International Journal of Obesity www.nature.com/ijo

REVIEW ARTICLE

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Behavior, Psychology and Sociology

Social media-based interventions for adults with obesity and overweight: a meta-analysis and meta-regression

Yue Lun Loh [1], Qin Ping Yaw [1] and Ying Lau [1] ✉

Social isolation and loneliness are growing public health concerns in adults with obesity and overweight. Social media-based interventions may be a promising approach. This systematic review aims to (1) evaluate the effectiveness of social media-based interventions on weight, body mass index, waist circumference, fat, energy intake and physical activity among adults with obesity and overweight and (2) explore potential covariates on treatment effect. Eight databases, namely, PubMed, Cochrane Library, Embase, CINAHL, Web of Science, Scopus PsycINFO and ProQuest, were searched from inception until December 31, 2021. The Cochrane Collaboration Risk of Bias Tool and Grading of Recommendations, Assessment, Development and Evaluation criteria evaluated the evidence quality. Twenty-eight randomised controlled trials were identified. Meta-analyses found that social media-based interventions had small-to-medium significant effects on weight, BMI, waist circumference, body fat mass and daily steps. Subgroup analysis found greater effect in interventions without published protocol or not registered in trial registries than their counterparts. Meta-regression analysis showed that duration of intervention was a significant covariate. The certainty of evidence quality of all outcomes was very low or low. Social media-based interventions can be considered an adjunct intervention for weight management. Future trials with large sample sizes and follow-up assessment are needed.

International Journal of Obesity; https://doi.org/10.1038/s41366-023-01304-6

INTRODUCTION

Obesity and overweight are serious public health problems involving more than 1.9 billion and 650 million, respectively, of global population [1] that attribute to four million global deaths and disability-adjusted life years [2]. Overweight and obesity can increase the risk of coronavirus disease 2019 [3, 4]. Both conditions have a considerable impact on the cardiometabolic comorbidities [5], medical and post-surgical complications [6], social costs and health-related quality of life [7]. Notably, weight discrimination is highly prevalent in adults with obesity and overweight [8, 9]. Weight stigma is likely to drive weight gain and poor metabolic health by triggering physiological and behavioural changes [10]. Greater weight bias is associated with greater loneliness among adults with obesity and overweight [11]. They are more likely to feel social exclusion owing to society's body standard [10]. They are also prone to lower emotional trust in close others, lower disclosure to close others and social withdrawal syndrome, all of which may lead to social isolation [11]. Thus, social isolation and loneliness are increasing among adults with overweight and obesity.

Social support is effective for improving weight management [12, 13]. A supportive network contributing supportive messages and positive reinforcement can reduce weigh loss [14]. Social media are a potential platform for weight management [15]. Social media are web-based communication channels that facilitate community-based interaction and content sharing [16], with 3.484 billion users in 2019 worldwide [17]. Majority (88%) of adults spend three hours daily on social media which is more heavily than older adults [18]. Social media-based interventions can improve engagement by 82.9%, positively impact health behaviours and outcomes by 88.8% [19] and provide wide accessibility across income levels, ages, education and ethnocultural groups [20]. With their high usability and engagement, positive impact and wide accessibility, social media-based interventions can potentially control weight.

The possible mechanism of social media-based interventions is illustrated on the basis of Bandura's social cognitive theory (SCT) [21], as shown in Fig. 1. SCT is a behavioural theory of motivation and action that contains essential concepts of social modelling, observational learning, verbal persuasion and vicarious reinforcement [22, 23]. Social modelling and verbal persuasion are the beliefs in capabilities to perform behaviour change [22, 24]. An individual can observe the performance of a given behaviour, learn and reproduce it subsequently [25] through step-by-step instructional videos and models for behaviour demonstration [26]. Verbal persuasion can develop self-efficacy through encouragement or videos that describe the behaviour [22]. Vicarious positive reinforcement is evident by increased matching behaviour changes [27].

Social media have five unique features, namely, data sharing, communication, activity data viewing, peer grouping and online

[1] Alice Lee Centre for Nursing Studies, Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore. ✉email: nurly@nus.edu.sg

Received: 4 May 2022 Revised: 20 March 2023 Accepted: 22 March 2023
Published online: 03 April 2023

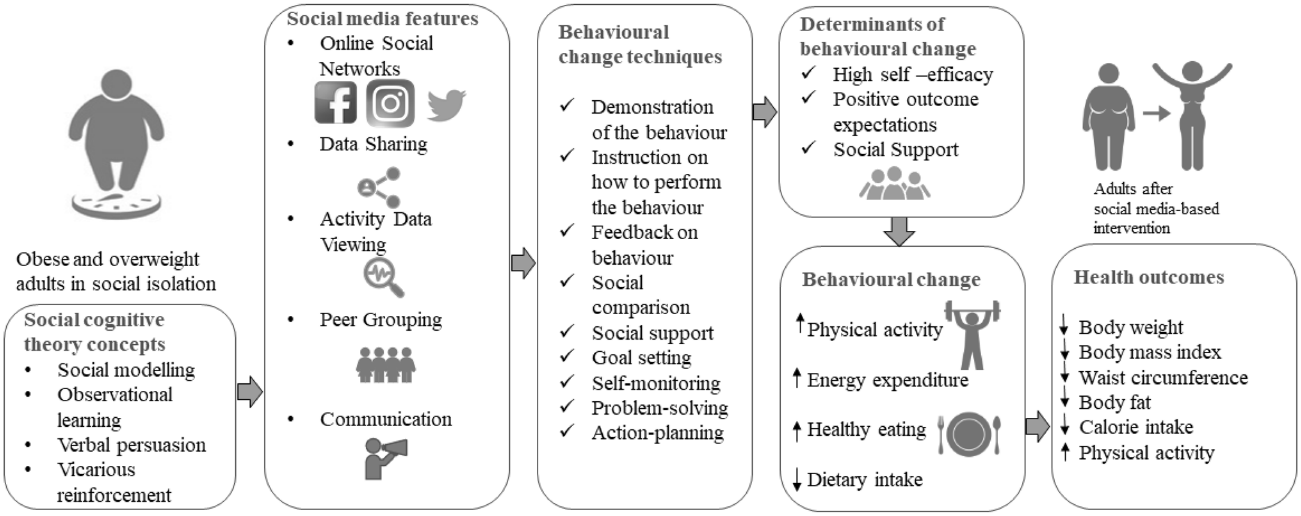


Fig. 1 Possible mechanism of social media-based interventions for health outcomes among adults with obesity and overweight.

social networks (OSNs) [28]. Examples of generic OSNs are Facebook©, Twitter©, Instagram©, Pinterest©, YouTube©, LinkedIn©, Google + © and Snapchat©, all of which enable data sharing of messages, tweets, photos and videos [29]. Many-to-many communication features include forums and chat rooms [28]. Subsequently, these new messages and activities are viewable as notifications and newsfeeds on Facebook, Instagram and Twitter [30], enabling individuals to read, comment or give symbolic support through thumbs-up or 'likes' [31]. Social media-based interventions incorporate social media features to facilitate behaviour change using behaviour change techniques [32]. Targeted SCT determinants of behaviour change are self-efficacy, outcome expectations and social support [25].

Self-efficacy is a major concept of SCT which can affect the person's behaviour and cognition relating to their activity choice, goal-setting, effort, learning and achievement [33]. High self-efficacy individuals can develop positive outcome expectations to believe in perceived benefits from behaviour change [34]. Social support encompasses emotional, instrumental, informational or appraisal support [24] that may be associated with increased physical activity, healthy eating and successful weight management [35]. Blogs can be used as social-mediated support to help lonely morbidly obese participants with their weight loss goals, who found online social support more beneficial, consistent and reliable than the little support they received from family and in real-life [36]. This showed how social media could provide online social support to individuals who felt alone in their weight loss journey and could not receive the help they needed. Individuals would have better health and weight loss outcomes if they were supported socially [37], or else, loneliness would arise when there is no companionship [38].

A growing number of systematic reviews use social media-based interventions among adolescents [39, 40], young adults [16, 40], adults [41] and individuals of any ages [42, 43]. Few of them focus on adults with obesity and overweight. However, these reviews are limited to few databases [43], mixed research design [16, 41], only narrative synthesis [39, 40, 42] and high heterogeneity [40]. Some reviews [16, 40, 42, 43] do not report certainty of evidence quality. None of them investigate the potential impact of covariates on effect size of trials. In addition, few reviews adopt the Hedges's *g* statistic for measuring the effect size, although they select trials with small sample sizes. To address the above-mentioned gaps in the literature, this systematic review aims to (1) evaluate the effectiveness of social media-based interventions on weight, BMI, waist circumference, fat, energy intake and physical activity among adults with obesity and overweight and (2) explore potential covariates on treatment effect.

METHODS

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2020 checklist (Table S1) [44] and was registered in the International Prospective Register of Systematic Reviews database (PROSPERO Number: CRD42022299587).

Eligibility criteria

The eligibility criteria are presented in Table S2. This review included studies on adults with obesity (BMI ≥ 30) [45] and overweight (BMI: 25–29) [45] aged ≥18 years. Social media-based interventions involved at least one social media feature including OSNs, data sharing, activity data viewing, communication and peer grouping providing social support. Purpose-designed OSNs were included together with generic OSNs, such as Facebook, Instagram and Twitter [46]. Comparators included standard care, waitlist or placebo control. Outcomes included weight (kg), BMI (kg/m^2), weight percentage (%), waist circumference (cm), body fat mass (kg), body fat percentage (%), energy intake (kcal/day), daily steps (steps/day) and moderate-to-vigorous physical activity change (MVPA, minutes/day). All types of randomised controlled trials (RCTs) were included because of the gold standard for studying causal relationships [47]. All searches were maximised by including published and unpublished articles in the English language without time restriction.

Information sources and searching strategies

Cochrane Databases of Systematic Review and PubMed Clinical Queries were searched to prevent duplication. A three-step comprehensive search strategy was created, with senior librarians following the Cochrane handbook for systematic review of interventions [48]. Firstly, we searched published and unpublished studies in databases from inception until December 31, 2021, using index terms and keywords documented (Table S3). We searched published studies in eight databases, namely, PubMed, Cochrane library, Excerpta Medica database, Cumulated Index to Nursing and Allied Health Literature, Web of Science, Scopus, PsycINFO and ProQuest Dissertations and Theses. Secondly, ongoing clinical trial registries, grey literature and targeted journals databases were also searched (Table S4). Ongoing trials were searched in six clinical trial registries, namely, ClinicalTrials.gov, Cochrane Controlled Register of Trials, Australian New

Zealand Clinical Trials Registry, CenterWatch, EU Clinical Trials Register and Singapore Clinical Trials Register. Additionally, we searched grey literature (*GreyResource* and *Google Scholar*) and targeted journals (*Obesity Reviews*, *Obesity Facts* and *International Journal of Obesity*). Thirdly, we manually searched the reference lists of RCTs and reviews to maximise potential trials.

Study selection

Study selection followed the identification, screening and inclusion of PRISMA flow diagram [44]. Duplicates were removed using EndNote 20 [49]. Two reviewers (YLL and QPY) independently screened the articles' titles and abstracts for assessment against the inclusion criteria. Cohen's kappa (k) was used to measure inter-rater agreement between two independent reviewers for study selection, data extraction and quality assessment. A kappa statistic of $k > 0.6$ showed an acceptable inter-rater agreement [50]. Disagreements were resolved with a third reviewer (YL).

Data items and collection

Two reviewers independently performed data extraction following the Cochrane Handbook for Systematic Reviews of Interventions [48]. Data extracted included RCT characteristics encompassing author, year, country, setting, design, population, BMI criteria, age, gender, intervention (name), comparator, sample size, outcome, measure, attrition rate, intention-to-treat (ITT), missing data management (MDM), protocol publication, registration in clinical registries and grant support. Description of intervention included social media features, content, regime (numbers of sessions, frequency, length and duration), provider or peer support, theory based and follow-up. The authors of trials were contacted to request additional data in case of insufficient and unclear information.

Risk of bias assessment in individual studies

Two reviewers (YLL and QPY) independently used the Cochrane risk of bias tool version 1 to assess the following six domains: allocation concealment, random sequence generation, outcome data completeness, selective outcome reporting, blinding of participant and personnel and blinding of outcome assessment to detect selection, performance, detection, attrition and reporting biases [51]. Each domain's risk of bias was graded as high, low or unclear. Attrition rate, MDM, ITT, protocol publication and registration in clinical registries were used to assess the evidence quality. Missing data occurs when a participant misses a data point such as a participant failing to complete a pedometer record [52] or failing to complete a 14-week follow-up [53]. These missing data could be managed through the baseline observation carried forward [54], or multiple imputation method to impute missing values for ITT analyses [55, 56]. ITT remains the gold standard to address missing data with the principle of analysing data of all participants regardless of treatment level received [57]. To prevent overly optimistic estimates of the effectiveness of the intervention, reporting of the ITT results are required to protect estimates of the intervention against a predictive equivalence produced from the original random participant allocation [58].

Data synthesis

The Comprehensive Meta-analysis software version 3 [59] was used to performed meta-analyses and meta-regression. Inverse-variance (IV) method was used to calculate the mean difference with 95% confidence interval (CI) of continuous data [60]. Z-statistics at a significant level of $P < 0.05$ was used to evaluate the overall effect following the Cochrane Handbook for Systematic Review [48]. Given the small sample size in selected RCTs, Hedges's g was adopted because it provides an accurate estimation of the corrected effect size [61]. Effect sizes' magnitude were interpreted as small (0.20), medium (0.5), large (0.8) and very large (1.2) [61]. Heterogeneity was determined by I^2 and Cochran's Q (Chi-square, χ^2 test) statistics. I^2 is the proportion of total variation across trials that is due to heterogeneity between trials rather than by chance [$I^2 = 100\%$ x (Q – degree of freedom, df)/Q.[48] I^2 value was used to quantify the consistencies across trials and interpreted as unimportant (0–40%), moderate (30–60%), substantial (50–90%) or considerable (75–100%) heterogeneity [48]. A statistical significance for heterogeneity was found with a threshold P value of < 0.10 in Q test. A narrative synthesis presented findings when statistical pooling was impossible.

Additional analyses

Subgroup and meta-regression analyses were conducted to explore the observed heterogeneity [48]. Subgroup analysis was conducted to identify intervention essential features of intervention and determine if its effectiveness is influenced by the different geographical regions, participant's gender, theoretical basis, protocol or register, use of ITT or MDM and type of social media platform [62, 63]. A series of univariate meta-regression analyses was conducted to explore whether covariates account for the treatment effect [64]. Potential covariates included year of publication, mean age, sample size, duration of intervention and attrition rate. Regression coefficients (β) were the estimated decreases in the effect size units of the covariates on weight change, and a $P < 0.05$ indicated a significant effect [65]. A bubble plot was adopted to present the results of the meta-regression.

Certainty of evidence and publication bias

GRADEpro GDT software was used to assess certainty of evidence through the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) criteria [66]. Overall evidence quality was rated between very low and high according to methodological limitations, indirectness, inconsistency, imprecision and publication bias [67]. Publications bias was assessed for an outcome with ≥10 RCTs via visual inspection of funnel plot and Egger's regression test [68]. Asymmetry of funnel plots [69] and P value > 0.05 of Egger's test [70] indicated no evidence of publication bias.

RESULTS

Study selection

Study selection is illustrated in Fig. 2, with 29,191 articles from eight databases and 1210 trials from seven registries. From the articles, 14,385 duplicates were removed via EndNote software. Two reviewers independently screened 15,894 articles' titles and abstracts, excluded 15,814, selected 80 for full-text retrieval, selected 51 for full-text eligibility and excluded 23 with reasons (Table S5). From the trials, 122 unpublished trials were excluded with reasons (Table S6). Twenty-eight RCTs were selected, that is, 25 published studies [37, 52–55, 71–91] and 3 trial reports [92–94]. Kappa statistics measured interrater reliability for study selection ($k = 0.90$), data extraction ($k = 0.96$), risk of bias ($k = 0.86$) and evidence certainty ($k = 0.81$) between two independent reviewers.

Study characteristics

Table 1 summarises the characteristics of the 28 RCTs in 29 articles [37, 52–55, 71–94] among 13,195 individuals across Australia ($N = 5$) [37, 52, 55, 75, 90], the United States of America ($N = 21$) [53, 54, 72–74, 77–80, 82–84, 86–89, 91–95], Malaysia ($N = 1$) [71] and the United Kingdom ($N = 1$) [85]. The RCTs were published between 2011 [88] and 2021 [94]. BMI criteria ranged between 25 kg/m^2 [53] and 55 kg/m^2 [80]. The mean age ranged between 20 years [87] and 50.3 years [84]. Sample sizes ranged between 18 [53] and 8112 [55] participants. Majority of them ($N = 26$) had grant support.

Risk of bias in studies

Attrition rates ranged between 0% [77] and 94.2% [90]. Less than half ($N = 13$) conducted ITT, and 17 RCTs adopted MDM. The risk

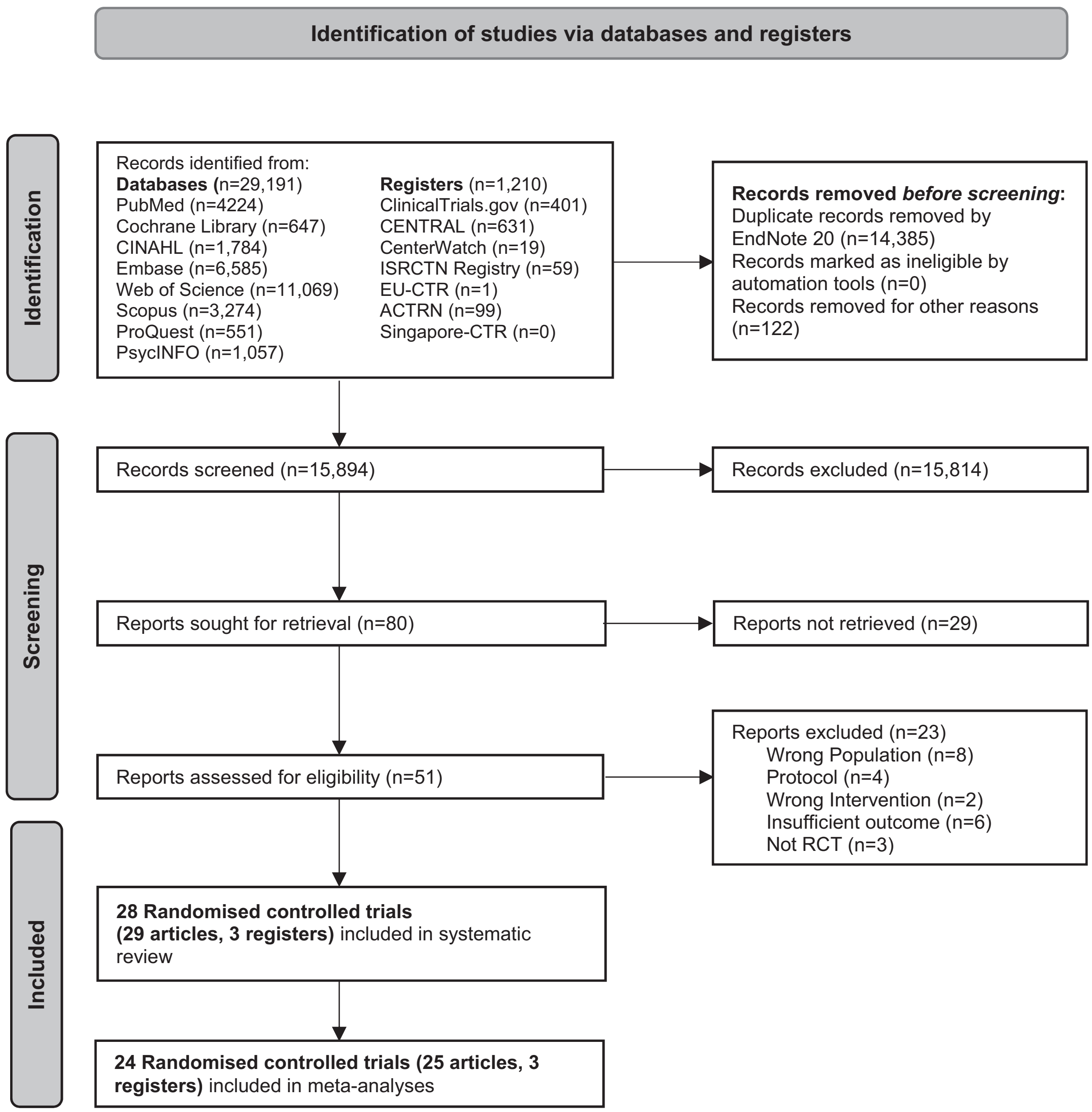


Fig. 2 Selection of trials for inclusion of the systematic review and meta-analysis.

of bias summary is illustrated in Fig. 3. The majority (91.07%) had low risks across six domains. All trials used random sequence generation. Allocation concealment was unclear in seven studies. Given that outcomes were measured objectively, all trials had low risk of performance and detection biases. Seventeen RCTs published protocols, and 20 RCTs registered in various clinical trial registries. Hence, majority ($N = 27$) of them rated low risk of selective reporting.

Social media-based intervention

The social media-based interventions are detailed in Table S7. Main RCTs ($N = 26$) used OSNs, 13 RCTs were theory based and 26 RCTs used multi-component interventions encompassing PA (100%), healthy diet (78.6%), weight management (75%) and SS (82.1%). Frequencies of social media features ranged between twice daily [88] and bimonthly [83]. More than half ($N = 21$) involved peer support, and 26 RCTs involved provider support through feedback, emails, short message service, text messages or in person. Intervention duration ranged between eight weeks [77, 82] and 24 months [72, 78]. Seven RCTs [71, 79, 80, 84–86, 94] conducted follow-up, ranging between two months [71] and one year [80].

Weight loss

In total, 21 RCTs [52–54, 71, 72, 74–76, 78–80, 82, 83, 85–89, 91, 93] with 22 arms relating using weight or weight change (kg) among 2120 participants. The pooled meta-analysis revealed a significant weight reduction of −1.45 kg (95% CI: −2.15 to −0.75) in social media-based interventions compared with that of the comparator group ($Z = -4.05$, $P < 0.001$) by using the inverse-variance method and random-effects model with small-to-medium effect size ($g = -0.29$, 95% CI: −0.43, −0.14). As substantial heterogeneity ($I^2 = 50.30{-}56.45\%$, $P < 0.10$) was detected, subgroup and meta-regression analyses were conducted to explore reasons of heterogeneity (Fig. 4).

Subgroup analyses on weight loss

A series of subgroup analyses was performed on the basis of categorial covariates such as geographical regions, participant's gender, theoretical basis, protocol publication or registration in clinical registry, use of ITT or MDM and type of social media platform (Table 2, Figs. S1–S6). Significant subgroup differences were observed for publication or registration status ($Q = 10.223$, $P = 0.001$). Social media-based intervention had a greater effect size for trial without protocol publication or not registered in

Table 1. Characteristics of selected 28 randomised controlled trials in 29 articles.

Author, Year	Country/ Setting	Design	Population (BMI criteria)	Age (M ± SD)	Intervention (name if any)	Comparator	Sample size	Outcome (Measures/unit)	Attrition rate (%)	ITT/ MDM	Protocol /Registry	Grant
Ashton et al., 2017	Australia/ Community	2-arm RCT	Male adults (Average BMI 25.5)	22.1 ± 2.0	Facebook-based (HEYMAN/ Harnessing Ehealth to enhance Young men's Mental health, Activity and Nutrition)	Waitlist	T: 50 I: 26 C: 24	• BMI change (kg/ m^2) • Body fat mass change (kg) • Energy intake change (kcal/ day) • MVPA change (min/day) • Physical activity (step/day) • WC change (cm) • Weight change (%) • Weight change (kg)	6%	Y/Y	Y/Y	Y
Brindal et al., 2012	Australia/ Community	3-arm RCT	Mixed adults (BMI: > 25)	45.0 ± 11.9	Online Total Wellbeing Diet Portal	Personalized meal planner	T: 8112 I: 3994 C:3935	• Weight change (%)	2.6%	Y/Y	Y/N	Y
Carson et al., 2013	USA/ Community	2-arm RCT	Female adults (BMI: 25–50)	45.8 ± 9.7	Online group chat sessions	No social contact	T: 73 I: 30 C: 43	• Weight change (kg)	9%	Y/Y	N/N	N
Chee et al., 2014	Malaysia/ Community	2-arm RCT	Mixed adults (BMI: 25–29)	18–59	Facebook group page based	Control group	T: 147 I: 44 C: 103	• BMI (kg/m^2) • Body fat percentage (%) • Fat mass (kg) • Physical activity (step/day) • WC (cm) • Weight (kg)	15.6%	N/N	N/N	Y
Godino et al., 2016	USA/ Community	2-arm RCT	Mixed adults (BMI: 25–34.9)	22.7 ± 3.8	Facebook-based (SMART/Social Mobile Approaches to Reduce weight)	Different website	T: 404 I: 202 C: 202	• BMI (kg/m^2) • WC (cm) • Weight (kg)	15.6%	Y/Y	Y/Y	Y
Greene et al., 2012	USA/ Community	2-arm RCT	Mixed adults (BMI: 31–33)	≥ 50 (60%)	Online social network with wireless monitoring devices	Standard care	T:349 I:180 C:169	• Total physical activity (min/ week) • Weight (lb)	0%	Y/Y	N/N	Y
Hales et al., 2016	USA/ Community	2-arm RCT	Mixed adults (BMI:25–49.9)	46.2 ± 12.4	OSN app (Social POD/Social Pounds Off Digitally)	Standard app	T: 51 I: 26 C: 25	• BMI change (kg/ m^2) • Energy intake change (kcal/ day) • Weight change (kg)	12%	Y/Y	N/Y	Y
Herring et al., 2014	USA/ Hospital	2-arm RCT	Female adults (BMI: ≥ 25)	24.2 ± 5.1	Facebook group based (Healthy4Baby)	Standard care	T: 18 I: 9 C: 9	• Weight change (kg) • Weight percentage change (%)	5.6%	Y/Y	Y/N	Y
Hutchesson et al., 2018	Australia/ Community	2-arm RCT	Female adults (BMI: 25.0–34.9)	27.1 ± 4.7	Facebook group and Instagram based (BPBH/Be Positive Be Health)	Waitlist	T: 57 I: 29 C: 28	• BMI change (kg/ m^2) • Body fat mass change (kg) • Body fat percentage (%) • Energy intake change (kJ/day) • MVPA change (min/day) • WC change (cm)	24.6%	Y/Y	Y/Y	Y

Table 1. continued

Author, Year	Country/ Setting	Design	Population (BMI criteria)	Age (M ± SD)	Intervention (name if any)	Comparator	Sample size	Outcome (Measures/unit)	Attrition rate (%)	ITT/ MDM	Protocol /Registry	Grant
								• Weight change (kg)				
Jane et al., 2017, 2018	Australia/ Community	3-arm RCT	Mixed adults (BMI: 25–40)	47.0 ± 2.3	Facebook group based	Standard care	T: 137 I: 23 C: 21	• BMI change (kg/ m^2) • Energy intake (kJ/d) • WC change (cm) • Weight (kg) • Weight change (%)	59.9%	N/Y	Y/Y	N
Joseph et al., 2015	USA/ Community	2-arm RCT	Female adults (Average BMI 31.2)	35 ± 5.0	Facebook-based	Print-based	T: 29 I: 14 C: 15	• BMI change (kg/ m^2) • MVPA change (min/week)	0%	N/N	N/Y	Y
Lytle et al., 2017	USA/ Community	2-arm RCT	Mixed adults (Average BMI 25.4)	22.7 ± 5.0	Online social networking website (CHOICES/ Choosing Healthy Options in College Environments and Settings)	Basic health promotion information	T: 441 I: 224 C: 217	• BMI (kg/m^2) • Body fat percentage (%) • WC (cm) • Weight (kg)	16.6%	N/Y	Y/Y	Y
Marquez & Wing, 2013	USA/ Community	2-arm RCT	Female adults (BMI: 27–50)	43.0 ± 10.2	Weight loss partner	Individual	T: 27 I: 13 C: 14	• Weight change (kg), • Weight change (%)	3.7%	Y/Y	Y/N	Y
Monroe et al., 2019	USA/ Community	2-arm RCT	Female adults (BMI: 25–55)	44.67 ± 8.96	Fitbit partner (NETworks/ Nutrition, Exercise, and Technology works for weight loss)	Standard behavioural treatment	T: 36 I: 18 C: 18	• Weight change (kg) • Weight change (%)	9%	N/Y	N/Y	Y
Munson et al., 2015	USA/ Community	3-arm RCT	Mixed adults (BMI: ≥ 30)	47 ± 11.68	Facebook-based (Commit to Steps)	No public announcement	T: 165 I: 54 C: 54	• Physical activity change (step/ day)	20.6%	N/N	N/Y	Y
Napolitano et al., 2013	USA/ Community	3-arm RCT	Mixed adults (BMI:25–50)	20.47 ± 2.19	Facebook-based	Waitlist	T: 52 I: 18 C: 17	• Weight change (kg)	4%	N/N	N/N	Y
Napolitano et al., 2021	USA/ Community	3-arm RCT	Mixed adults (BMI: 25–45)	23.3 ± 4.4	Facebook-based	Generic wellness content	T: 459 I_1: 150 I_2:152 C: 157	• Weight change (kg)	27.8%	N/Y	Y/Y	Y
Pagoto, 2021 (trial)	USA/ Community	2-arm RCT	Mixed adults (BMI: 27–45)	45.4 ± 11.4	Twitter-based (Get Social)	In-person group program	T:329 I:167 C:162	• Energy intake change (kcal/ day) • Weight change (%)	7.3%	N/N	Y/Y	Y
Rovniak et al. 2016	USA/ Community	3-arm RCT	Mixed adults (Average BMI 28.9)	50.3 ± 8.3	Online networking website (SNAP/ Social Networks for Activity Promotion)	No contact	N:308 I: 104 C: 96	• BMI change • MVPA (min/day) • WC change (cm)	20%	N/N	Y/Y	Y
Simpson et al., 2020	UK/ Community	3-arm RCT	Mixed adults (BMI: ≥ 30)	47.3 ± 10.7	Social support-based website (HelpMeDoIt!)	Healthy lifestyle leaflet	T: 109 I: 73 C: 36	• BMI change (kg/ m^2) • MVPA change (min/day) • Physical activity (step/day) • Weight change (kg) • Weight percentage change (%)	17.4%	Y/Y	Y/Y	Y

Table 1. continued

Author, Year	Country/ Setting	Design	Population (BMI criteria)	Age (M ± SD)	Intervention (name if any)	Comparator	Sample size	Outcome (Measures/unit)	Attrition rate (%)	ITT/ MDM	Protocol /Registry	Grant
Spring et al., 2017	USA/ Community	3-arm RCT	Mixed adults (BMI: 30–40)	39.3 ± 11.7	OSN app (ENGAGED/E-Networks Guiding Adherence to Goals in Exercise and Diet)	No interventionist contact	T: 96 I: 32 C: 32	• Weight change (kg)	13.5%	Y/Y	N/Y	Y
Stephens et al., 2017	USA/ Community	2-arm RCT	Mixed adults (BMI: 25–40)	20 ± 5.19	Smartphone technology (Lose it!)	Control group	T: 62 I: 31 C: 31	• BMI (kg/m^2) • Energy intake (kcals/day) • WC (cm) • Weight (kg)	5%	N/N	Y/N	Y
Thompson, 2020 (Trial)	USA/ Hospital	2-arm RCT	Female adults (BMI: 25–40)	30.9 ± 5.8	Facebook private group-based	Standard care	T: 42 I: 20 C: 22	• Energy intake change (kcal/ day) • Weight change (lbs)	28.6%	N/N	Y/Y	Y
Turner-McGrievy & Tate, 2011	USA/ Community	2-arm RCT	Mixed adults (BMI: 25–45)	42.6 ± 10.7	Twitter-based (Mobile POD/ Mobile Pounds Off Digitally)	Podcast only	T: 96 I: 47 C: 49	• Energy intake change (kcal/ day) • Weight change (%) • Weight change (kg)	10.4%	Y/Y	N/Y	Y
Valle et al., 2013	USA/ Community	2-arm RCT	Mixed adults (Average BMI 28.4)	31.7 ± 5.1	Facebook-based	Self-help	T: 86 I: 45 C: 41	• BMI change (kg/ m^2) • MVPA change (min/week) • Weight change (kg)	18.6%	Y/Y	N/Y	Y
Vandelanotte et al., 2017	Australia/ Community	2-arm RCT	Mixed adults (Average BMI: 28.69)	40.21 ± 12.6	Web 2.0 website (WALK 2.0)	10,000 Steps website	T: 1328 I: 722 C: 606	• BMI (kg/m^2)	94.2%	N/Y	Y/Y	Y
Waring et al., 2021	USA/ Community	2-arm RCT	Female adults (BMI: ≥ 25)	32.8 ± 4.0	Facebook group based	In-person group meetings	T: 62 I: 30 C: 32	• Weight change (%)	12.9%	N/N	Y/Y	Y
Willis et al., 2017	USA/ Community	2-arm RCT	Mixed adults (BMI: 30.0–45.0)	47 ± 12.4	Online Social Network group	Phone	T: 70 I: 34 C: 36	• BMI change (kg/ m^2) • Physical activity (step/day) • WC change (cm) • Weight change (%) • Weight change (kg)	14.3%	Y/Y	Y/Y	Y

App application, *BMI* Body Mass Index, *C* Control, *cal* calories, *F2F* Face-to-face, *I* Intervention, *ITT* Intention-to-treat analysis, *kcal* calorie, *kg* kilogram, *kg/m^2* kilograms divided by the square of the height in meters, *MDM* Missing data management, *min/day* minutes per day, *MVPA* Moderate-to-vigorous physical activity, *NR* Not reported, *OSN* Online Social Network, *RCT* Randomised Controlled Trial, *SMS* short message service, *UK* United Kingdom, *USA* United States of America, *WC* Waist circumference.

clinical registries ($g = -0.80$, 95% CI: -1.17, -0.44) than trial with published or registered protocol ($g = -0.17$, 95% CI: -0.29, -0.05). Non-significant subgroup differences were found in other subgroup comparisons. However, heterogeneity remained unexplained.

Meta-regression on weight loss

Random-effect univariate meta-regression analyses were conducted to examine whether the mean differences in weight were related to continuous covariates (i.e. publication year, mean age, sample size, duration of intervention and attrition rate). Meta-regression revealed duration of intervention ($\beta = 0.03$, $P = 0.024$) was a significant covariate on weight change as shown in Table 3. This result indicated greater weight change in intervention groups than comparator groups for every one-unit decrease in weeks of intervention. A bubble plot of regression of difference in means of weight change on duration of intervention is presented in Fig. S7. The findings showed that publication year ($\beta = 0.14$, $P = 0.233$), mean age ($\beta = -0.02$, $P = 0.664$), sample size ($\beta < 0.001$, $P = 0.0.54$) and attrition rate ($\beta = 0.02$, $P = 0.551$) did not have any impact on weight change (Table 3).

Body mass index

Thirteen RCTs [37, 52, 71, 72, 74, 75, 77, 78, 85, 87, 89–91] assessed the effectiveness of social media-based interventions among 1659 participants using BMI or BMI change. The pooled meta-analysis revealed a significant BMI change ($Z = -3.60$, $P < 0.001$) with a mean difference of $-0.65\ kg/m^2$ (95% CI: -1.00 to -0.30), with medium effect size ($g = -0.61$, 95% CI: -1.15 to -0.08) favouring social media-based interventions (Fig. 5). High heterogeneity ($I^2 = 72.45–95.85\%$, $P < 0.10$) was revealed.

Weight percentage, waist circumference, fat, energy intake and physical activity

Meta-analyses of other outcomes are summarised in Table 4, and their forest plots are shown in Figs. S1–S14. Social media-based interventions showed significant differences for waist circumference (-1.96 cm, 95% CI: -3.22, -0.70, $Z = -3.06$, $P < 0.001$) in eight trials [37, 52, 71, 72, 75, 78, 87, 91] involving 1139 participants; body fat mass (-3.11 kg, 95% CI: -5.23, -1.00, $Z = 2.88$, $P < 0.001$) in four trials [37, 52, 71, 75] involving 266 participants and daily steps (1510 steps/day, 95% CI: 259, 2761, $Z = 2.37$, $P = 0.02$) in four trials [52, 71, 85, 91] involving 274 participants. No significant differences were observed in weight percentage in 10 trials [37, 52, 53, 79, 80, 85, 88, 91, 92, 94], body fat percentage in 4 trials [37, 71, 75, 78], energy intake in 8 trials [37, 52, 74, 75, 87, 88, 92, 93] and MVPA in 5 trials [52, 75, 77, 85, 89]. Moderate to considerable heterogeneities were found for weight percentage ($I^2 = 63\%$), waist circumference ($I^2 = 52.80\%$), body fat mass ($I^2 = 85.03\%$), body fat percentage ($I^2 = 84\%$), and daily steps ($I^2 = 77.27\%$).

Narrative synthesis

Four RCTs [55, 73, 81, 84] had insufficient data for meta-analysis. Several emails were sent to request supplementary data from the authors of trials but to no avail. Hence, we conducted a narrative synthesis for these trials. The pattern of results was similar to the findings of meta-analyses in weight percentage; no statistically significances were observed in the weight percentage between intervention and comparator in one trial [55]. The social media-based intervention group significantly lost more weight [73] and increased daily steps [81] than the comparator groups. Similar MVPA [73, 84], BMI [84] and waist circumferences [84] were revealed between social media-based intervention and comparator groups.

Certainty of evidence

The certainty of evidence was graded in accordance with the GRADE criteria (Table S8). Domains of inconsistency, indirectness

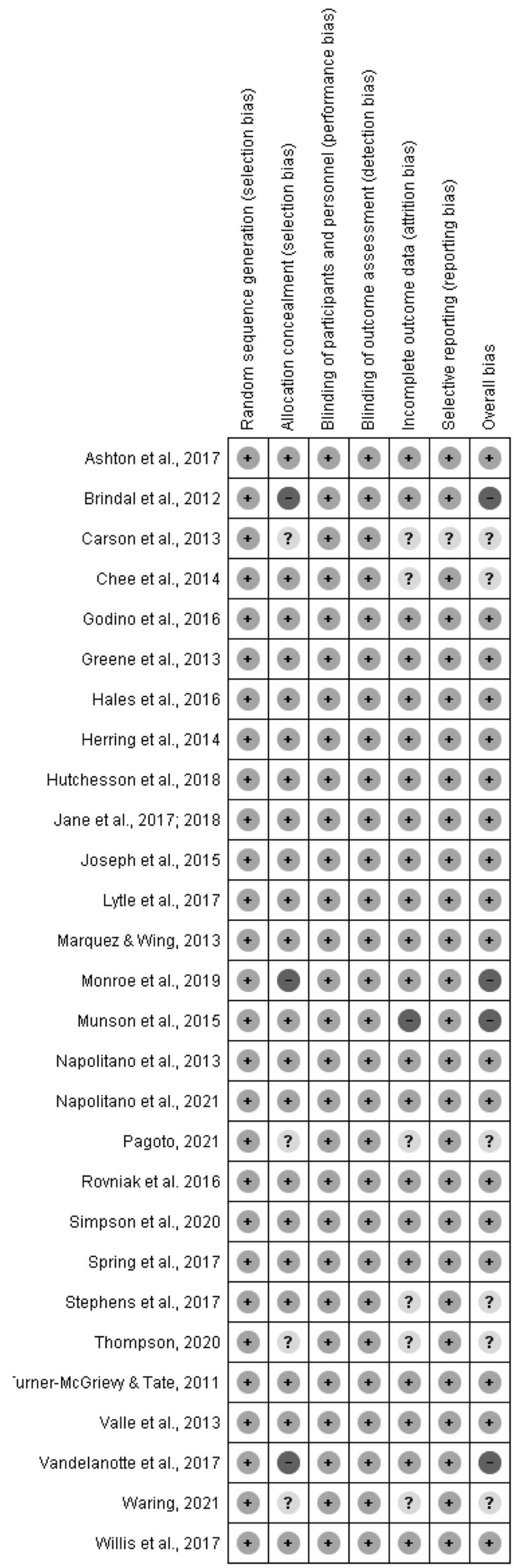
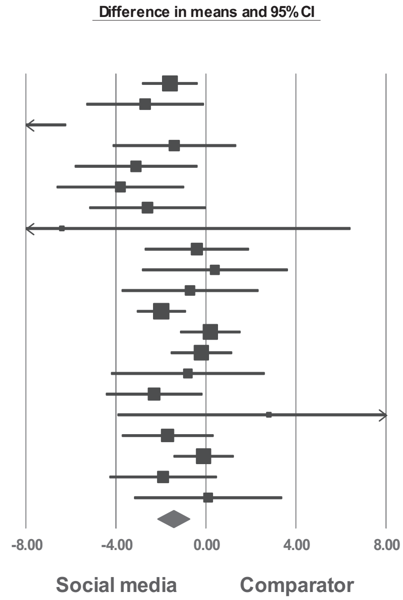


Fig. 3 Risk of bias summary.

and imprecision were downgraded due to considerable heterogeneity, variations in regime of intervention and comparators, small sample size and wide confidence interval. The *P*-value of Egger's regression tests were 0.09, 0.07 and 0.39 for weight (kg), BMI and weight change (%), respectively, and the funnel plots

Weight, kg (Difference in means)

Study name	Difference in means	Lower limit	Upper limit	Z-Value	p-Value	Social media	Comparator
	Statistics for each study					*Sample size*	
Ashton et al., 2017	-1.60	-2.84	-0.36	-2.53	0.01	26	24
Carson et al., 2013	-2.70	-5.32	-0.08	-2.02	0.04	30	43
Chee et al., 2014	-11.01	-15.82	-6.20	-4.49	0.00	35	85
Godino et al. 2016	-1.40	-4.14	1.34	-1.00	0.32	202	202
Hales et al., 2016	-3.10	-5.83	-0.37	-2.22	0.03	21	21
Herring et al., 2014	-3.80	-6.64	-0.96	-2.63	0.01	8	9
Hutchesson et al., 2018	-2.59	-5.19	0.01	-1.95	0.05	29	28
Jane et al., 2018	-6.40	-19.23	6.43	-0.98	0.33	22	17
Lytle et al. 2017	-0.40	-2.72	1.92	-0.34	0.74	205	201
Marquez et al., 2013	0.40	-2.84	3.64	0.24	0.81	13	14
Monroe et al., 2019	-0.70	-3.75	2.35	-0.45	0.65	17	16
Napolitano et al., 2013	-1.98	-3.07	-0.89	-3.55	0.00	18	17
Napolitano et al., 2021.1	0.20	-1.15	1.55	0.29	0.77	110	62
Napolitano et al., 2021.2	-0.20	-1.56	1.16	-0.29	0.77	119	62
Simpson et al., 2020	-0.80	-4.22	2.62	-0.46	0.65	50	32
Spring et al., 2017	-2.30	-4.45	-0.15	-2.10	0.04	32	32
Stephens et al., 2017	2.80	-3.93	9.53	0.82	0.42	29	30
Thompson., 2020	-1.70	-3.74	0.34	-1.63	0.10	15	22
Turner-McGrievy & Tate, 2011	-0.10	-1.44	1.24	-0.15	0.88	47	49
Valle et al., 2013	-1.90	-4.29	0.49	-1.56	0.12	32	34
Willis et al., 2017	0.10	-3.19	3.39	0.06	0.95	28	32
	-1.45	-2.15	-0.75	-4.05	0.00	1088	1032



Effect size, Hedges' *g*

Study name	Hedges's g	Lower limit	Upper limit	Z-Value	p-Value	Social media	Comparator
	Statistics for each study					*Sample size*	
Ashton et al., 2017	-0.70	-1.27	-0.14	-2.45	0.01	26	24
Carson et al., 2013	-0.48	-0.94	-0.01	-1.99	0.05	30	43
Chee et al., 2014	-0.90	-1.30	-0.49	-4.31	0.00	35	85
Godino et al. 2016	-0.10	-0.29	0.10	-1.00	0.32	202	202
Hales et al., 2016	-0.67	-1.28	-0.06	-2.16	0.03	21	21
Herring et al., 2014	-1.21	-2.20	-0.22	-2.39	0.02	8	9
Hutchesson et al., 2018	-0.51	-1.03	0.01	-1.92	0.05	29	28
Jane et al., 2018	-0.31	-0.93	0.31	-0.97	0.33	22	17
Lytle et al. 2017	-0.03	-0.23	0.16	-0.34	0.74	205	201
Marquez et al., 2013	0.09	-0.64	0.82	0.24	0.81	13	14
Monroe et al., 2019	-0.15	-0.82	0.51	-0.45	0.65	17	16
Napolitano et al., 2013	-1.17	-1.88	-0.47	-3.27	0.00	18	17
Napolitano et al., 2021.1	0.05	-0.26	0.36	0.29	0.77	110	62
Napolitano et al., 2021.2	-0.04	-0.35	0.26	-0.29	0.77	119	62
Simpson et al., 2020	-0.10	-0.54	0.34	-0.46	0.65	50	32
Spring et al., 2017	-0.52	-1.01	-0.03	-2.06	0.04	32	32
Stephens et al., 2017	0.21	-0.30	0.71	0.81	0.42	29	30
Thompson., 2020	-0.53	-1.19	0.12	-1.60	0.11	15	22
Turner-McGrievy & Tate, 2011	-0.03	-0.43	0.37	-0.15	0.88	47	49
Valle et al., 2013	-0.38	-0.86	0.10	-1.54	0.12	32	34
Willis et al., 2017	0.02	-0.49	0.52	0.06	0.95	28	32
	-0.29	-0.43	-0.14	-3.84	0.00	1088	1032

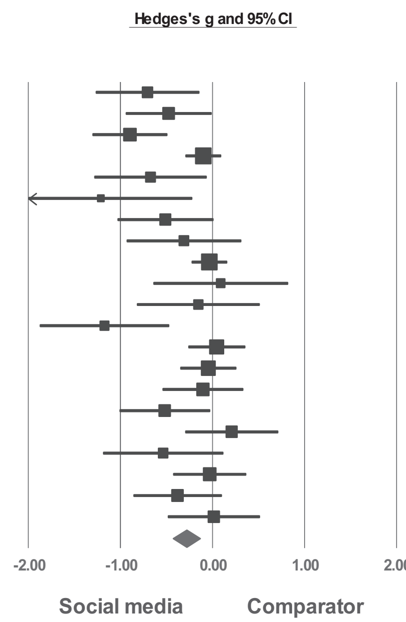


Fig. 4 Forest plot of difference in means and effect size in weight for social media-based intervention and comparator.

indicate symmetrical distribution of included RCTs (Figs. S15–17). Hence, no evidence of publication biases was detected. Overall, the level of certainty of evidence was rated low or very low.

DISCUSSION

This systematic review included 28 RCTs enrolling 13,195 individuals across four countries. Meta-analyses supported using social media-based interventions in significantly reducing weight, BMI, waist circumference and body fat mass (kg) and improving daily steps. Subgroup analyses showed a greater effect size of weight change in interventions without published protocol or registration in clinical trial registries than their counterparts. Univariate random-effect meta-regression analysis detected that duration of intervention was a significant covariate on weight change. No publication bias was detected in this review. The certainty of evidence for all outcomes ranged from very low to low.

Our meta-analyses revealed that weight and BMI had statistically significant reduction with small-to-medium effect sizes after social media-based interventions. This finding is consistent with previous meta-analyses [40, 43, 96]. It can be possibly explained by the similar intervention components and delivery methods used. The effectiveness of weight and BMI loss can be related to the combined effect of social media features and behaviour change techniques (Fig. 1). Adults with obesity and overweight learned to adopt healthy behaviours through educational posts, including didactic videos, peer-led videos for behaviour modelling [83],

Table 2. Subgroup analyses of social media-based intervention on weight (kg) in 20 randomised controlled trials with 21 arms.

Characteristics	Subgroups	No. of arm	Sample size	*g*	95% CI		*Z*-value	*P*-value	I^2	Subgroup differences (*Q*-value), *P*-value
					lower	Upper				
Geographical regions	Non-United States	5	348	−0.52	−0.82	−0.21	−3.27	0.001**	47.25%	$Q = 3.211$ $P = 0.073$
	United States	16	1772	−0.20	−0.35	−0.06	−2.67	0.007**	46.89%	
Participants' gender	Female only	6	171	−0.41	−0.76	−0.06	−2.32	0.020*	22.37%	$Q = 2.927$ $P = 0.231$
	Male only	1	50	−0.71	−1.27	−0.14	−2.45	0.014*	NA	
	Mixed	15	1899	−0.24	−0.40	−0.08	−2.93	0.003**	60.30%	
Theoretical basis	No	7	902	−0.26	−0.54	−0.02	−1.82	0.07	67.0%	$Q = 0.098$ $P = 0.755$
	Yes	14	1218	−0.31	−0.48	−0.14	−3.50	<0.001***	48.30%	
Protocol or register	No	3	228	−0.80	−1.17	−0.44	−4.294	<0.001***	36.25%	$Q = 10.223$ $P = 0.001$**
	Yes	18	1892	−0.17	−0.29	−0.05	−2.822	0.005**	29.46	
Use of ITT or M DM	No	4	251	−0.58	−1.19	0.02	−1.890	0.059	79.23%	$Q = 1.527$ $P = 0.217$
	Yes	17	1869	−0.20	−0.32	−0.07	−3.154	0.002**	29.74%	
Type of social media platform	Existing social network	1	27	0.09	−0.64	0.82	0.24	0.81	NA	$Q = 7.286$ $P = 0.200$
	Facebook	9	1071	−0.40	−0.67	−0.14	−2.95	<0.001***	71.82%	
	Facebook + Instagram	1	57	−0.51	−1.03	0.01	−1.92	0.05	NA	
	Facebook + Youth	1	50	−0.70	−1.27	−0.14	−2.45	0.01*	NA	
	Purpose-designed online social networks	8	819	−0.18	−0.37	0.02	−1.79	0.07	33.62%	
	Twitter	1	96	−0.03	−0.43	0.37	−0.15	0.88	NA	

CI Confidence interval, *g* Hedges's *g* (effect size), *ITT* Intention-to-treat, *MDM* Missing data management, *NA* Non-applicable, *protocol* published trial's protocol, *Q* Cohan Q, *register* registration in clinical trials, *Z* Z statistics.
***$P < 0.001$; **$P < 0.01$; *$P < 0.05$.

Table 3. Random-effects univariate meta-regression analyses of covariates on weight loss (kg) in 20 randomised controlled trials with 21 arms.

Covariates (Unit)	Univariate meta-regression					
	β	SE	95% CI		*Z*-value	*P*-value
			Lower	Upper		
Year of publication (years)	0.14	0.11	−0.08	0.36	1.22	0.233
Mean age (years)	−0.02	0.04	−0.09	0.06	−0.43	0.664
Sample size (Number)	<0.001	<0.001	<−0.001	0.01	1.93	0.054
Duration of intervention (weeks)	0.03	0.01	<0.001	0.05	2.25	0.024*
Attrition rate (%)	0.02	0.04	−0.05	0.10	0.60	0.551

β Regression coefficient, *CI* Confidence interval, *SE* Standard error; *Z* Z statistic.
*$P < 0.05$.

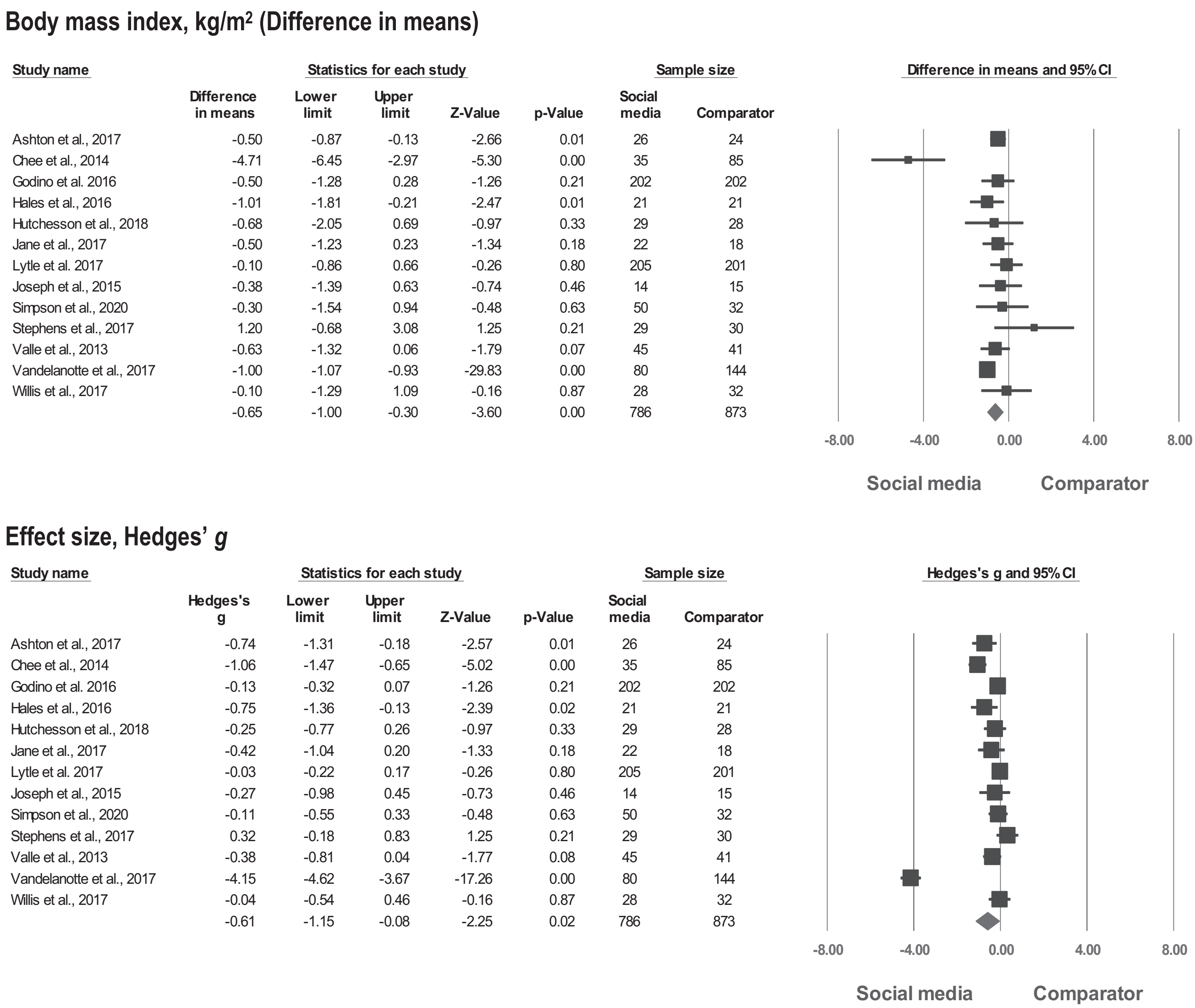


Fig. 5 Forest plot of difference in means and effect size in body mass index for social media-based intervention and comparator.

cooking videos, PA demonstrations [52] and audio lectures [91]. Participants were given personalised feedback and reinforced messages on their health behaviour and progress [53, 80, 83, 88, 89, 91]. The communication and peer grouping features allow peer interaction through discussion forums and group chats within the private OSN groups [52–54, 75, 83, 89, 91]. Data-sharing features involve poll voting [82, 83], audio blogs of weight loss individuals [88] and goal and activity data sharing between participants [74, 85]. Activity data viewing and communication features involve sending notifications, reminders and text messages for self-monitoring of diet, PA and weight [52, 53, 74, 75, 80, 82, 83, 85, 86, 89]. Self-monitoring reminders

Table 4. Effectiveness of social media-based interventions on weight percentage, waist circumference, fat and physical activity.

Outcomes	No. of trials	Sample size	Statistical method & Analysis model	MD (95% CI)	Overall effect		I^2	Effect size *g* (95% CI)
					Z	*P*-value		
Weight percentage (%)	10	792	IV & D-Laird & Random effects	−0.35 (−1.60, 0.91)	−0.54	0.59	63%	−0.08 (−0.34, 0.17)
Waist circumference (cm)	8	1139	IV & D-Laird & Random effects	−1.96 (−3.22, −0.70)	−3.06	<0.001***	52.80%	−0.33 (−0.58, −0.09)
Body fat mass (kg)	4	266	IV & D-Laird & Random effects	−3.11 (−5.23, −1.00)	−2.88	<0.001***	85.03%	−0.85 (−1.11, −0.59)
Body fat percentage (%)	4	613	IV & D-Laird & Random effects	−2.78 (−5.99, 0.42)	−1.70	0.09	84%	−0.42 (−0.92, 0.08)
Energy intake (kcal/day)	8	680	IV & D-Laird & Random effects	−9.95 (−99.45, 0.22)	−0.22	0.83	0%	<−0.001 (−0.15, −0.03)
Physical activity (steps/day)	4	274	IV & D-Laird & Random effects	1510 (259, 2761)	2.37	0.02*	77.27%	0.75 (−0.09, 1.58)
MVPA (minutes/day)	5	240	IV & D-Laird & Random effects	1.45 (−6.27, 9.18)	0.37	0.71	31.65%	0.06 (−0.24, 0.36)

CI Confidence Interval, *D-Laird* DerSimonian and Laird analysis model, *g* Hedges's *g* (effect size); I^2 Heterogeneity, *IV* Inverse variance statistical method, *kcal* calorie, *MD* mean difference, *min* minutes, *MVPA* Moderate-to-vigorous physical activity, *N* sample size, *random* random effects model, *ref* reference list, *Z* z-statistics.
***$P < 0.001$; *$P < 0.05$.

contributing to frequent real-time data can result in positive reinforcement and significantly greater weight change [97].

Skills training with weight-related behaviour change techniques were taught, including problem solving, goal setting [53, 75, 79, 80, 82, 83, 85, 86, 89, 91], action planning [79, 80], social comparison [85] and social support [75, 80, 82, 85, 89, 91]. These behaviour change techniques play a key role in modifying dietary intake and PA [98]. Thus, these promising techniques delivered by social media should be considered when designing future interventions. Particularly, self-monitoring and goal setting are more valued among participants [75]. Subsequently, self-efficacy is constructed via feedback, advice [74, 89], goal-setting and self-efficacy messages incorporating informational social support [80]. The self-efficacy theory points out that participants who believe in being successful in a behaviour would be more likely to make behavioural changes to produce desirable effects, playing an important role in physical health, psychological adjustment, and behavioural change strategies [99]. Outcome expectation messages incorporate positive outcomes of healthy behaviours related to PA, diet and weight [74]. Hence, participants can reduce their weight and BMI after intervention.

Our subgroup finding suggested greater effect in RCTs without published protocol or registered trial. This can be a result of outcome-reporting bias that may be related to a distortion of presented data from trials without protocol because authors can add, remove or upgrade outcomes to favour a statistically positive result [100, 101]. One study shows that 34% of RCTs are not registered, and 21% are inadequately registered [101]. Indeed, protocol provides full transparency, and it should be publicly available to prevent selective outcome-reporting bias [102]. However, a large majority of the authors (77%) stated that it was not mandatory for them to register their systematic review protocol by their institutes which would give them the leeway to manipulate the outcomes to suit their preferences [103].

Our meta-regression showed that longer duration of social media-based intervention can slow down weight loss outcome. The case may be linked higher non-compliance with longer period [104]. Adherence behaviour may be dynamic and influenced by beliefs about the need for intervention and its effectiveness based on the health belief model [105]. Adults with overweight and obesity may lose their beliefs for managing weight loss maintenance in a long period of intervention. Another possibility may be related to social media fatigue with a longer duration on social media platforms [106]. Participants may feel overwhelmed and feeling tired of social media activities. Hence, adults with obesity and overweight who participated in longer duration of social media-based interventions may seem to like a slower pace for weight loss.

Our meta-analyses revealed significant change of waist circumference, body fat mass and daily step in social media-based interventions. This can be possibly explained by social media's usefulness to improving weight management through social support provided by family, partners and friends [107] and through companionship [74] and encouragement offering emotional support [74, 80, 89, 91]. For instance, participants could invite a friend or family member to offer support and ensure self-monitoring compliance [82, 85]. This could highlight the importance of inviting family members to participate in the family therapy, who could give feedback or encouragement about the efficacy of the treatment sessions [108]. The app could advise participants on how to harness social support from their family and friends [85]. This can be facilitated by social media features that enable commenting, 'likes' and peer messaging [82, 91]. This could also show how the intra- and inter-personal factors of the socio-ecological theory interact, including the home environment and lifestyles of family members, which could greatly influence the obesity risk of the participants [109].

Given that four RCTs were included for body fat mass and daily steps, caution is required in interpretation of results owing to overestimated effects within small sample sizes [110]. Notably, social media-based interventions had no impact on weight percentage change, body fat percentage, energy intake and MVPA. This non-significant difference can be possibly explained by mixture of measurement tools, various comparators and limited number of included trials. Doing more than speculate is impossible at this stage. These findings require more investigations.

Strengths and limitations

This review has several strengths. We followed the PRISMA checklist strictly and used a comprehensive three-step search strategy in published and unpublished studies in eight databases, ongoing trials, grey literature and targeted journals. We included solely RCT design. We adopted subgroup analyses and random-effects meta-regression analyses to compare the effect sizes of groups and explore a covariate of the intervention effect. The certainty of the evidence was assessed to provide the confidence of implementation. The use of clinical anthropometry indicators such as waist circumference, are low-cost and easy-to-use methods to accurately define visceral obesity and best identify groups at risk for obesity for earlier intervention [111]. Furthermore, a meta-analysis has supported that a large waist circumference is predictive of higher mortality among participants even with normal BMI values, which makes it advantageous in suggesting the changes in body fat composition for clinical practice [112].

Nonetheless, this systematic review has several limitations. Firstly, most RCTs occurred in high-income Western countries and restricted to the English language articles which could limit the findings' generalisation. Secondly, all outcomes with low to very low certainty of evidence could lower the findings' internal validity. Thirdly, outcomes had sustainable heterogeneities, which are possibly due to various comparators and different regimes of intervention, thereby resulting in the low accuracy of the pooled estimates [113]. Fourthly, most RCTs had no follow-up data, so sustainability remains unclear. Fifthly, meta-analysis results could be subjected to ecological fallacy or Simpson's paradox [114]. Lastly, there exist several drawbacks to using social media for weight loss strategies since social media serves as both a platform for cultivating weight stigma and finding body positivity communities [115]. This could result in individuals developing weight-related beliefs and attitudes, reflecting their differential exposure to weight stigmatisation. In particular, overweight and obese youth may face adverse effects associated with exposure to weight stigmatisation which include anxiety, body dissatisfaction, depression, poor academic performance and avoidance of health care [116].

Implications for clinical practice and policy

Social media-based interventions can reduce weight, BMI, waist circumference, fat mass and energy intake and increase daily steps among adults with obesity and overweight. As the certainty of evidence is mostly low [67], the effectiveness of implementing social media-based interventions in the clinical practice for weight management remains uncertain. We only suggest that social media-based interventions be considered as an adjunct intervention for weight control. Additionally, we would need to take into consideration that social media use is heterogenous across the different age groups where most young adults aged 18 to 24 use Instagram (76%), TikTok (55%) and Snapchat (75%). On the other hand, Facebook and YouTube are the most used social media platforms by the older population [117]. Nonetheless, the meta-regression analysis highlighted that duration of intervention can impact weight loss. Further investigation should identify an ideal duration of social media-based intervention that can maximise the treatment effect.

Future research

Future RCTs need a large sample size to accurately estimate the effects of intervention. More RCTs should be conducted in low income non-Western countries to improve generalisation of findings. RCTs with follow-up assessments are few; future studies can include follow-up durations to ensure sustainability. Considering that included trials contained variations in regime of social media-based intervention, the essential features of intervention are difficult to identify. Future studies should define the optimal sessions, lengths, frequency and duration of intervention. All trials' protocol should be registered in clinical registries or published in peer-reviewed journal, and authors should adhere to protocol to prevent selective outcome-reporting bias [100–102]. Future studies could include conducting meta-analyses on children and adolescents for obesity management.

CONCLUSION

Our systematic review demonstrates that social media-based interventions are effective to change weight, BMI, waist circumference, fat mass and energy intake and increase daily steps among adults with obesity and overweight. Subgroup analyses suggest that future intervention designs should register or publish trials' protocol. Meta-regression analyses find significant impact of duration of intervention on weight change. Given that the certainty of evidence is rated low or very low, the results must be interpreted with caution. Social media-based interventions can be implemented as adjuvant to standard weight management among adults with obesity and overweight. RCTs with a larger sample size and follow-up assessment are needed.

DATA AVAILABILITY

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

REFERENCES

1. World Health Organization. Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. Accessed June 9, 2021.
2. Dai H, Alsalhe TA, Chalghaf N, Riccò M, Bragazzi NL, Wu J. The global burden of disease attributable to high body mass index in 195 countries and territories, 1990–2017: An analysis of the Global Burden of Disease Study. PLoS Med. 2020;17:e1003198.
3. Malik VS, Khaiwal R, Verma AS, Bhadada Sanjay K, Singh M. Higher body mass index is an important risk factor in COVID-19 patients: a systematic review and meta-analysis. Environ Sci Pollut Res. 2020;27:42115–23.
4. Popkin BM, Du S, Green WD, Beck MA, Algaith T, Herbst CH, et al. Individuals with obesity and COVID-19: A global perspective on the epidemiology and biological relationships. Obes Rev. 2020;21:e13128.
5. Norris T, Mansukoski L, Gilthorpe MS, Hamer M, Hardy R, Howe LD, et al. Distinct body mass index trajectories to young-adulthood obesity and their different cardiometabolic consequences. Arterioscler Thromb Vasc Biol. 2021;41:1580–93.
6. Musich S, MacLeod S, Bhattarai GR, Wang SS, Hawkins K, Bottone FG Jr, et al. The impact of obesity on health care utilization and expenditures in a medicare supplement population. Gerontol Geriatr Med. 2016;2:1–9.
7. Hecker J, Freijer K, Hiligsmann M, Evers SMAA. Burden of disease study of overweight and obesity; the societal impact in terms of cost-of-illness and health-related quality of life. BMC Public Health. 2022;22:46.
8. Puhl RM, Lessard LM. Weight Stigma in Youth: Prevalence, Consequences, and Considerations for Clinical Practice. Curr Obes Rep. 2020;9:402–11.
9. Adil O, Kuk JL, Ardern CI. Associations between weight discrimination and metabolic health: A cross sectional analysis of middle aged adults. Obes Res Clin Pract. 2022;16:151–7.
10. Tomiyama AJ, Carr D, Granberg EM, Major B, Robinson E, Sutin AR, et al. How and why weight stigma drives the obesity 'epidemic' and harms health. BMC Med. 2018;16:123.
11. Jung FU, Luck-Sikorski C. Overweight and Lonely? A Representative Study on Loneliness in Obese People and Its Determinants. Obes Facts. 2019;12:440–7.
12. Ufholz K. Peer support groups for weight loss. Curr Cardiovasc Risk Rep. 2020;14:19.

13. Karfopoulou E, Anastasiou CA, Avgeraki E, Kosmidis MH, Yannakoulia M. The role of social support in weight loss maintenance: results from the MedWeight study. J Behav Med. 2016;39:511–8.
14. Danielli S, Coffey T, Ashrafian H, Darzi A. Systematic review into city interventions to address obesity. EClinicalMedicine. 2021;32:1–10.
15. Young LE, Soliz S, Xu JJ, Young SD. A review of social media analytic tools and their applications to evaluate activity and engagement in online sexual health interventions. Prev Med Rep. 2020;19:101158.
16. Klassen KM, Douglass CH, Brennan L, Truby H, Lim MSC. Social media use for nutrition outcomes in young adults: a mixed-methods systematic review. Int J Behav Nutr Phys Act. 2018;15:70.
17. Karim F, Oyewande AA, Abdalla LF, Chaudhry Ehsanullah R, Khan S. Social media use and its connection to mental health: a systematic review. Cureus. 2020;12:e8627.
18. Hruska J, Maresova P. Use of social media platforms among adults in the United States—behavior on social media. Societies. 2020;10:27.
19. Giustini D, Ali SM, Fraser M, Kamel Boulos MN. Effective uses of social media in public health and medicine: a systematic review of systematic reviews. Online J Public Health Inform. 2018;10:e215–e.
20. Welch V, Petkovic J, Pardo Pardo J, Rader T, Tugwell P. Interactive social media interventions to promote health equity: an overview of reviews. Health Promot Chronic Dis Prev Can. 2016;36:63–75.
21. Bandura A. Social foundations of thought and action: A social cognitive theory. New Jersey, United States: Prentice-Hall; 1986.
22. Nabi RL, Prestin A. Social Cognitive Theory. In The International Encyclopedia of Media Psychology. Bulck, J. (ed). New Jersey, United States: Wiley Blackwell; 2020. https://doi.org/10.1002/9781119011071.iemp0159.
23. Arguel A, Perez-Concha O, Li SYW, Lau AYS. Theoretical approaches of online social network interventions and implications for behavioral change: a systematic review. J Eval Clin Pract. 2018;24:212–21. 2018;24:212–21
24. Laranjo L. Social media and health behavior change. In: Syed-Abdul S, Gabarron E, Lau AYS, editors. Participatory health through social media. Massachusetts, United States: Academic Press; 2016. pp 83–111.
25. Oyibo K, Adaji I, Vassileva J. Social cognitive determinants of exercise behavior in the context of behavior modeling: a mixed method approach. Digit Health. 2018;4:1–19.
26. Anderson RB. Vicarious and persuasive influences on efficacy expectations and intentions to perform breast self-examination. Public Relat Rev. 2000;26:97–114.
27. Mahoney MJ. Self-reward and self-monitoring techniques for weight control. Behav Ther. 1974;5:48–57.
28. Elaheebocus S, Weal M, Morrison L, Yardley L. Peer-based social media features in behavior change interventions: systematic review. J Med Internet Res. 2018;20:e20.
29. Voorveld HAM, van Noort G, Muntinga DG, Bronner F. Engagement with social media and social media advertising: the differentiating role of platform type. J Advert. 2018;47:38–54.
30. Arigo D, Pagoto S, Carter-Harris L, Lillie SE, Nebeker C. Using social media for health research: Methodological and ethical considerations for recruitment and intervention delivery. Digit Health. 2018;4:1–15.
31. Chung C-F, Agapie E, Schroeder J, Mishra S, Fogarty J, Munson SA. When personal tracking becomes social: examining the use of instagram for healthy eating. Proc SIGCHI Conf Hum Factor Comput Syst. 2017;2017:1674–87.
32. Carey RN, Connell LE, Johnston M, Rothman AJ, de Bruin M, Kelly MP, et al. Behavior change techniques and their mechanisms of action: a synthesis of links described in published intervention literature. Ann Behav Med. 2019;53:693–707.
33. Nabavi RT. Bandura's Social Learning Theory & Social Cognitive Learning Theory. Journal of Personality and Social Psychology, 2012;1:589.
34. Yoon H-J, Tourassi G. Analysis of online social networks to understand information sharing behaviors through social cognitive theory. Annu ORNL Biomed Sci Eng Cent Conf. 2014;2014:1–4.
35. Elfhag K, Rössner S. Who succeeds in maintaining weight loss? A conceptual review of factors associated with weight loss maintenance and weight regain. Obes Rev. 2005;6:67–85.
36. Grigg E. Social Cognitive Theory VS. Social Comparison Theory: examining the relationship between social influence and weight loss. In: Maddux JE editors. The power of believing you can. Handbook of positive psychology. New York: Oxford University Press; 2012;2002:277–87.
37. Jane M, Hagger M, Foster J, Ho S, Kane R, Pal S. Effects of a weight management program delivered by social media on weight and metabolic syndrome risk factors in overweight and obese adults: A randomised controlled trial. PloS One. 2017;12:e0178326.
38. Grant N, Hamer M, Steptoe A. Social Isolation and Stress-related Cardiovascular, Lipid, and Cortisol Responses. Annals of Behavioral Medicine. 2009;37:29–37.
39. Partridge SR, Raeside R, Singleton A, Hyun K, Redfern J. Effectiveness of text message interventions for weight management in adolescents: systematic review. JMIR Mhealth Uhealth. 2020;8:e15849.
40. Lozano-Chacon B, Suarez-Lledo V, Alvarez-Galvez J. Use and effectiveness of social-media-delivered weight loss interventions among teenagers and young adults: a systematic review. Int J Environ Res Public Health. 2021;18:8493.
41. Petkovic J, Duench S, Trawin J, Dewidar O, Pardo Pardo J, Simeon R, et al. Behavioural interventions delivered through interactive social media for health behaviour change, health outcomes, and health equity in the adult population. Cochrane Database Syst Rev. 2021;5:1–317.
42. Chang T, Chopra V, Zhang C, Woolford SJ. The role of social media in online weight management: systematic review. J Med Internet Res. 2013;15:e262.
43. Ashrafian H, Toma T, Harling L, Kerr K, Athanasiou T, Darzi A. Social networking strategies that aim to reduce obesity have achieved significant although modest results. Health Aff. 2014;33:1641–7.
44. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.
45. Seidell JC, Halberstadt J. The global burden of obesity and the challenges of prevention. Ann Nutr Metab. 2015;66:7–12.
46. Jain AK, Sahoo SR, Kaubiyal J. Online social networks security and privacy: comprehensive review and analysis. Complex and Intell Syst. 2021;7:2157–77.
47. Hariton E, Locascio JJ. Randomised controlled trials - the gold standard for effectiveness research: Study design: randomised controlled trials. BJOG. 2018;125:1716.
48. Higgins JP, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al. eds. Cochrane Handbook for Systematic Reviews of Interventions. New Jersey, United States: John Wiley & Sons; 2019.
49. The EndNote Team. EndNote. EndNote 20 ed. Philadelphia, PA: Clarivate, 2013.
50. McHugh ML. Interrater reliability: the kappa statistic. Biochemia Medica (Zagreb). 2012;22:276–82.
51. Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019;366:l4898.
52. Ashton LM, Morgan PJ, Hutchesson MJ, Rollo ME, Collins CE. Feasibility and preliminary efficacy of the 'HEYMAN' healthy lifestyle program for young men: a pilot randomised controlled trial. Nutr J. 2017;16:2.
53. Herring SJ, Cruice JF, Bennett GG, Davey A, Foster GD. Using technology to promote postpartum weight loss in urban, low-income mothers: a pilot randomized controlled trial. J Nutr Educ Behav. 2014;46:610–5.
54. Carson TL, Eddings KE, Krukowski RA, Love SJ, Harvey-Berino JR, West DS. Examining social influence on participation and outcomes among a network of behavioral weight-loss intervention enrollees. J Obes. 2013;2013:1–8.
55. Brindal E, Freyne J, Saunders I, Berkovsky S, Smith G, Noakes M. Features predicting weight loss in overweight or obese participants in a web-based intervention: randomized trial. J Med Internet Res. 2012;14:e173.
56. Kang H. The prevention and handling of the missing data. Korean J Anesthesiol. 2013;64:402–6.
57. Nich C, Carroll KM. Intention-to-treat meets missing data: implications of alternate strategies for analyzing clinical trials data. Drug Alcohol Depend. 2002;68:121–30.
58. Gupta SK. Intention-to-treat concept: A review. Perspect Clin Res. 2011;2:109–12.
59. Comprehensive meta-analysis software. A computer program for meta-analysis. Englewood, New Jersey: Biostat; 2014.
60. Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. A basic introduction to fixed-effect and random-effects models for meta-analysis. Res Synth Methods. 2010;1:97–111.
61. Hedges LV, Olkin I. Statistical methods for meta-analysis. Massachusetts, United States: Academic press; 2014.
62. Richardson M, Garner P, Donegan S. Interpretation of subgroup analyses in systematic reviews: A tutorial. Clin Epidemiol Glob Health. 2019;7:192–8.
63. Fan J, Song F, Bachmann MO. Justification and reporting of subgroup analyses were lacking or inadequate in randomized controlled trials. J Clin Epidemiol. 2019;108:17–25.
64. Ranganathan P, Pramesh CS, Aggarwal R. Common pitfalls in statistical analysis: Logistic regression. Perspect Clin Res. 2017;8:148–51.
65. Deeks JJ, Higgins JPT, Altman DG. Chapter 10: Analysing data and undertaking meta-analyses. Cochrane, 2019. Available from: https://training.cochrane.org/handbook/current/chapter-10.
66. GRADE Working Group. GRADEpro GDT: GRADEpro Guideline Development Tool [Software]. McMaster University and Evidence Prime: United States; 2021. https://www.gradepro.org/.
67. Guyatt, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, et al. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. J Clin Epidemiol. 2011;64:383–94.

68. Lin L, Chu H. Quantifying publication bias in meta-analysis. Biometrics. 2018;74:785–94.
69. Sterne JAC, Sutton AJ, Ioannidis JPA, Terrin N, Jones DR, Lau J, et al. Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. BMJ. 2011;343:d4002.
70. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ. 1997;315:629.
71. Chee HP, Hazizi AS, Barakatun Nisak MY, Mohd, Nasir MT. A Randomised Controlled Trial of a Facebook-based Physical Activity Intervention for Government Employees with Metabolic Syndrome. Malays J Nutr. 2014;20:165–81.
72. Godino JG, Merchant G, Norman GJ, Donohue MC, Marshall SJ, Fowler JH, et al. Using social and mobile tools for weight loss in overweight and obese young adults (Project SMART): a 2 year, parallel-group, randomised, controlled trial. Lancet Diabetes Endocrinol. 2016;4:747–55.
73. Greene J, Sacks R, Piniewski B, Kil D, Hahn JS. The impact of an online social network with wireless monitoring devices on physical activity and weight loss. J prim care community health. 2013;4:189–94.
74. Hales S, Turner-McGrievy GM, Wilcox S, Fahim A, Davis RE, Huhns M, et al. Social networks for improving healthy weight loss behaviors for overweight and obese adults: A randomized clinical trial of the social pounds off digitally (Social POD) mobile app. Int J Med Inform. 2016;94:81–90.
75. Hutchesson MJ, Callister R, Morgan PJ, Pranata I, Clarke ED, Skinner G, et al. A targeted and tailored eHealth weight loss program for young women: the be positive be healthe randomized controlled trial. Healthcare. 2018;6:39.
76. Jane M, Foster J, Hagger M, Ho S, Kane R, Pal S. Psychological effects of belonging to a Facebook weight management group in overweight and obese adults: Results of a randomised controlled trial. Health Soc Care Community. 2018;26:714–24.
77. Joseph RP, Keller C, Adams MA, Ainsworth BE. Print versus a culturally-relevant Facebook and text message delivered intervention to promote physical activity in African American women: a randomized pilot trial. BMC Women's Health. 2015;15:30.
78. Lytle LA, Laska MN, Linde JA, Moe SG, Nanney MS, Hannan PJ, et al. Weight-Gain Reduction Among 2-Year College Students: The CHOICES RCT. Am J Prev Med. 2017;52:183–91.
79. Marquez B, Wing RR. Feasibility of enlisting social network members to promote weight loss among Latinas. J Acad Nutr Diet. 2013;113:680–7.
80. Monroe CM, Geraci M, Larsen CA, West DS. Feasibility and efficacy of a novel technology-based approach to harness social networks for weight loss: the NETworks pilot randomized controlled trial. Obes Sci Pract. 2019;5:354–65.
81. Munson SA, Krupka E, Caroline R, Resnick P. Effects of public commitments and accountability in a technology-supported physical activity interv ention. CHI '15: Proc 33rd Annual ACM Conf Hum Factors Comput Syst. 2015:1–10.
82. Napolitano MA, Hayes S, Bennett GG, Ives AK, Foster GD. Using Facebook and text messaging to deliver a weight loss program to college students. Obesity. 2013;21:25–31.
83. Napolitano MA, Whiteley JA, Mavredes M, Tjaden AH, Simmens S, Hayman LL, et al. Effect of tailoring on weight loss among young adults receiving digital interventions: an 18 month randomized controlled trial. Transl Behav Med. 2021;11:970–80.
84. Rovniak LS, Kong L, Hovell MF, Ding D, Sallis JF, Ray CA, et al. Engineering online and in-person social networks for physical sctivity: a randomized trial. Ann Behav Med. 2016;50:885–97.
85. Simpson SA, Matthews L, Pugmire J, McConnachie A, McIntosh E, Coulman E, et al. An app-, web- and social support-based weight loss intervention for adults with obesity: the 'HelpMeDoIt!' feasibility randomised controlled trial. Pilot Feasibility Stud. 2020;6:133.
86. Spring B, Pellegrini CA, Pfammatter A, Duncan JM, Pictor A, McFadden HG, et al. Effects of an abbreviated obesity intervention supported by mobile technology: The ENGAGED randomized clinical trial. Obesity (Silver Spring). 2017;25:1191–8.
87. Stephens JD, Yager AM, Allen J. Smartphone technology and text messaging for weight loss in young adults: a randomized controlled trial. J Cardiovasc Nurs. 2017;32:39–46.
88. Turner-McGrievy G, Tate D. Tweets, Apps, and Pods: Results of the 6-month Mobile Pounds Off Digitally (Mobile POD) randomized weight-loss intervention among adults. J Med Internet Res. 2011;13:e120.
89. Valle CG, Tate DF, Mayer DK, Allicock M, Cai J. A randomized trial of a Facebook-based physical activity intervention for young adult cancer survivors. J Cancer Surviv. 2013;7:355–68.
90. Vandelanotte C, Kolt GS, Caperchione CM, Savage TN, Rosenkranz RR, Maeder AJ, et al. Effectiveness of a web 2.0 intervention to increase physical activity in real-world settings: randomized ecological trial. J Med Internet Res. 2017;19:e390.
91. Willis EA, Szabo-Reed AN, Ptomey LT, Steger FL, Honas JJ, Al-Hihi EM, et al. Distance learning strategies for weight management utilizing online social networks versus group phone conference call. Obes Sci Pract. 2017;3:134–42.
92. Pagoto S. Get social: randomized trial of a social network delivered lifestyle intervention. 2021. https://clinicaltrials.gov/show/NCT02646618
93. Thompson D. Helping moms to be healthy after baby. 2020. https://clinicaltrials.gov/show/NCT03257657
94. Waring M. The healthy moms study: comparison of a post-partum weight loss intervention delivered via Facebook or in-person groups. 2021. https://clinicaltrials.gov/show/NCT03700736
95. Paul J Resnick. Impacts of Public Announcements of Goals and Outcomes on Goal Completion (Commit to Steps). 2013. https://clinicaltrials.gov/show/NCT01811407
96. An R, Ji M, Zhang S. Effectiveness of social media-based interventions on weight-related behaviors and body weight status: review and meta-analysis. Am J Health Behav. 2017;41:670–82.
97. Burke LE, Styn MA, Sereika SM, Conroy MB, Ye L, Glanz K, et al. Using mHealth technology to enhance self-monitoring for weight loss: a randomized trial. Am J Prev Med. 2012;43:20–26.
98. Michie S, Abraham C, Whittington C, McAteer J, Gupta S. Effective techniques in healthy eating and physical activity interventions: a meta-regression. Health Psychol. 2009;28:690–701.
99. Maddux JE. The power of believing you can. Handbook of positive psychology. New York: Oxford University Press; 2002:277–87.
100. Dwan K, Altman DG, Cresswell L, Blundell M, Gamble CL, Williamson PR. Comparison of protocols and registry entries to published reports for randomised controlled trials. Cochrane Database Syst Rev. 2011;2011:MR000031.
101. Killeen S, Sourallous P, Hunter IA, Hartley JE, Grady HLO. Registration Rates, Adequacy of Registration, and a Comparison of Registered and Published Primary Outcomes in Randomized Controlled Trials Published in Surgery Journals. Ann Surg. 2014;259:193–6.
102. Mathieu S, Boutron I, Moher D, Altman DG, Ravaud P. Comparison of Registered and Published Primary Outcomes in Randomized Controlled Trials. JAMA. 2009;302:977–84.
103. Tawfik GM, Giang HTN, Ghozy S, Altibi AM, Kandil H, Le H-H, et al. Protocol registration issues of systematic review and meta-analysis studies: a survey of global researchers. BMC Medical Research Methodology. 2020;20:213.
104. Subedi S, Paudel K, Thapa DK. Treatment Non-Compliance in Patients with Schizophrenia. J Univers College Med Sci. 2020;8:3–8.
105. Green EC, Murphy EM, Gryboski K. The Health Belief Model. In: Sweeny K, Robbins ML, Lee MC, editors. The Wiley Encyclopedia of Health Psychology. Toronto, Canada: John Wiley & Sons Ltd; 2020. pp 211-4.
106. Zheng H, Ling R. Drivers of social media fatigue: A systematic review. Telemat Inform. 2021;64:101696.
107. Jane M, Hagger M, Foster J, Ho S, Pal S. Social media for health promotion and weight management: a critical debate. BMC Public Health. 2018;18:932.
108. Bishop JA, Irby MB, Kaplan SG, Arnold EM, Skelton JA. What Can We Learn About Family-Based Obesity Treatment From Family Therapists? Glob Pediatr Health. 2015;2:2333794x15607316.
109. Quick V, Martin-Biggers J, Povis GA, Hongu N, Worobey J, Byrd-Bredbenner C. A Socio-Ecological Examination of Weight-Related Characteristics of the Home Environment and Lifestyles of Households with Young Children. Nutrients. 2017;9:604.
110. Zhang Z, Xu X, Ni H. Small studies may overestimate the effect sizes in critical care meta-analyses: a meta-epidemiological study. Crit Care. 2013;17:1–9.
111. Roriz A, Passos L, Cunha de Oliveira C, Eickemberg M, Moreira P, Ramos L. Anthropometric clinical indicators in the assessment of visceral obesity: An update. Nutr. clín. diet. hosp. 2016;36:168–79.
112. Coutinho T, Goel K, Corrêa de Sá D, Kragelund C, Kanaya AM, Zeller M, et al. Central Obesity and Survival in Subjects With Coronary Artery Disease: A Systematic Review of the Literature and Collaborative Analysis With Individual Subject Data. Journal of the American College of Cardiology. 2011;57:1877–86.
113. Melsen WG, Bootsma MCJ, Rovers MM, Bonten MJM. The effects of clinical and statistical heterogeneity on the predictive values of results from meta-analyses. Clin Microbiol Infect. 2014;20:123–9.
114. Cooper H, Patall EA. The relative benefits of meta-analysis conducted with individual participant data versus aggregated data. Psychol Methods. 2009;14:165–76.
115. Clark O, Lee MM, Jingree ML, O'Dwyer E, Yue Y, Marrero A, et al. Weight Stigma and Social Media: Evidence and Public Health Solutions. Front Nutr. 2021;8:739056.
116. Puhl RM, King KM. Weight discrimination and bullying. Best Pract Res Clin Endocrinol Metab. 2013;27:117–27.
117. Brooke A, Monica A. Social Media Use in 2021. Washington, D.C, United States: Pew Research Center; 2021.

AUTHOR CONTRIBUTIONS

YLL and YL conceived and designed this study. YLL, PY and YL conducted the database searches, screened titles, abstract, and full text. YLL and PY extracted data. YLL and PY assessed the study quality. YLL, PY and YL did statistical analysis. YLL did data visualization. YLL drafted the manuscript. All Authors contributed data interpretation and review and revision of manuscript. YL was responsible for overall supervision to this study.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s41366-023-01304-6.

Correspondence and requests for materials should be addressed to Ying Lau.

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