Use of Extrinsic Motivators to Improve the Body Mass Index of Obese or Overweight Adolescents: A Systematic Review

Ana Gonçalves, Pedro Augusto Simões, Bernardo Sousa-Pinto, Tiago Taveira-Gomes

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Ana Gonçalves[1, 2] MD; Pedro Augusto Simões[1] MD, PhD; Bernardo Sousa-Pinto[3] MD, PhD; Tiago Taveira-Gomes[4] MD, PhD

[1]Faculty of Health Sciences University of Beira Interior Covilhã PT
[2]Faculty of Medicine University of Porto Porto PT
[3]Department of Community Medicine, Information and Health Decision Sciences (MEDCIDS), Faculty of Medicine of the University of Porto Porto PT
[4]Centre for Health Technology and Services Research, Health Research Network (CINTESIS@RISE), Faculty of Medicine of the University of Porto Porto PT

Corresponding Author:
Ana Gonçalves MD
Faculty of Medicine University of Porto
Alameda Prof. Hernâni Monteiro
Porto
PT

Abstract

Background: The prevalence of overweight and obesity is increasing at an alarming rate in children and adolescents worldwide. Given the dimension of the problem, treatments of childhood obesity are recognized as of extreme importance. Current evidence indicates that behavioural and cognitive behavioural strategies combined with diet and physical activity approaches may assist in reducing adolescent obesity.

Objective: The purpose of this systematic review is to evaluate the use of extrinsic motivators in improving the BMI of obese or overweight adolescents.

Methods: The inclusion criteria were as follows: 1) overweight or obese adolescents, 2) intervention using extrinsic motivators, 3) outcome variables related to weight status. The exclusion criteria were associated chronic disease. The search process was conducted in PubMed and Web of Science (last searched on 23/04/2023). The risk of bias was evaluated independently by two authors with the Cochrane's tools: RoB2 (RCT), ROBINS-I and ROBINS-E.

Results: From 3,163 studies identified, 20 articles (corresponding to 18 studies) were included in the analysis. The studies differ in study design, sample size, follow-up duration, outcomes reported, and extrinsic motivators used. Most of the studies had videogames or apps as intervention. Nine studies (50%) showed a statistically significant decrease of BMI. The most used extrinsic motivators were "Motivation" (n=13), "Feedback" (n=10) and "Rewards" (n=9), and the ones that seem to have a higher impact on decreasing BMI are "Reminders" (100%) and "Peer-support" (80%).

Conclusions: The heterogeneity of studies makes analysis difficult. No study has evaluated the extrinsic motivators in isolation. Most of the studies have a moderate or high risk of bias. The extrinsic motivators that seem to be more useful are "Reminders" and "Peer-support", but more studies are needed, namely well designed RCTs, homogeneity in BMI measure and extrinsic motivators definitions, and longer duration to better understand long-term impact of extrinsic motivators on weight management success.

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ORIGINAL PAPER

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Authors:

Ana Gonçalves
Faculty of Medicine University of Porto, Porto, Portugal
Faculty of Health Sciences University of Beira Interior, Covilhã, Portugal

Pedro Augusto Simões
Faculty of Health Sciences University of Beira Interior, Covilhã, Portugal

Bernardo Sousa-Pinto
Department of Community Medicine, Information and Health Decision Sciences (MEDCIDS), Faculty of Medicine of the University of Porto, Porto, Portugal

Tiago Taveira-Gomes
Department of Community Medicine, Information and Health Decision Sciences (MEDCIDS), Faculty of Medicine of the University of Porto, Porto, Portugal

Corresponding Author: Ana Gonçalves; Alameda Prof. Hernâni Monteiro 4200-319 Porto, Portugal; +351 225513600; an.goncalves@ubi.pt

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Conclusions: The heterogeneity of studies makes analysis difficult. No study has evaluated the extrinsic motivators in isolation. Most of the studies have a moderate or high risk of bias. The extrinsic motivators that seem to be more useful are "Reminders" and "Peer-support", but more studies are needed, namely well designed RCTs, homogeneity in BMI measure and extrinsic motivators definitions, and longer duration to better understand long-term impact of extrinsic motivators on weight management success.

Key words: Adolescents; Obesity; Overweight; Extrinsic motivators; BMI

Introduction

The prevalence of overweight and obesity is increasing at an alarming rate in children and adolescents worldwide, and the rise has occurred similarly among both boys and girls [1,2]. Over 340 million children and adolescents aged 5-19 were overweight or obese in 2016 [2]. In the United States of America (USA), in 2020-2021, 17% of ages 10 to 17 had obesity, with rates significantly higher for non-Hispanic Black (22.9%), Hispanic (22.4%), and non-Hispanic American Indian/Alaska Native (20.5%) [3]. Similarly, in China, in 2020, the prevalence of overweight (including obesity) was 19% for children aged 6-17 [4] and, in Europe, in 2018, 19% 15-years-old was either overweight or obese [5]. The data available in Portugal are different, with a prevalence of overweight (including obesity) between 20 to 40% [6].

The obesity widespread among the young people is generating significant social concern for public health, not only for the number of children affected but also because of its consequences [7]. The raised body mass index (BMI) is a major risk factor for cardiovascular diseases, diabetes, musculoskeletal disorders and some cancers and the risk for these diseases increases, with increases in BMI [2]. Obesity has, also, psychological consequences, such as low self-esteem, sadness, nervousness, and a negative self-image [7]. Overweight and obesity, as well as their related diseases, are largely preventable [2]. The global prevalence of obesity in children and adolescents almost doubled between 1980 and 2015 [8]. In view of the high and increasing prevalence an early and effective intervention seems to be urgently required [9].

Adolescence is a vulnerable period for the development of obesity, and adolescent weight tracks strongly into adulthood. Is also a unique period of development, with puberty resulting in considerable physical, hormonal and psychosocial changes, which need to be considered when evaluating the efficacy of treatment programmes [10].

Given the dimension of the problem, treatments of childhood obesity are recognized as of extreme importance. Fundamental is to produce a change of food intake and quality, to increase their effort in physical activity and to reduce sedentary habits [7]. Current evidence indicates that behavioural and cognitive behavioural strategies combined with diet and physical activity approaches may assist in reducing adolescent obesity [10].

According to the Self-Determination Theory, extrinsic motivation is a type of motivation in which the behaviour is a means of achieving external outcomes. Is motivated by external controls prescribed by others. There are four different types of extrinsic motivation, which vary on a spectrum according to the degree of internalisation and autonomy: external regulation (motivated by external controls prescribed by others, like gaining rewards or avoiding punishment); introjected regulation (motivated by internal pressure from internalised constructs of external controls, such as, feeling self-approval or avoiding feeling guilty); identified regulation (motivated because behaviour is perceived as important and useful, like exercises to get healthy or lose weight); and integrated regulation (motivated because the behaviour is in concordance with one’s values and sense of self, as feeling of identification) [11]. Some examples of extrinsic motivators are rewards/points, avatars, challenges, and feedback [11–13].

The purpose of this systematic review is to evaluate the use of extrinsic motivators in improving the BMI of obese or overweight adolescents.

Methods

The present review was conducted according to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines to identify articles on the use of extrinsic motivators in improving the BMI of obese or overweight adolescents.

Eligibility criteria

The review question was framed using PICO framework and the following eligibility criteria were used:

a) Population: overweight (P85-95 for age and gender) or obese (≥P95 for age and gender) adolescents (age range 10-19 years, according to WHO);
b) Intervention: extrinsic motivators;
c) Comparison: usual care or other interventions;
d) Outcome: variables related to weight status (weight and/or body mass index/ z-scores).

The exclusion criteria were associated chronic disease and language not understanded by none of the authors.

Information sources

The search process was conducted in PubMed and Web of Science (last searched on 23/04/2023).

Search strategy

The databases PubMed and Web of Science were interrogated using the following terms: adolescent, obesity, overweight, pediatric obesity, weight loss, gamification, and telemedicine.

The search on PubMed was carried out by the title, abstract and MeSH terms; the search on Web of Science included topic by the title, abstract and keywords (full strategy used in Annex).

Selection process

Titles and abstracts acquired from the search were transferred to the site "Rayyan" for the relevance assessment process. Potentially eligible studies were firstly screened by title and abstract to evaluate if they met the inclusion criteria by two authors (A.G., P.S.) independently. Then, full texts were read independently by the same two authors and a decision was made about their inclusion in the review. Disagreements were achieved by consensus among the authors.

Data collection process

The data were collected from each report by two authors (A.G., P.S.) independently with Excel®. Disagreements were achieved by consensus among the authors. A set of variables were chosen from consensus of all authors, and the following data were systematically extracted for each eligible article: bibliographic information, study design, target population, inclusion criteria, exclusion criteria, sample size, demographic characteristics, duration of the study/follow-up/time of data collection, purpose, intervention, extrinsic motivator, and outcome BMI.

Study risk of bias assessment

The risk of bias was evaluated with the Cochrane's tools: RoB2 for randomized controlled trial (RCT), ROBINS-I for interventional studies and ROBINS-E for exposure studies. Two authors (A.G., P.S.) independently assigned the risk of bias to each study, and disagreements were settled by consensus among the authors.

Results

In total, 3,163 studies were identified from the searched databases and, after removing the duplicates, 2,653 articles were left for the following steps. Thus, of the remaining studies, 2,558 were deleted after analysing the title and abstract. There were 92 articles retrieved for more detailed assessment (3 articles can't be retrieved after contacting the authors), which have been evaluated considering the inclusion/ exclusion criteria. After the evaluation of the full-text, 72 articles were excluded for not meeting de inclusion criteria (i) population, (ii) intervention, (iii) outcome, and (iv) language. Finally, 20 articles (corresponding to 18 studies) met the inclusion criteria and were included in the analysis ([14–33].

Figure 1 shows the steps of the study selection process for the systematic review, following the PRISMA statement.

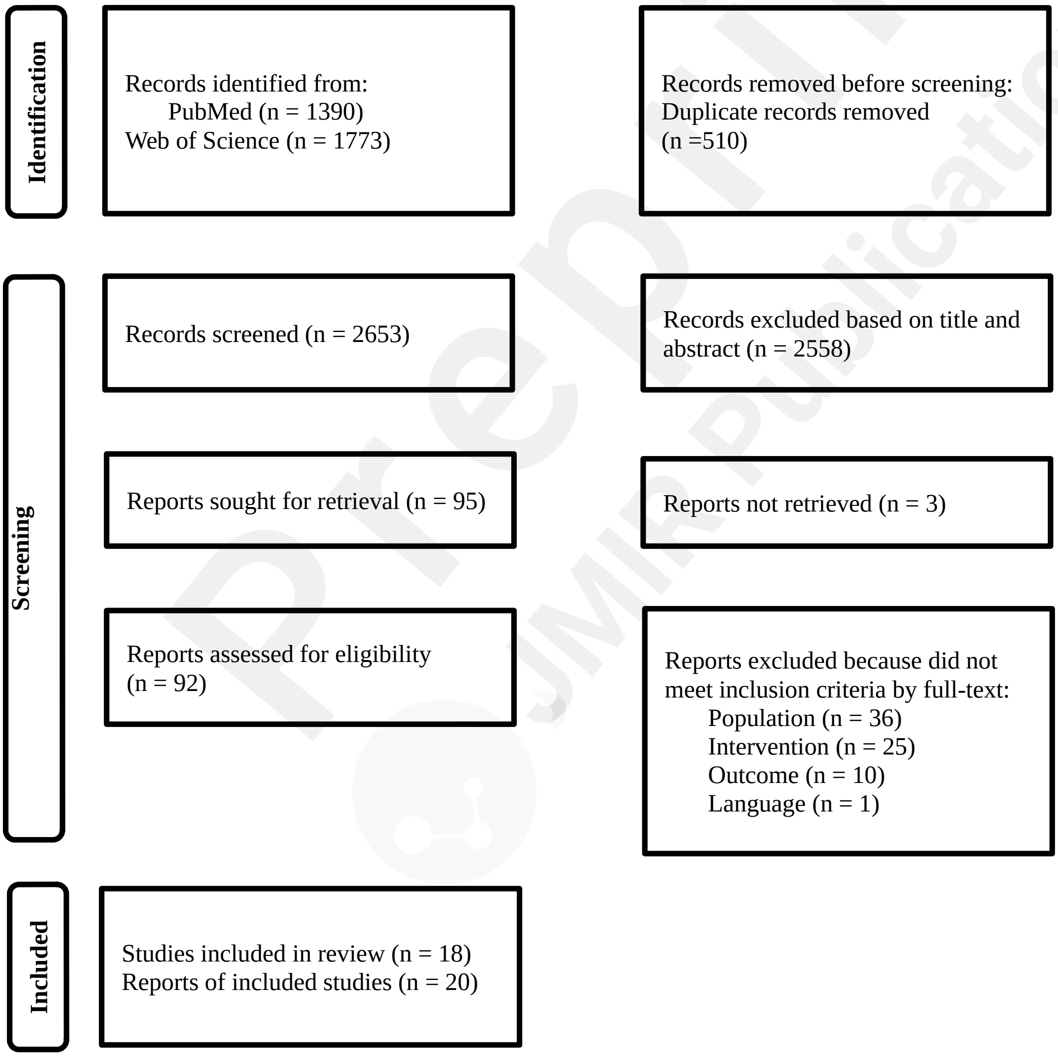

Figure 1. Flow diagram showing the article selection process

Study characteristics

The studies included were published between 2006 and 2022, 12 in the last 10 years, and were performed in eight different countries: 11 in the USA, 1 in China, 1 in Singapore, 1 in Korea, 1 in Canada, 1 in Switzerland, 1 in Italy, and 1 in New Zealand.

Risk of bias in studies

There is heterogeneity between the studies' design: 13 clinical trials (being 9 RCT), 4 cohorts and 1 retrospective observational. Detailed information concerning the risk of bias for each study is described in figures 2, 3 and 4. Most of the RCTs presented a moderate risk of bias and all the others study designs had a high/serious risk.

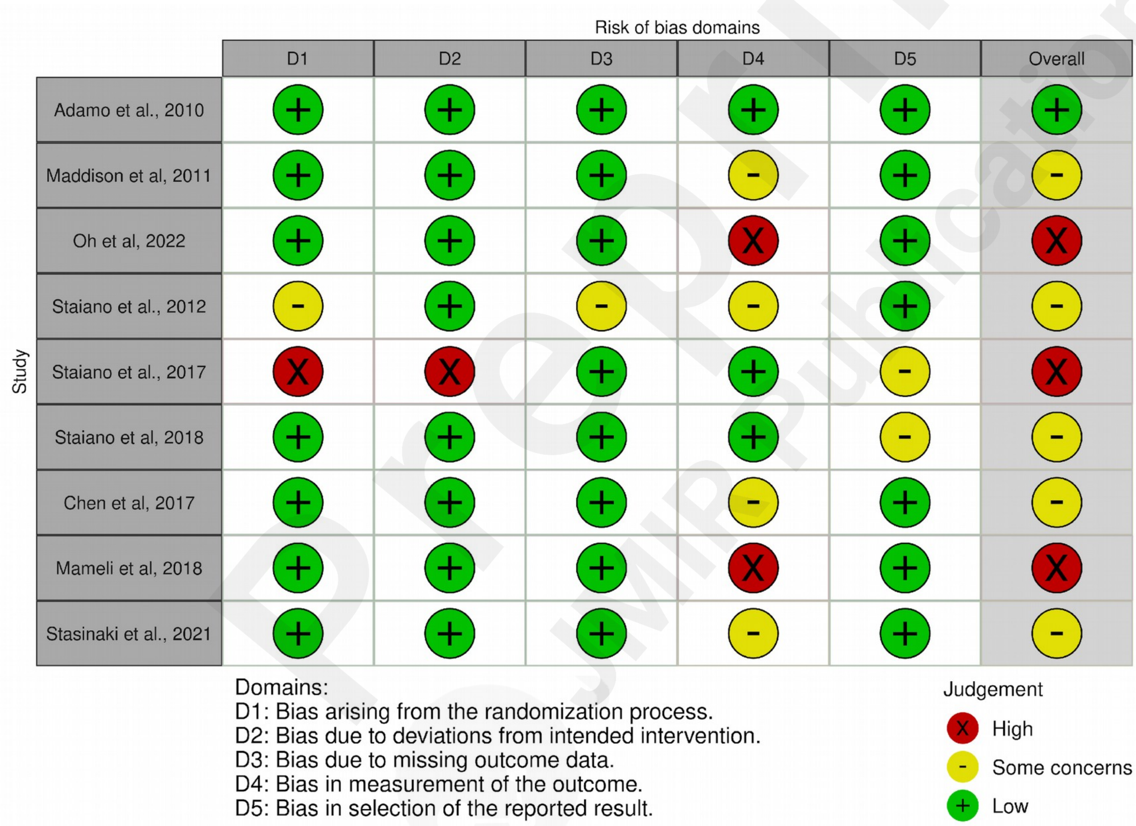

Figure 2. Risk of bias according to the ROB-2 tool

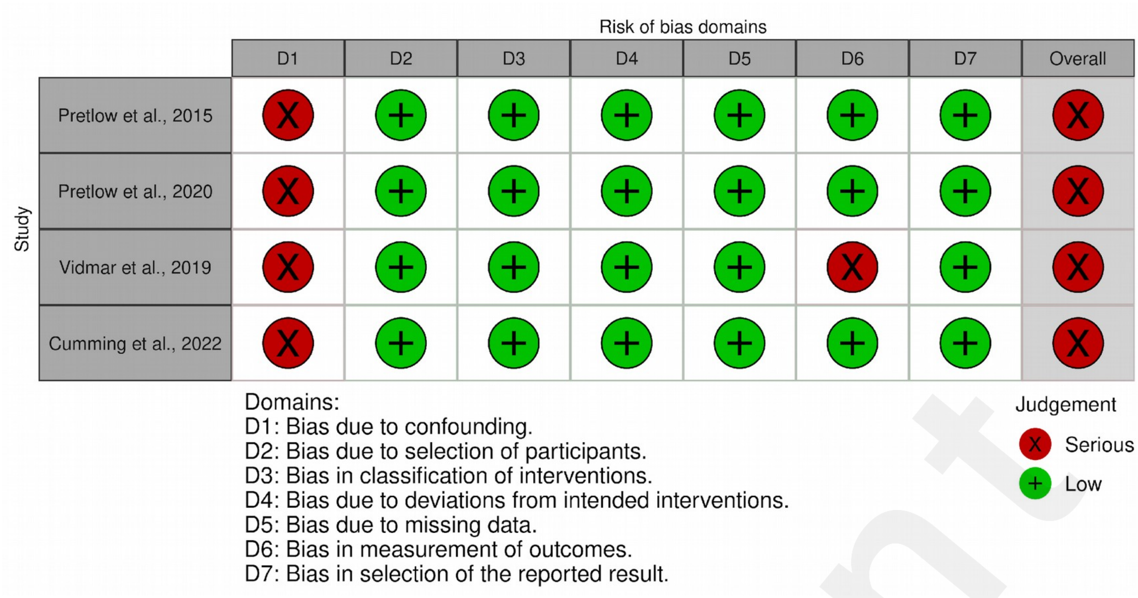

Figure 3. Risk of bias according to the ROBINS-I

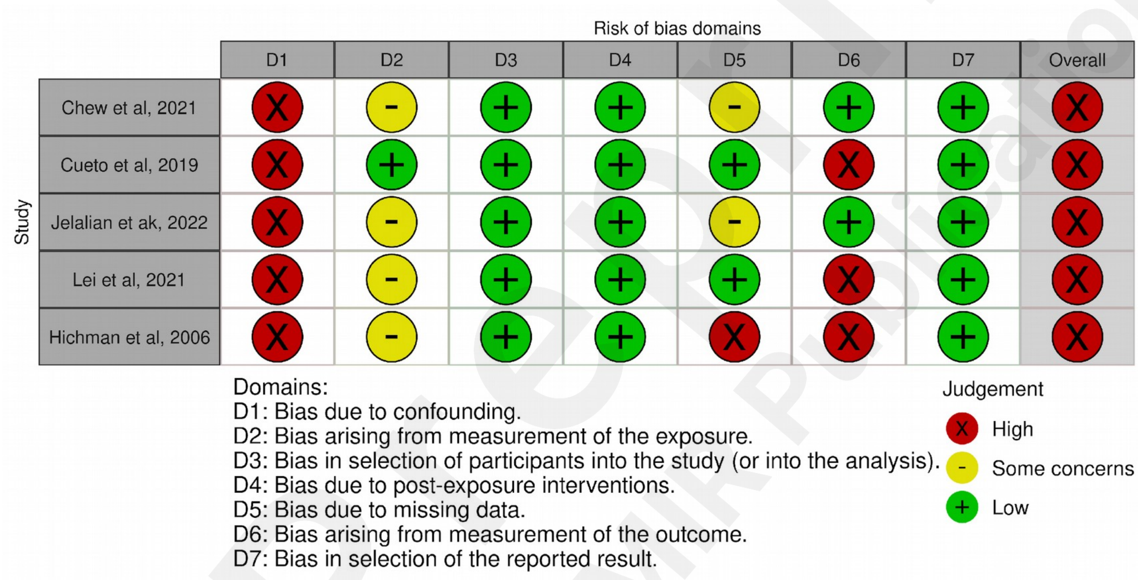

Figure 4. Risk of bias according to the ROBINS-E

Results of individual studies

The characteristics of the included studies are summarised in Table 1.

Table 1. Main characteristics of the selected studies

Author, Year, Country	Study design	Target population	Subjects	Follow-up	Intervention	Control	Extrinsic motivator
Adamo et al. 2010 Canada (14)	RCT	IC: 12-17 years, pBMI >95 or pBMI >85 with high-risk of type 2 diabetes or cardiovascular disease EC: Medication or supplement that affects body composition, regular physical activity, psychiatric illness, contraindication to physical activity	Sample: 26 (13 I, 13 C) Gender: 53.8% (I, C) female Mean age: 13.9±1.4 (I), 15.1±1.8 (C) pBMI: 97.9±1.5 (I), 97.8±2.7 (C) Ethnicity: not mentioned	2,5M	Active videogame cycling	Stationary cycling to music	Feedback Select games
Maddison et al. 2011 New Zealand (15)	RCT	IC: 10-14 years, overweight/obese EC: Own active video games or contraindication to physical activity	Sample: 322 (160 I, 162 C) Gender: 72.5% (I), 73.5% (C) male Mean age: 11.6±1.1 (I, C) zBMI: 1.3±1.1 (I, C) Ethnicity: 57.5% (I), 56.2% (C) NZ European	6M	Active videogame	Nonactive videogames	Avatar Select game
Oh et al. 2022 Korea (16)	RCT	IC: 10-17 years, pBMI >85 EC: Pharmacologic treatment, sign of hormonal/orthopaedic/metabolic/cardiovascular illness or physical activity outside school	Sample: 24 (12 I, 12 C) Gender: 83.33% (I, C) male Mean age: 13.58±1.44 (I), 13.08±2.35 (C) BMI: 24.99±1.35 (I), 25.03±1,92 (C) Ethnicity: not mentioned	3W	Active Videogame SUIKA (Super Kids Adventure)	Active videogame NINS (Nintendo Switch "Ring Fit Adventure")	Avatar Feedback Reminder Reward
Staiano et al. 2012 USA (17)	RCT	IC: African American, 15-19 years, pBMI ≥75 EC: Not mentioned	Sample: 54 (19 CP, 19 CO, 16 C) Gender: 55.6% female Mean age: not mentioned pBMI: 94.7±6.0 Ethnicity: African American	5M	Active videogame (Nintendo Wii Active): cooperative or competitive	Usual daily activities	Motivation Peer-support Reward
Staiano et al. 2017 USA (18)	RCT	IC: 14-18 years, pBMI ≥85, female and post-menarcheal EC: Pregnancy, contraindication to physical activity, recent hospitalization for mental illness or inability to comply with study procedures	Sample: 41 (22 I, 19 C) Gender: 100% female Mean age: 15.3±1.2 (I), 16.1±1.4 (C) pBMI: 97.4±2.9 (I), 97.1±3.3 (C) Ethnicity: 64% (I), 61% (C) African American	3,5M	Active videogame	Self-directed care control	Motivation Reward Select games
Staiano et al. 2018 USA (19)	RCT	IC: 10-12 years, pBMI ≥85 EC: Pregnancy, contraindication to physical activity	Sample: 46 (23 I, 23 C) Gender: 54% male Mean age: 11.2±0.8 zBMI: 2.06±0.46 (I), 2.10±0.42 (C) Ethnicity: 57% African American, 41% white	6M	Active videogame	Usual level of physical activity	Challenge Feedback Motivation Select game
Chen et al. 2017 USA (20)	RCT	IC: 13-18 years, BMI≥ P85 EC: not mentioned	Sample: 40 (23 I, 17 C) Gender: 58% (I), 53% (C) male Mean age: 15±1.69 (I), 14.77±1.60 (C) zBMI: 1.6±0.50 (I), 1.54±0.42 (C) Ethnicity: 90% Chinese American	6M	App (iStart Smart for Teens online program)	Online program's content with information from AAP	Motivation
Chew et al. 2021 Singapore (21)	Cohort	IC: 10-17 years, pBMI >85 EC: Secondary causes of obesity, parents non-English speakers, logistic problems	Sample: 40 Gender: 58% male Mean age: 13.8±1.7 BMI: 80% obesity Ethnicity: 45% Chinese, 33% Malay	6M	App (Kurbo)	No	Feedback Motivation
Cueto et al. 2019 USA (22)	Cohort	IC: 5-19 years EC: pBMI <85 at the baseline or data measurement errors	Sample: 1120 Gender: 68.04% female Mean age: 12.0±2.5 pBMI: 96.6±3.1 Ethnicity: not mentioned	4W 3-4M 6M	App (Kurbo)	No	Feedback Motivation

Jelalian et al. 2022 USA (23)	Cohort	IC: 5-17 years, pBMI> 85 EC: Missing data, follow-up age > 240.5 months, measurement error	Sample: 3500 Gender: 71.3% female Mean age: 12.79±2.41 BMI: 29.65±5.56; %BMIp95: 116.31±19,57 Ethnicity: not mentioned	0-3M 3-6M 6-12M 12-18M >18M	App (Kurbo)	No	Feedback Motivation
Lei et al. 2021 China (24)	Obser-vational	IC: 10-17 years, pBMI ≥85 EC: Secondary causes of obesity, pharmacologic/cirurgic intervention for weight reduction, logistic problems, outliers	Sample: 2825 Gender: 54.8% female Mean age: 14.4±2.2 pBMI: 48% ≥ 97 Ethnicity: not mentioned	4M	App (MetaWell)	No	Challenge Feedback
Mameli et al. 2018 Italy (25)	RCT	IC: 10-17 years, pBMI ≥95 and Caucasian ethnic group. EC: Genetic/syndromic obesity, psychiatric disease and any condition compromising the ability to walk.	Sample: 30 (16 I, 14 C) Gender: 68.8% (I), 57.1% (C) male Mean age: 12.6±1.7 (I), 12.4±2.2 (C) BMI-SDS: 2.20±0.47 (I), 2.09±0.34 (C) Ethnicity: Caucasian	3M	App (MeTeDa)	Mediterranean diet + physical activity	Challenge Feedback Motivation
Pretlow et al. 2015 USA (26)	Pilot Clinical Trial Without Control	IC: Child/adolescent with overweight/obesity EC: Motivation scores <50/100, logistic problems	Sample: 43 Gender: 65.1% female Mean age: 16±0.43 pBMI: 37.2% >98 Ethnicity: 83.7% White	5M	App	No	Motivation Peer-support Reward
Pretlow et al. 2020 USA (27)	Clinical Trial Without Control	IC: 10-20 years, pBMI ≥95, motivation score >50/100 EC: not mentioned	Sample: 35 Gender: 51.4% female Mean age: 13.8±0.52 pBMI: 34.3% ≥99 Ethnicity: 65.7% Caucasian	4M	App	No	Motivation Peer-support Reminder Reward
Stasinaki et al. 2021 Switzerland (28)	RCT	IC: 10-18 years, pBMI >97 or >90 with ≥1 risk factor or co-morbidity EC: not controlled psychiatric disease; medication that affected weight; participation in another obesity treatment program in the past year	Sample: 31 (18 I, 13 C) Gender: 61,1% (I), 53,8% (C) male Mean age: 12.6 (I), 13.7 (C) BMI-SDS: 2.5 (I, C) Ethnicity: not mentioned	12M	App (PathMate2) + multicomponent behaviour change intervention	Multicomponent behaviour change intervention	Challenge Feedback Motivation Reward
Vidmar et al. 2019 USA (29)	Pilot Clinical Trial	IC: 12–18 years, YFAS-c + EC: Obesity co-morbidities, psychiatric disease and/or developmental delay, inability to read English	Sample: 35 (18 I, 17 C) Gender: 72.22% (I), 47.06% (C) female Mean age: 14.44±1.65 (I), 14.35±1,77 (C) BMI: not mentioned Ethnicity: 61.11% (I) vs 64.71% (C) Hispanic	6M	App (W8Loss2Go)	EMPOWER program	Motivation Peer-support Reward
Cummings et al. 2022 USA (30)	Clinical Trial Without Control	IC: 13-18 years, pBMI >90 EC: Contraindication to use scanner, psychiatric medication, pregnancy, co-morbidities and visual acuity that could not be corrected	Sample: 26 Gender: 54% male Mean age: 14.81±1.59 pBMI: 97.07±1.85 Ethnicity: 93% White	3M	Digital Health program	No	Challenge Feedback Motivation Reward
Hinchman et al. 2006 USA (31)	Cohort	IC: 11-17 years who completed Operation Zero in 2001–2002, at-risk-of-overweight and overweight EC: not mentioned	Sample: 85 (43 I, 42 C) Gender: 56% (I), 45% (C) female Age: 56% (I), 57% (C) ≥13 years pBMI: 98% (I), 85% (C) >95 Ethnicity: not mentioned	12M	Operation Zero	Members who never attended Operation Zero	Challenge Peer-support Reward

BMI: Body Mass Index; BMI-SD: BMI Standard Deviation; C: Control; EC: Exclusion criteria; IC: Inclusion criteria; I: Intervention; M: months; NZ: New Zealand; pBMI: BMI's percentile; RCT: Randomized Clinical Trial; W: week; YFAS-c: Yale Food Addiction Scale for Children; zBMI: BMI z-score.

Attending the sample size, we verified that 14 studies had less than 100 participants (minimum 24 and maximum 85), one with 322 and the other three with more than 1,000 participants (minimum 1,120 and maximum 3,500). The follow-up of the studies varied between 3 weeks to more than 18 months. However, most of the studies had a follow-up of 3 to 6 months.

Regarding the demographic characteristics of the participants, 10 studies had a sample composed mainly of female adolescents (one of them being only female participants); the mean age reported by the studies varied between 11.2 and 16 years; 11 studies reported information about ethnicity (8 in USA, 1 in Italy, 1 in Singapore and 1 in New Zealand) and the majority were Caucasian and African American.

Intervention of the studies

Adamo et al. [14] made an intervention that consisted of 60-minute sessions two times per week with a GameBike interactive video gaming system (with a handlebar-mounted game controller) interfaced with a Sony PlayStation 2. It reads the participant's speed by cycling cadence, and the faster the individual pedalled, the faster they moved in the virtual world on screen; the participants were allowed to select video games to play while cycling and were permitted to switch games during the exercise sessions; there was no nutritional intervention or parental involvement; the participants were weighted in lab at the end of the sessions.

In Maddison et al. [15] the participants assigned to the intervention received a Sony PlayStation EyeToy, dance mat, and a selection of active video games (e.g., Play3, Kinetic, Sport, and Dance Factory), from which the participants could choose from five different games. The motion camera places a picture of the gamer on the screen, which the gamer then interacts with. The participants were asked to achieve the recommended 60 minutes of moderate-to-vigorous physical activity on most days of the week by supplementing periods of inactivity with active video game play and substituting periods of traditional nonactive video game play with the active version. There was no nutritional intervention nor parental involvement. The participants were weighted at a central location (at baseline, 12- and 24-weeks) by the researchers.

Oh et al. [16] made an intervention using Super Kids Adventure game that provides upper extremity stretching, lunging, boxing, side-bending, squatting, and arm and jumping exercises. They asked participants to do 30 minutes five times per week, with and intensity of about 4-6 metabolic equivalent of task; there was no intervention in nutrition; the participants could select various characters to play; there was real-time visual and auditory feedback given by the game; when participants performed the correct posture for any of the exercises the character moved and scored; there was an alarm function that reminds participants to exercise regularly; they were compensated along with the quantity of training they operate and maintain to progress; there was no parental involvement; the participants were weighted after all the sessions.

Staiano et al. [17] made an intervention that consisted of 30-60 minutes of active videogame every school day, a group did it in a cooperative way (earn the most points and expend the most calories as a team) and another did it in a competitive way (compete against their opponent to earn the most points and expend the most calories); there was no intervention in nutrition; during the sessions the coordinators encouraged completion of each daily exergame routine through periodic verbal reinforcement; the was no parental involvement; weight was measured at the school-based wellness clinic.

Staiano et al. [18] made an intervention that consisted of three 1-hour exergaming dancing sessions per week; the participants were allowed to self-select the games, songs, dance mode, intensity level and dance partner(s); the 'Gaming Coaches' provided ongoing motivation, and gifts were provided throughout the 12 weeks to encourage attendance and motivate participants to exercise at a high level; there was no nutritional intervention or parental involvement; the participants were weighted at clinic visits (baseline and endpoints).

Staiano et al. [19] provided the intervention group a Kinect® and Xbox 360® gaming console, a 24-week Xbox Live subscription, four exergames (Your Shape: Fitness Evolved 2012, Just Dance 3, Disneyland Adventures, and Kinect Sports Season 2), and a Fitbit Zip to wear. The participants were encouraged to meet a goal of 60 minutes/day of moderate-vigorous physical activity, three days/week with a family member or friend. Participants could choose between the four active videogames provided. They received three challenges each week with increasing intensity, difficulty, and duration. They also had telehealth coaching: meeting with a fitness coach (videochat or exergame console), on a weekly basis for the first six weeks and biweekly thereafter with individualised feedback, motivation, encouragement to meet the goal and help to create solutions to barriers for physical activity. There was no nutritional nor parental involvement. The participants were weighted at the clinic (at baseline and endpoint).

In Chen et al. [20], the intervention group received a Fitbit Flex and downloaded an app and a link to the iStart Smart for Teens program to their mobile phone. The Fitbit Flex recorded and tracked their physical activity, sedentary activity, and food intake in the diary. The iStart Smart for Teens online educational program had eight modules (the participants were asked to do one module per week) that focused on nutrition and physical activity. The participants also received instructions by mobile phone or computer and supplementary information and tips by app messages. There was no parental involvement. The participants were weighted in the clinic (at baseline, 3 and 6 months).

Chew et al. [21], Cueto et al. [22], and Jelalian et al. [23] used as intervention the Kurbo that is a mobile app developed to aid adolescents and their families with weight management through dietary self-monitoring (promotion of gradual reduction of high-calorie foods over time by using the traffic light diet to categorise foods), physical activity behaviours (recommended 60 minutes of moderate-to-vigorous physical activity each day), and weekly individualised coaching sessions (via video, phone, or text) with feedback. Chew et al. [21] asked participants to weigh themselves at least weekly and the participants were weighted at the clinic visit (at 3 and 6 months), and the other two only asked participants to weigh themselves at the baseline and end-point.

Lei et al. [24] made an intervention that consisted of a nutritional program based on calorie restriction with meal replacement, and individualised low calorie meal plans; physical activity was encouraged but with no specific exercise recommendations; participants had access to their weight loss progress, and snapshot of their current health data and optimal measures of BMI; there was parental involvement; the participants were asked to weigh themselves on a daily basis (wireless scale).

Mameli et al. [25] gave the intervention group a wristband that they should use at least five days per week (to measure the energy expenditure), and an app that allowed real-time recording of food consumption (to measure the energy intake), by asking participants to enter the raw foods into the app. It had a visual database of foods and three portion sizes (small, medium, and large) for each food. They gave the participants personalised lifestyle programmes based on previous week energy intake (for nutritional recommendations) and expenditure (for physical activity recommendation). There was weekly feedback on the adequacy of the diet and physical activity (compliance to the diet, the energy gap, the sedentary time, the physical activity level and the quality of the diet) via text messages and gave suggestions on how to reach each of these five goals; a positive feedback was included in the text messages every time a participant reached at least one goal, with specification of the reached goal(s). There was parental involvement. The participants were weighted at clinic visits (at 1, 2 and 3 months).

Pretlow et al. [26] and Vidmar et al. [29] focused on sequential withdrawal from problem foods, snacking, and excessive food amounts at meals; the participants had four face-to-face group meetings, weekly phone meetings, and text messages five days per week; the participants also had access to mentor's contact details, and peer support by app bulletin boards and "weight loss buddies" (chat); money incentive proportional to completion of requirements of the study; there was no physical activity intervention nor parental involvement; the participants were asked to weight themselves daily (wireless scale) and they were also weighted in the face-to-face meetings.

Pretlow et al. [27] had an intervention similar to the Pretlow et al. [26] in which they added a motor addiction component that consisted of (a) viewing aversive photos/videos or snapping a rubber band against the wrist to quell eating urges, (b) stress reduction, (c) avoiding triggers, (d) relaxation techniques, (e) competing behaviours, (f) distractions, and (g) distress tolerance. Another motor addiction method was the Worry List - a stress reduction feature that prompted participants to journal their current worries and create an action plan for each worry. The participants received daily notifications to login and answer questions about the eating behaviour and if they used any sensory and motor addiction treatment methods (if they reported addictive eating behaviour, the app asked why this had happened and what was the participant’s plan to keep this from happening again), and weekly app prompts to update their worry lists and plans.

Stasinaki et al. [28] made individual multi component behaviour changing interventions following Swiss guidelines, including handouts on nutritional education and physical activity and with the support of PathMate2 app. The participants had daily challenges (e.g., number of steps per day). The app included two chat channels: virtual coach (daily interaction, encouraging them to achieve challenges to earn virtual rewards) and human coach (maximum 10 min during all intervention). In the app dashboard the participants could also see their progress. There were four on-site visits, two remote counselling sessions (via telephone). There was no parental involvement. The participants were weighted on clinical visits (at 6 and 12 months).

Cummings et al. [30] gave the participants a Fitbit device to track daily goals of >60 active minutes or ≥10,000 steps of exercise (participants could choose which one they wanted to achieve); weekly goals depended upon the level of activity in the prior weeks; the participants received feedback on daily and weekly progress with daily texts about whether they met their goal the previous day (and praised them if they met their goal or reminded them to do so if they did not meet their goal), and weekly texts about whether they met their weekly goal (praising them if they did and providing encouragement if they did not); these texts also informed adolescents of the amount of incentives earned that week and the goal for the upcoming week; monetary reinforcement (debit card once per week); there was no nutritional intervention nor parental involvement; the participants were weighted on clinic visits (at baseline and endpoint).

Hinchman et al. [31] used a family-oriented approach and incorporated behaviour change strategies to address the behaviours, knowledge, attitudes, and self-efficacy of patients and their parents regarding nutrition and physical activity. In the nutritional intervention they aimed to increase milk consumption until drinking four glasses a day; decrease milk fat until drinking fat-free milk; increase fruit and vegetable servings until eating five servings a day; eat breakfast every morning. In the physical activity intervention, they aimed to increase the number of days being physically active for 60 minutes until active five days a week; decrease sedentary behaviour to less than one hour per day; increase the number of steps per week on a pedometer until taking 70,000 steps per week. The participants and their parents had weekly 1-h group appointments (with health educator/clinician, nursing staff and dietitian or chef) that included pedometer games, interactive learning, competition (for prizes), cooking demonstrations, and exercising as a group, and where were defined the weekly goals for nutrition and physical activity. Participants and their parents received the Operation Zero manual (with health education, activities, and recipes). The participants were weighted weekly in the appointments.

In short, in seven studies the interventions focused on only Physical Activity, four only on Nutrition, and seven on both. Seven studies had parental involvement and in three the weight of the participants was only measured by themselves.

Regarding the extrinsic motivators, the most used was “Motivation” (by coaches, messages, and sessions), followed by “Feedback”, and “Rewards” (that included points and money). From the studies that used videogames as the intervention, the most used were “Select Game”, “Reward”, and “Feedback”. From the studies that used an app as the intervention, the most used were “Motivation”, “Feedback”, and “Reward”.

Outcome

The outcomes related to BMI reported for interventions and controls are summarised in Table 2.

Table 2. Outcomes related to BMI reported for participants and controls by the selected studies

Author, Year, Country	Outcome	Intervention group	Control group	Intervention group vs Control group
Adamo et al., 2010, Canada (14)	BMI (B vs E) pBMI (B vs E)	35.5±9.3 vs 35.5±9.7, p > 0.05 97.8±1.4 vs 97.5±1.8, p > 0.05	39.3±8.9 vs 39.4±8.9, p > 0.05 97.8±2.7 vs 97.8±2.3, p > 0.05	
Maddison et al., 2011, New Zealand (15)	BMI (Δ|B vs E) zBMI (Δ|B vs E)	25.6±4.1 vs 24.8±3.6 1.3±1.1 vs 1.1±1.1	25.8±4.3 vs 25.8±4.2 1.3±1.1 vs 1.3±1.0	-0.24 (95%CI -0.44 to -0.04) p=0.02 -0.06 (95%CI -0.12 to -0.03) p=0.03
Oh et al., 2022, Korea (16)	BMI (B vs E)	24.99±1.35 vs 23.93±1.83, p = 0.02	25.03±1.92 vs 24.29±1.83, p = 0.03	
Staiano et al., 2012, USA (17)	Weight adjusted to growth curve (BvsE)	CO: 93.93 (SD 26.02) vs 84.74 (SD 14.23) CP: 96.22 (SD 17.92) vs 95.17 (SD 20.94)	95.48 (SD 22.72) vs 94.23 (SD 20.88)	CO [-1.65 (SD=4.52)] vs C [0.86 (SD=3.01)], p=0.021 CP [0.04 kg (SD=3.46)] did not differ from the others
Staiano et al., 2017, USA (18)	ΔzBMI ΔpBMI	-0.002 (SE 0.02), p > 0.05 -0.1 (SE 0.2), p > 0.05	0.004 (SE 0.02), p > 0.05 0.1 (SE 0.2), p > 0.05	-0.01 (SE 0.03), p > 0.05 -0.2 (SE 0.3), p > 0.05
Staiano et al., 2018, USA (19)	ΔzBMI Δ%BMIp95	-0.06 (SE 0.03) -2.2 (SE 1.1)	0.03 (SE 0.03) 0.9 (SE 1.1)	-0.06 (SE 0.03) vs 0.03 (SE 0.03), p=0.016) -2.1 (SE 1.1) vs 0.9 (SE 1.1), p = 0.07
Chen et al., 2017, USA (20)	BMI (B vs E) zBMI (B vs E)	27.37 (SD 3.26) vs 26.93 (SD 3.43) 1.60 (SD 0.50) vs 1.42 (SD 0.38)	28.35 (SD 4.36) vs 29.18 (SD 3.88) 1.54 (SD 0.42) vs 1.80 (SD 0.50)	z = -4.37, p=0.001 z = -4.36, p=0.001
Chew et al., 2021, Singapore (21)	ΔzBMI	0.045 (SD 0.15; 95% CI -0.024 to 0.114), p = 0.19		
Cueto et al., 2019, USA (22)	Δ%BMIp95	4 weeks: -5.4 (95%CI -6.2 to -4.5), p <0.001 12-16 weeks: -4.8 (95%CI -5.3 to -4.3), p <0.001 24 weeks: -6.9 (95%CI -8.3 to -5.6), p <0.001 differences between age-group (p = 0.09): 5-11 years: -5.6 (SD 7.9) 12-14 years: -4.7 (SD 5.9) 15-18 years: -5.2 (SD 5.6)		
Jelalian et al., 2022, USA (23)	ΔBMI Δ%BMIp95	-0.7 (SD 2.19) -4.45 (SD 8.5)		
Lei et al., 2021, China (24)	ΔBMI ΔzBMI Δ%BMIp95	-3.13 (MOE:0.21), p<0.001 -0.42 (MOE: 0.03), p>0.001 -11,51 (MOE: 0,77), p>0.001		
Mameli et al., 2018, Italy (25)	ΔBMI-SDS	-0.03 (95%CI = 0.14 to 0.09)	-0.04 (95%CI = 0.16 to 0.08)	0.01 (95%CI = 0.15 to 0.18), p=0.87
Pretlow et al., 2015, USA (26)	Δ %overBMI	−0.051; p < 0.01		
Pretlow et al., 2020, USA (27)	ΔBMI ΔzBMI	-1.6, p not reported -0.22, p < 0.001		
Stasinaki et al., 2021, Switzerland (28)	ΔBMI-SDS	-0.09 (range: -0.4 to 0.4), p = 0.33	-0.16 (range: -1.9 to 0.3), p >0.05	
Vidmar et al., 2019, USA (29)	zBMI (Δ|B vs E) %BMIp95 (Δ|B vs E)	-0.09 (95%CI = -0.13 to -0.05), p < 0.001 127.17±21.10 vs 118.83±22.73, p < 0.001	2.39±0.34 vs 2.33±0.38, p=0.004 136.45±22.76 vs 132.20±22.49, p=0.002	-0.02 (95%CI = -0.04 to 0.01), p=0.316 -2.04 (95%CI = -4.16 to 0.08), p=0.059
Cummings et al., 2022, USA (30)	%BMIp95 (B vs E)	110.2±11.42 vs 110.46±10.33, p = 0.80		
Hinchman et al., 2006, USA (31)	ΔBMI ΔpBMI	1.22 (SD 2.8), p<0.05 0.22 (SD 1.2), p>0.05	1.60 (SD 2.29), p<0.05 0.76 (SD 1.86), p<0.05	No differences between groups at 1 year

B: baseline; BMI: Body Mass Index; BMI-SDS: BMI standard deviation score; C: control; CO: Cooperative; CP: Competitive; E: endpoint; MoE: Margin of error; pBMI: BMI's percentile; SD: standard deviation; SE: standard error; zBMI: BMI z-score; 95% CI: 95% Confidence Interval; %BMIp95: percent over the 95th percentile.

Of the 18 studies, nine had a statistically significant decrease of BMI [16,17,19,20,22,24,26,27,29] and nine did not [14,15,18,21,23,25,28,30,31]. One of the studies that had a statistically significant decrease [17] only showed this decrease in one of the two intervention arms (the cooperative arm).

From the nine RCT, four [16,17,19,20] showed a statistically significant decrease of BMI and five [14,15,18,25,28] did not. The clinical trial with control [29] showed a statistically significant decrease of BMI. From the three clinical trials without control, two [26,27] showed a statistically significant decrease of BMI and the other [30] did not. From the four cohorts, one [22] showed a statistically significant decrease of BMI and three [21,23,31] did not. The observational study [24] showed a statistically significant decrease of BMI.

Of the 18 studies, 15 had a follow-up under or equal to six months and from these nine [16,17,19,20,22,24,26,27,29] showed a statistically significant decrease of BMI and six [14,15,18,21,25,30] did not. The three studies [23,28,31] that had a follow-up higher than six months did not show a statistically significant decrease of BMI.

From the 10 studies that used an app as an intervention, six [20,22,24,26,27,29] showed a statistically significant decrease of BMI and four [21,23,25,28] did not. From the six studies that used a videogame as an intervention, three [16,17,19] showed a statistically significant decrease of BMI and three [14,15,18] did not. The other two studies [30,31] that used different interventions did not show a statistically significant decrease of BMI.

Regarding the analysis on the extrinsic motivators, of the two that used “Avatar” as a motivator, one [16] showed a statistically significant decrease of BMI and the other [15] did not. Of the six that used “Challenge” as a motivator, two [19,24] showed a statistically significant decrease of BMI and four [25,28,30,31] did not. Of the ten that used “Feedback” as a motivator, four [16,19,22,24] showed a statistically significant decrease of BMI and six [14,21,23,25,28,30] did not. Of the 13 that used “Motivation” as a motivator, six [19,20,22,26,27,29] showed a statistically significant decrease of BMI, six [18,21,23,25,28,30] did not, and one [17] showed a statistically significant decrease in the cooperative arm, but not in the competitive arm. Of the five that used “Peer-support” as a motivator, three [26,27,29] showed a statistically significant decrease of BMI, one [31] did not, and one [17] showed a statistically significant decrease in the cooperative arm (the only arm that had peer-support). The two studies [16,27] that used “Reminders” as a motivator showed a statistically significant decrease of BMI. Of the nine that used “Rewards'' as a motivator, four [16,26,27,29] showed a statistically significant decrease of BMI, four [18,28,30,31] did not, and one [17] showed a statistically significant decrease in the cooperative arm. From these, five used “money incentives”, three [26,27,29] decreased BMI and two [30,31] did not, and three used “points”, two decreased BMI [16,29], and one [17] showed a statistically significant decrease in the cooperative arm, but not in the competitive arm. Of the four that used “Select games” as a motivator, one [19] showed a statistically significant decrease of BMI and three [14,15,18] did not.

According to the number of the extrinsic motivators applied, one study [20] only applied one motivator (Motivation) and it showed a statistically significant decrease of BMI. Of the seven studies that applied two extrinsic motivators, one of them being the competitive arm of the study of Staiano et al. [17], two [22,24] showed a statistically significant decrease of BMI and five [14,15,17,21,23] did not. Of the six studies that applied three extrinsic motivators, one of them being the cooperative arm of the study of Staiano et al. [17], three [17,26,29] showed a statistically significant decrease of BMI and three [18,25,31] did not. Of the five studies that applied four extrinsic motivators, three [16,19,27] showed a statistically significant decrease of BMI and two [28,30] did not.

Analysis of studies that compared the impact of the intervention with the control

From the eight studies that compared the impact of the intervention with the control, four [17,19,20,29] showed a statistically significant decrease of BMI (three RCT and one Clinical trial with control) and four [15,18,25,31] did not (three RCT and one cohort).

Seven studies [15,17–20,25,29] had a follow-up under or equal to six months (four decreased BMI and three did not) and the study that had a follow-up higher than six months [31] did not decrease BMI.

Three studies [20,25,29] used an app as an intervention (two decreased BMI and one did not), four [15,17–19] used a videogame (two decreased BMI and two did not), and the one that used Operation Zero as the intervention [31] did not decrease BMI.

One study [15] used "Avatar" (did not decrease), three [19,25,31] "Challenge" (one decreased and two did not), two [19,25] "Feedback" (one decreased and one not), six [17–20,25,29] "Motivation" (three decreased, two did not, and one decreased only in the cooperative arm), three [17,29,31] "Peer-support" (two decreased and one not), three [17,18,29] "Rewards" (one decreased, one not, and one decreased only in the cooperative arm), two [18,19] "Select Games" (one decreased and one not).

One study [20] only applied one motivator (decreased BMI), two (one of them being the competitive arm) [15,17] applied two motivators (both did not decreased), five (one of them being the cooperative arm) [17,18,25,29,31] applied three motivators (two decreased and three did not), and one [19] applied four motivators (decreased).

Discussion

This review aimed to systematically assess the evidence regarding the use of extrinsic motivators in improving the BMI of obese or overweight adolescents.

Half of the studies showed a statistically significant decrease of BMI, and the same to the subanalysis of the studies that compared the impact of the intervention with the control. This shows how varied the impact on BMI is.

None of the studies that had a follow-up higher than six months showed a statistically significant decrease of BMI. This is in line with the literature [34,35] that shows no significant effect of financial incentives on weight loss or maintenance in the long-term. One hypothesis for this is that extrinsic motivators can work as a boost for initial change but decrease over time.

According to the intervention, from the studies that used an app as an intervention, 64% showed a statistically significant decrease of BMI. The literature [36,37] has limited and mixed evidence on the impact of mobile app use on motivation and goal-setting behaviour and obesity-related outcomes. As for videogame as an intervention, only half showed a statistically significant decrease of BMI. This is in line with another systematic review [38] that found that using only videogames for weight management does not deliver satisfying results.

From the extrinsic motivators, of the studies that used “Select games”, only 25% showed a statistically significant decrease of BMI. To our knowledge there are no other studies that analysed this. One hypothesis for the low impact of the extrinsic motivator “Select games” is that in most interventions the games were similar, so the adolescent does not feel they have much control and it's really their choice. As for “Challenge”, only 33% showed a statistically significant decrease of BMI. One hypothesis for this, is that most of the “Challenges” were imposed and not self-chosen, namely in the studies that used an app as intervention, which could negatively influence the motivation to complete it.

On the other hand, of the studies that used “Rewards” as a motivator, the ones that used “money incentives” 60% showed a statistically significant decrease of BMI. This is in line with the literature [35] that showed that financial incentives produce significant weight loss during the intervention, but normally weight is regained following cessation of the incentive [34,35]. The ones that used “points”, 75% showed a statistically significant decrease. The mechanism of influence seems to be like the “money incentives” as both work as rewards [39]. Those that used “Peer-support”, 80% showed a statistically significant decrease of BMI. When analysing the study of Staiano et al. [17] we can see that this extrinsic motivator has a major impact on the outcome because only the intervention arm with it (cooperative arm) showed a statistically significant difference with the control group. This is in line with a meta-analysis [40] that found that peer-support appears to be associated with decreased weight and BMI levels in individuals with overweight and obesity. One hypothesis is that peers can personalise weight control intervention for individuals with overweight or obesity in a way that medical professionals often fail. As for “Reminders”, all showed a statistically significant decrease of BMI. One hypothesis is that these “Reminders” can help adolescents to not forget about the activities and goals that they have.

The number of extrinsic motivators used was not related to the outcome. This may be due to the different definitions applied to each extrinsic motivator between different studies. As, for example, “Motivation” could be done by coaches, messages, sessions or a mixture of them, so the impact of it would be different.

In studies where intrinsic motivation already existed, all of them showed a statistically significant decrease of BMI. Compared with academic performance [41], students with primarily intrinsic motivation had better academic performance than those with primarily extrinsic motivators. Only for less interesting or enjoyable tasks can extrinsic motivation become an essential strategy [41,42]. Therefore, having intrinsic motivation could be more important than extrinsic motivation in achieving the goal, and extrinsic motivation can be a boost for more boring tasks.

The trends observed in the subanalysis of studies that evaluated the impact of intervention with control, in most cases, were overlapping with those of the general analysis.

The studies included had many limitations, as the heterogeneity of study design, sample size, follow-up duration, outcomes reported (BMI, BMI z-score, BMI percentile, percent over the 95th percentile, BMI standard deviation score), outcome analysis (some reported the baseline and endpoint values and others the variation of the outcome), and extrinsic motivators used make the comparisons and result analysis difficult. Furthermore, no study has evaluated the extrinsic motivators in isolation, therefore, in each study there are numerous confounding factors. Finally, most of the studies have a moderate or high risk of bias.

As limitations of the review process, we could not obtain three studies, although we contacted the authors, therefore, we excluded them. We also excluded one study due to language limitation (Korean). Finally, we only searched two databases.

Future studies, namely RCTs, should be well designed to minimise the heterogeneity of BMI measure and extrinsic motivators definitions. They should also focus on the impact of specific extrinsic motivators on BMI reduction. Studies of longer duration are also needed to better understand long-term impact of extrinsic motivators on weight management success.

Conclusion

The extrinsic motivators that seem to have a higher impact on decreasing BMI are “Reminders” and “Peer-support”, although there are few studies. More studies are needed with specific extrinsic motivators definitions, that assess their impact on BMI reduction and its long-term impact.

Conflicts of Interest

The authors declare no conflict of interest.

Abbreviations

BMI – Body Mass Index
PRISMA – Preferred Reporting Items for Systematic Review and Meta-Analysis
RCT – Randomized Controlled Trial
USA – United States of America

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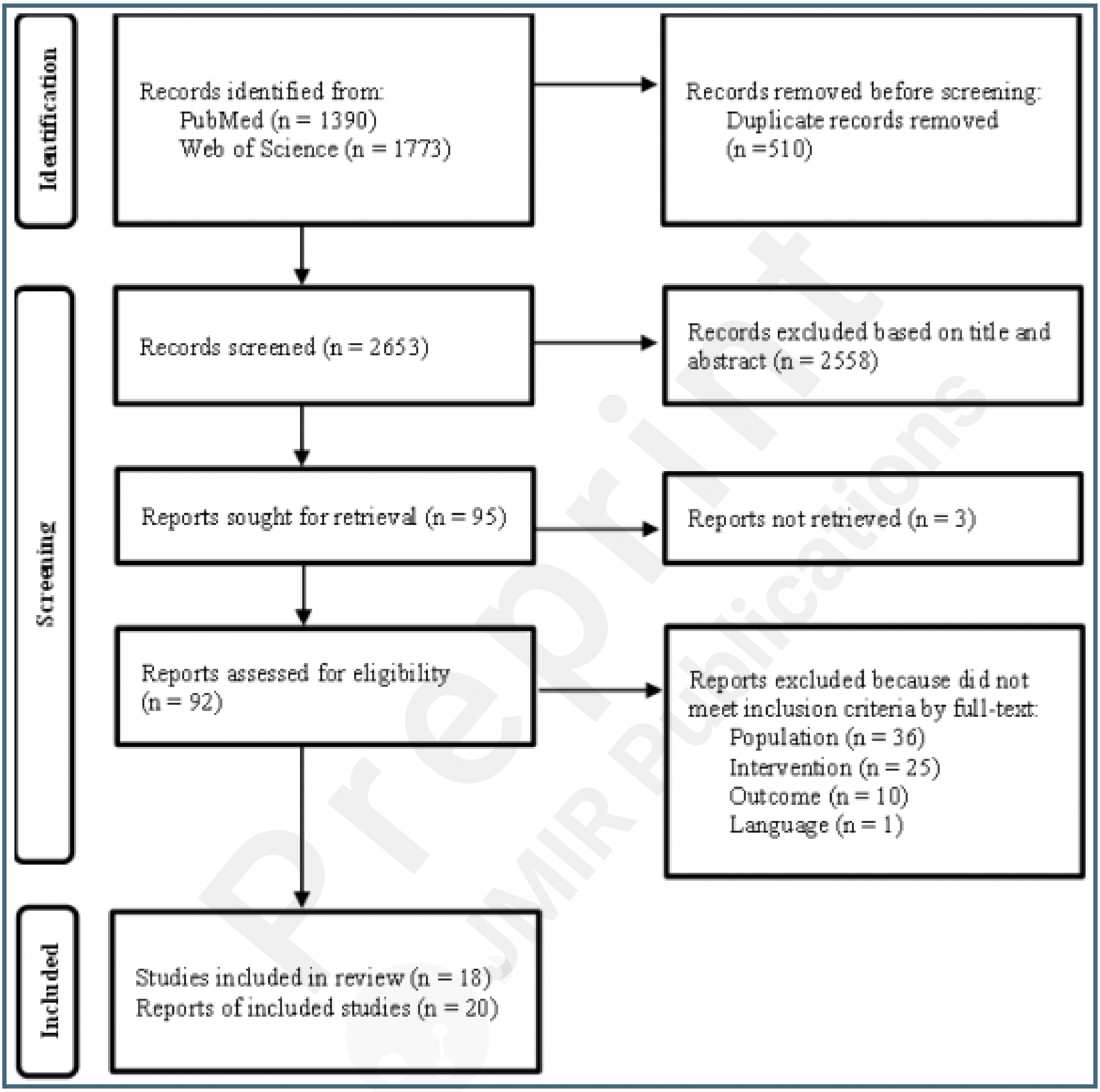
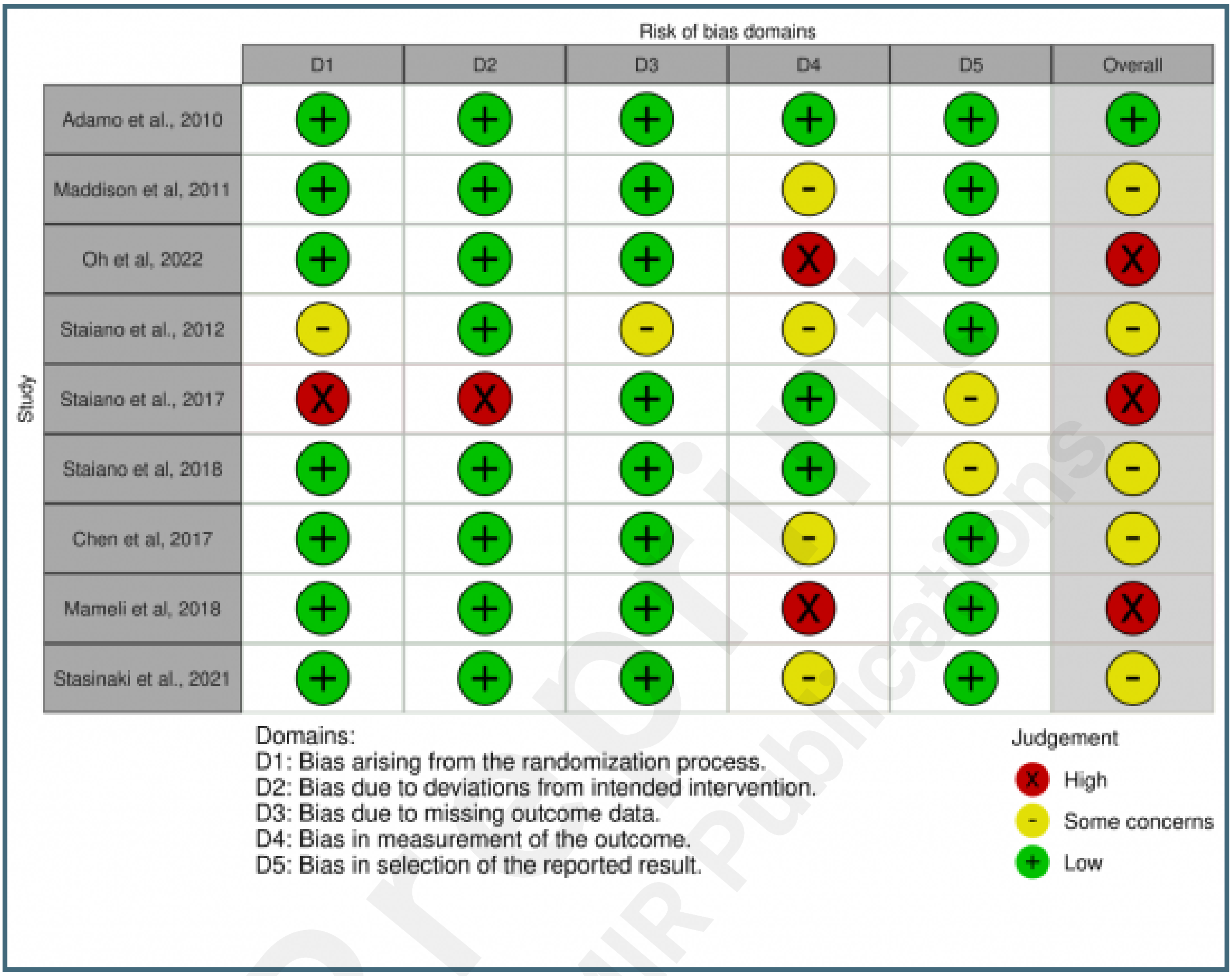
Supplementary Files

Figures

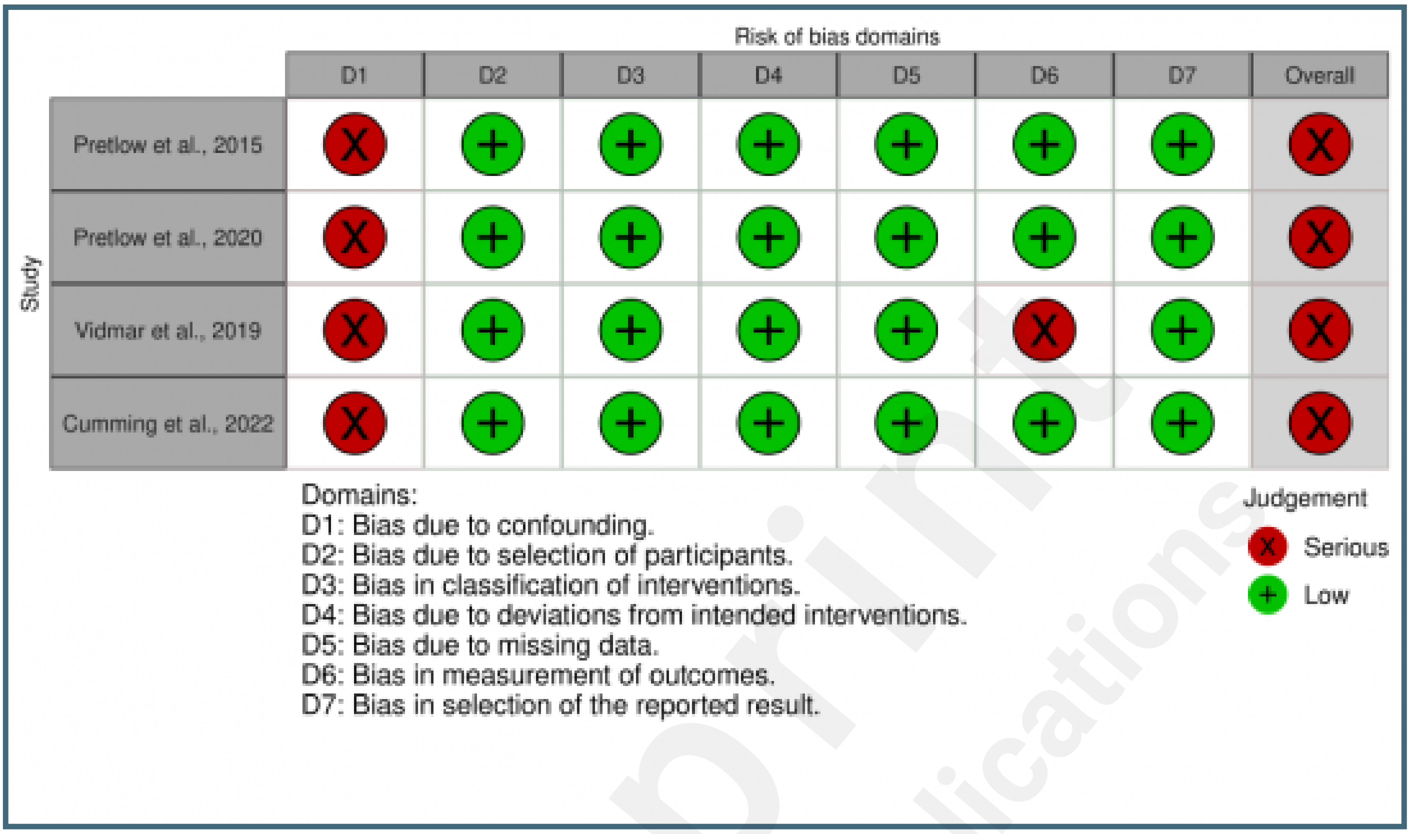
Flow diagram showing the article selection process.



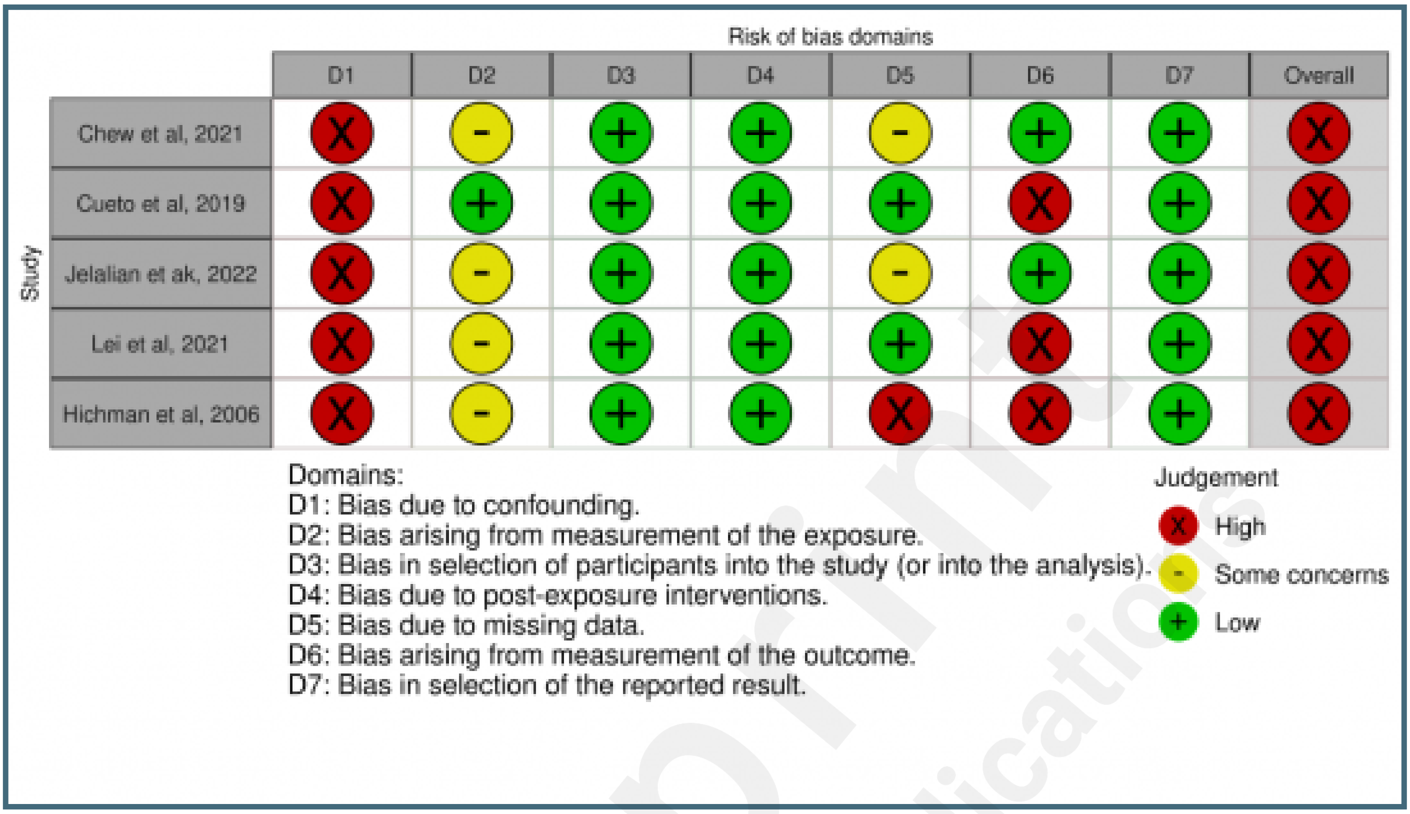
Risk of bias according to the ROB-2 tool.



Risk of bias according to the ROBINS-I.



Risk of bias according to the ROBINS-E.



Multimedia Appendixes

Search strategy.
URL: http://asset.jmir.pub/assets/dac4aa2088d1f9ff49f25c2f518992f4.docx