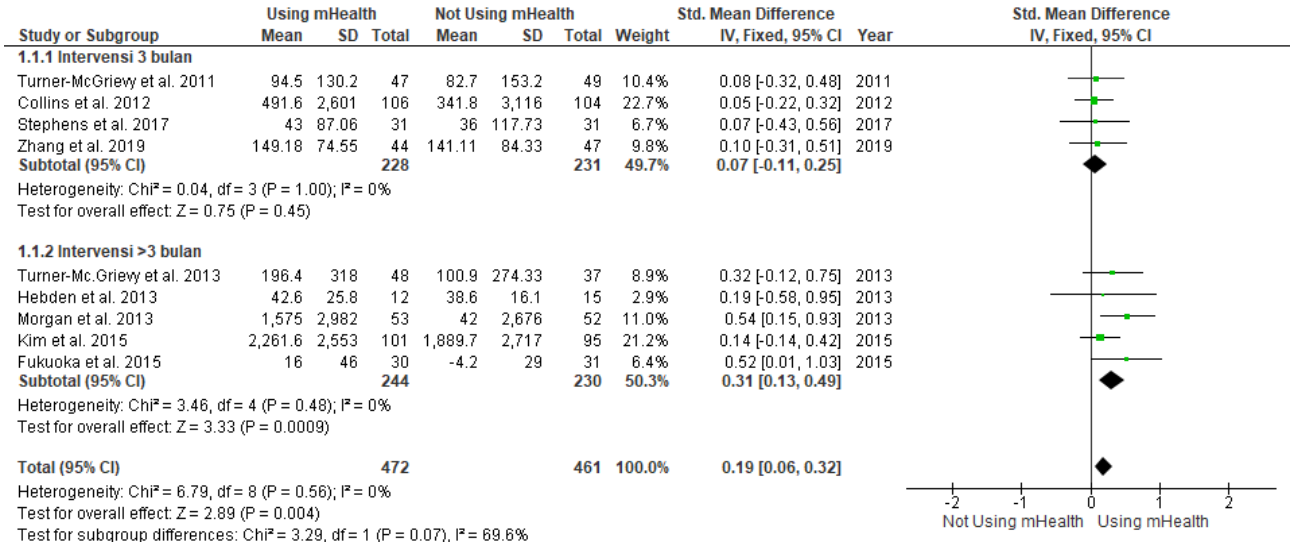

Figure 3. Forest Plot the Effect of Using the mHealth Application on Increasing Physical Activity

The forest plot meta-analysis of 9 randomized control trials in Figure 3 shows that the use of the mHealth application can increase physical activity by 0.19 compared to controls (SMD = 0.19; 95% CI = 0.06 to 0.32); p= 0.004). The intervention using the mHealth application for more than 3 months was more effective and statistically significant for increasing physical activity (SMD= 0.31; 95% CI= 0.13 to 0.49); p < 0.001) than the intervention carried out for 3 months. The heterogeneity of the research data shows I^2 = 0% so that the distribution of the data is declared homogeneous (fixed effect model).

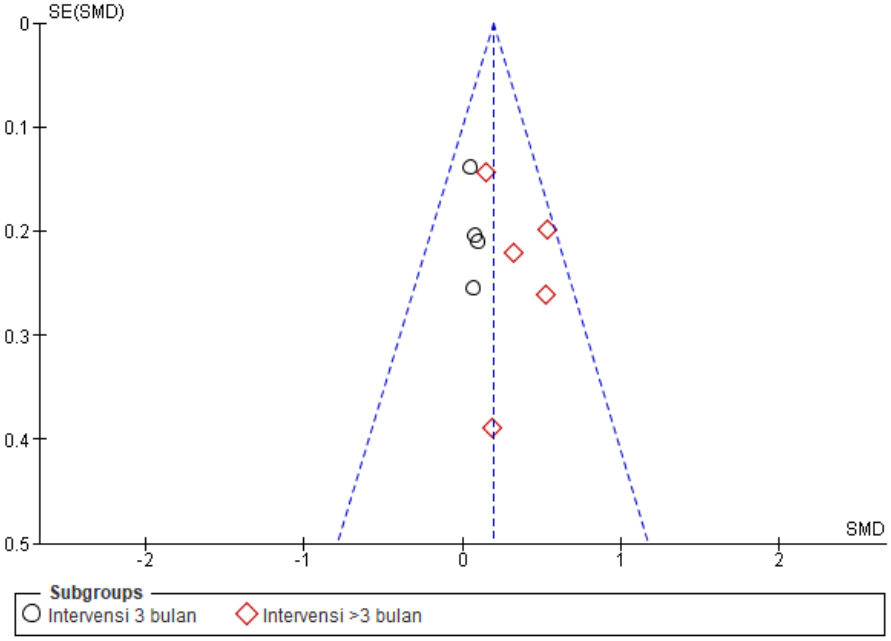

Figure 4. Funnel plot the Effect of Using the mHealth Application on Increasing Physical Activity

The funnel plot in Figure 4 shows no publication bias as indicated by the symmetry of the right and left plots where 3 plots are on the right and 4 plots are on the left, and 2 plots are attached to a vertical line. The plot on the right of the graph appears to have a standard error (SE) between 0.2 and 0.3. The plot on the left of the graph appears to have a standard error (SE) between 0.1 and 0.3. However, when viewed from the length of the intervention, there was a publication bias in the 3-month intervention with an underestimate effect and in the intervention more than 3 months with an overestimated effect.

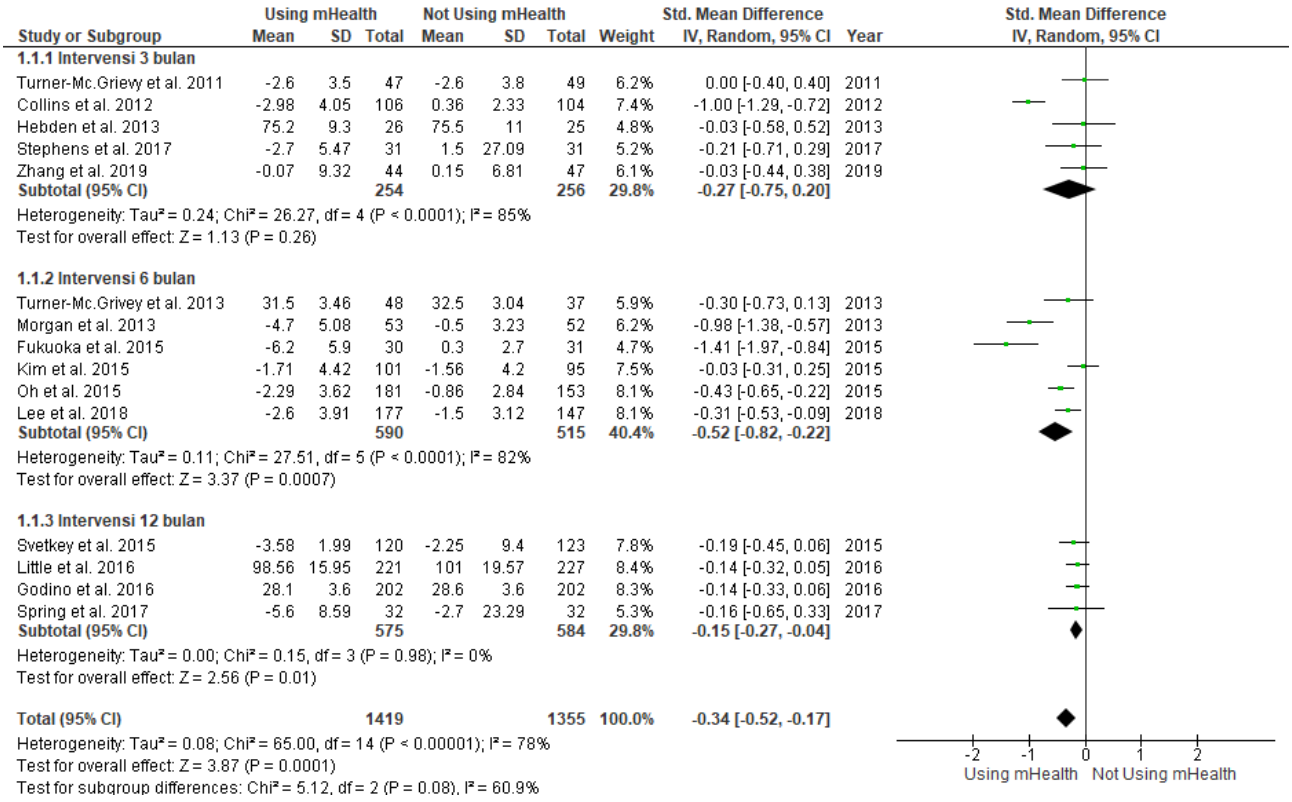

Figure 5. Forest Plot the Effect of Using the mHealth Application on Weight Loss

The forest plot meta-analysis of 15 randomized controlled trials in Figure 5 shows that the use of the mHealth application can reduce body weight by 0.34 compared to without the use of the mHealth application (SMD = -0.34; 95% CI = -0.52 to -0.17); p < 0.001). The intervention using the mHealth application for 6 months was more effective and statistically significant for weight loss (SMD= -0.52; 95% CI= -0.82 to -0.22); p < 0.001) than the intervention carried out for 3 months and 12 months. The heterogeneity of the research data shows I^2= 78% so that the distribution of the data is declared heterogeneous (random effect model).

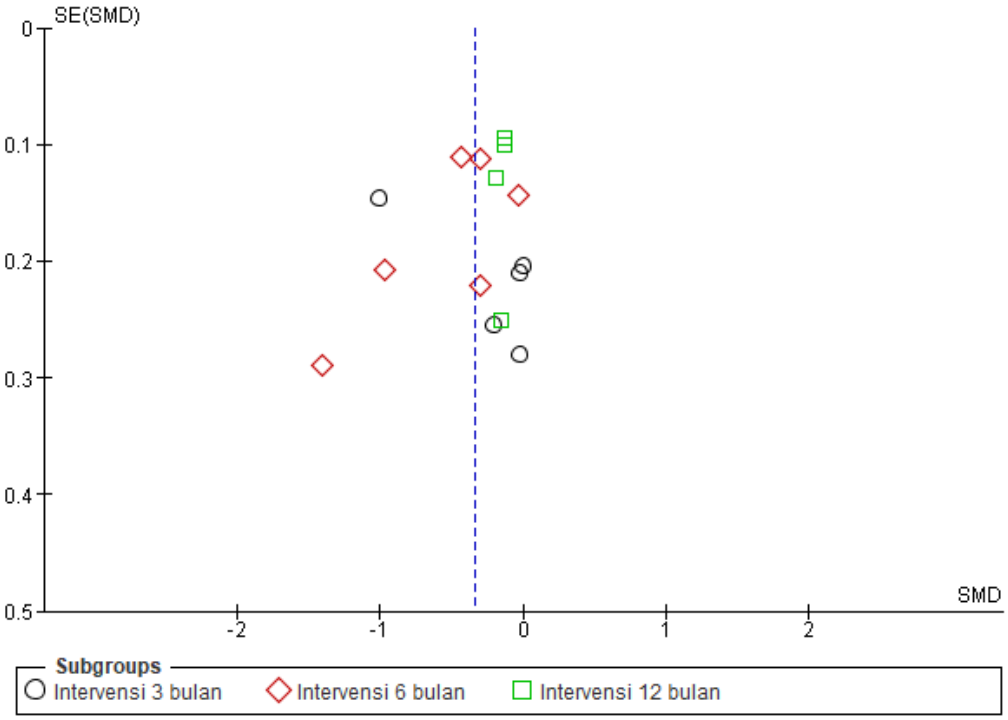

Figure 6. Funnel Plot the Effect of Using the mHealth Application on Weight Loss

The funnel plot in Figure 6 shows a publication bias which is indicated by the asymmetry of the right and left plots where 9 plots are on the right and 4 plots are on the left, and 2 plots are attached to the vertical line. The plots on the right and left of the graph appear to have a standard error (SE) between 0.1 and 0.3. When viewed from the length of the intervention time, the plots for the 3-month and 12-month interventions are mostly on the right with an overestimated effect.

DISCUSSION

Globally, overweight and obesity are significant contributors to morbidity and mortality, which in turn can reduce productivity and increase the burden of healthcare costs. Interventions to treat obesity include a comprehensive lifestyle approach (diet, physical activity, and behavioral therapy) to achieve and maintain weight loss (Jensen et al., 2014). Weight loss interventions are carried out by achieving an energy balance between calories consumed and calories used.

One method for monitoring weight loss program interventions is the use of a mobile health application (mHealth). mHealth is a health intervention using cellular communication and network technology as a medical and public health practice supported by cellular phones or smartphones, personal digital assistants (PDAs), tablets, smart watches and other wireless devices.

Currently mHealth is one of the supporting elements that can contribute to improving health monitoring by helping people adopt a healthier lifestyle. The mHealth intervention has been widely reported to achieve greater weight loss than other approaches (Allen et al., 2013; Fenton et al., 2021; Hernández-Reyes et al., 2020). This app is considered satisfactory, easy to use, and helpful in achieving weight loss

goals by patients. The potential of this application in facilitating weight loss lies in its ability to improve medication adherence through self-monitoring strategies (Dounavi and Tsoumani, 2019).

The results of data processing using the RevMan 5.3 application on 933 samples from 9 articles originating from the Americas, Australia, Asia showed that the use of the mHealth application was able to increase physical activity in adults with overweight overall by 0.19 compared to without the use of the mHealth application (SMD). = 0.19; 95% CI = 0.06 to 0.32; p = 0.004), although the results of the short-term intervention (3 months) did not show significant results. Higher intervention outcomes were obtained from interventions for more than 3 months (SMD = 0.31; 95% CI = 0.13 to 0.49; p < 0.001).

This is not in line with the meta-analysis of the 12 primary studies conducted by Islam et al. (2020), who revealed that there was no statistically significant increase in physical activity after using a mobile phone application (SMD= 0.17, 95% CI 2.21 to 2.55, p= 0.88). The results are also not in line with the meta-analysis of 12 primary studies conducted by (Mateo et al., 2015), which revealed that there was no statistically significant increase in physical activity after using mobile phone applications (SMD= 0.40, 95% CI 0.07 to 0.87).

The results of data processing using the RevMan 5.3 application on 2,774 samples from 15 articles originating from the Americas, Australia, Asia, Europe showed that the use of the mHealth application was able to lose weight in adults with overweight overall by 0.34 compared to without the use of the mHealth application (SMD= -0.34; 95% CI= -0.52 to -0.17; p< 0.001), although the results of the short-term intervention (3 months) did not show a significant result. Higher intervention outcomes were obtained from the 6-month intervention (SMD= -0.52; 95% CI= -0.82 to -0.22, p < 0.001).

This is in line with the systematic review and meta-analysis of Hutchesson et al. (2015) which showed that the effectiveness of traditional and technology-based weight loss interventions was greatest during the first 6 months. A meta-analysis of 12 primary articles conducted by Mateo et al. (2015) also suggested that the use of mobile phone applications can reduce body weight statistically significantly compared to controls -1.04 kg (95% CI = -1.75 to -0.34; I^2 = 41%).

The results of previous studies showed that although intervention involvement and study retention were high, behavioral principles were included in both interventions, and weight loss occurred in all treatment groups, intervention outcomes did not lead to sustained weight loss relative to controls. Effective interventions may require the efficiency of mobile technology, social support and human interaction from personal mentoring, and an adaptive approach to intervention design (Svetkey et al., 2015). Results Meta-analysis of intervention studies targeting healthy behavioral changes in physical activity and diet revealed that the five most effective techniques were self-regulation and included intention formation, goal setting, self-monitoring, feedback, and goal review (Godino et al., 2016; Hutchesson et al., 2015).

This is in accordance with the Social Cognitive Theory (SCT) proposed by Albert Bandura on a behavioral theory which suggests that environmental and cognitive factors interact to influence the learning of human behavior. There is reciprocal determinism in the central concept of SCT, which refers to the interaction between the individual (individual characteristics and learning from experience), environment

(external social context), and behavior (response to a stimulus to achieve goals), and reciprocal behavior. and influence each other.

Interactions that arise when providing feedback and interactions in the mHealth application user community are thought to increase self-efficacy and user confidence so that they are able to complete the stated goals of the intervention program.

The conclusion from the results of this meta-analysis showed that the long-term use of the mHealth application was effective for increasing physical activity and losing weight in overweight adults. However, the effect of short-term intervention for 3 months has not shown significant results.

AUTHOR CONTRIBUTION

Farida Nur Aisyiyah contributed in choosing topics, searching, collecting and processing research data. Bhisma Murti and Eti Poncorini Pamungkasari contributed in analyzing data and reviewing research documents.

FUNDING AND SPONSORSHIP

This study is self-funded.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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