REVIEW

Types of Interventions Targeting Dietary, Physical Activity, and Weight-Related Outcomes among University Students: A Systematic Review of Systematic Reviews

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ABSTRACT

A plethora of studies aiming to improve dietary, physical activity (PA), and weight-related (WR) outcomes among university students have been implemented and summarized in a series of systematic reviews, with unclear conclusions regarding their effectiveness. This overview aims to identify systematic reviews and meta-analyses of studies aiming to improve health outcomes in university students, to assess their methodological quality, to identify the different types of interventions used and outcomes assessed, and to estimate their overall effect. Four electronic databases were searched until 19 March, 2018 following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The identified reviews were described and their methodological quality was rated. The studies of reviews were investigated to identify the different types of interventions used and outcomes assessed. Effectiveness was assessed by measuring the overall number of improved outcomes out of the total number of outcomes reported. As a result, 8 reviews were identified targeting food sales ($n = 2$), dietary ($n = 3$), PA ($n = 1$), WR ($n = 1$), or all outcomes ($n = 1$). The methodological quality of the reviews was moderate ($n = 5$) to low ($n = 3$). In all, the reviews included 122 studies, of which 36 used an environmental, 51 a face-to-face, 30 an e-intervention, and 5 a combined approach. Environmental interventions improved a moderate number of food sales (32 of 61) and dietary intake (22 of 47) outcomes. Face-to-face interventions improved a high number of dietary cognitive outcomes (15 of 18), a moderate number of dietary intake (28 of 65) and WR (11 of 18) outcomes, and a low number of PA behavioral (22 of 69) and cognitive (2 of 14) outcomes. E-interventions improved a high number of dietary cognitive variables (11 of 16) but had a low effect (≤33%) on the other types of outcomes. In conclusion, face-to-face and e-interventions improved cognitive variables toward diet or PA but were less effective in changing actual behaviors. Environmental interventions favorably changed food sales. Face-to-face and e-interventions moderately affected WR outcomes. Future research should focus on long-term studies. *Adv Nutr* 2019;10:848–863.

Keywords: nutrition, diet, food habits, physical activity, exercise, weight gain, interventions, university, college, systematic review

Introduction

Studying at university is often characterized by unhealthy changes in dietary and physical activity (PA) habits and consequent weight gain (1). The large prospective CARDIA study in the United States showed that young people, aged 18–30 y, who followed a healthy lifestyle had a 5% reduced cardiovascular disease risk in the subsequent 20 y (2). Analysis of the same data set found that frequent visitors to fast-food outlets gained an extra 4.5 kg and had a 2-fold greater increase in insulin resistance in the following 15 y (3).

Many interventions aimed at improving lifestyle habits of university students have been implemented and there exists a plethora of studies, summarized in systematic reviews. Despite the general increase in numbers of systematic reviews and meta-analyses, only 3% are recognized as being of good quality and enhancing the knowledge needed for evidence-based practice (4). An additional issue when synthesizing

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Abbreviations used: AMSTAR, A MeaSurement Tool to Assess systematic Reviews; PA, physical activity; PICOS, Population, Intervention, Comparison, Outcomes, and Study design; POP, point of purchase; WR, weight-related.

studies aimed at improving the health of university students is that the outcomes and interventions of these studies vary considerably, making the synthesis of results challenging. The main outcomes with regards to diet are food intakes (5), sales of foods (6), or cognitive variables reflecting dietary behavior (e.g., self-efficacy) (7). PA interventions vary in terms of the types of exercise prescribed (aerobic, flexibility, resistance) and their intensity (light, moderate, vigorous) (8) and outcomes are often cognitive, reflecting exercise intentions and self-efficacy toward exercise behavior (9). Weight gain and changes in body composition are also outcomes of poor dietary habits and low activity levels reported in some studies (10). A variety of interventions have been used with examples including online programs (11), in-class courses (12), education delivered by peers (13), and nutrition labeling on food items available in university canteens (6). Therefore, the way authors conduct a systematic review of this literature in terms of framing the question, search criteria, outcomes of interest, and methods of assessing and analyzing the results might lead to different conclusions or difficulties in comparing apparently similar systematic reviews and meta-analyses (4).

As more than one attempt has been made to synthesize studies aiming to improve health-related outcomes in university students, conducting an overview of systematic reviews is an appropriate method to explore the different types of interventions and outcomes and elaborate on reviewers' conclusions. It is also possible that combining the results of the multiple reviews will provide information on the types of interventions that benefit dietary, PA, and weight-related (WR) outcomes as well as identify gaps in research knowledge and practice.

The objectives of this overview were to identify systematic reviews and meta-analyses of studies aiming to improve dietary, PA, or WR outcomes in university students, to assess their methodological quality, identify the different types of interventions used and outcomes assessed, and estimate the overall effect of the different types of interventions.

Methods

A systematic review of systematic reviews (overview) was undertaken following the methods suggested by Smith et al. (14) and guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (15). A protocol for the overview is not available.

Eligibility criteria

Systematic reviews of trials evaluating the effect of interventions to improve dietary intake, PA, or WR variables among university students were considered for inclusion. Reviews with both meta-analyses and narrative combination of results were included.

The acronym PICOS (Population, Intervention, Comparison, Outcomes, and Study Design) was used to develop a focused question and establish inclusion and exclusion criteria for this overview (16). The PICOS criteria are listed in **Table 1**.

Search methods for identification of reviews

We searched the following 4 electronic databases—PubMed, Medical Literature Analysis and Retrieval Systems Online (MEDLINE) OvidSP, Cochrane Database of Systematic Reviews (The Cochrane Library), and Google Scholar—for systematic reviews from their inception dates until 7 June, 2016 and updated our search on 19 March, 2018.

The reference lists of included reviews were searched and reviews identified from the "similar articles" feature in PubMed were assessed against the inclusion criteria. In addition, the database WorldCat and the libraries of 2 universities were searched for dissertations, conference proceedings, and press articles. The authors of the included reviews were contacted to enquire about their knowledge of other relevant reviews in the field. All searching was undertaken by 1 author.

Keywords and Medical Subject Heading terms such as intervention, nutrition, diet, food habits, physical activity, exercise, and university were used to run the search in each database. Searching was limited to "systematic reviews" or "reviews" and no language limitation was applied (**Supplementary Methods**).

Selection and extraction of reviews

Titles and abstracts were examined on the screen against the inclusion and exclusion criteria by 1 author and relevant articles were retrieved based on their title or abstract. After removing duplicates and excluding irrelevant reviews by abstract, the 2 reviewers worked independently to assess the eligibility of the full-text articles and any inconsistencies were resolved by discussion between them.

Synthesis of findings

Summary of characteristics of identified reviews.

The following descriptive data were extracted for each identified review: first author and year of publication, main objective of the review, searching methodology (number and time period of databases searched and search limitations), characteristics of individual studies (number of studies and study design, total number of participants, quality rating of studies based on reviewers' quality assessment), outcomes reported within studies, the approach used to synthesize/present the overall results of studies, number of studies reporting having a positive impact on outcomes (as stated by the authors of the reviews), and authors' conclusions.

Methodological quality of reviews.

Quality appraisal of the identified reviews was based on the AMSTAR 2 (A MeaSurement Tool to Assess systematic Reviews) criteria (17). The AMSTAR 2 tool is suitable for assessing methodological issues in reviews including both randomized and nonrandomized health care interventions.

TABLE 1 The PICOS criteria for inclusion of reviews[1]

Acronym	Category	Inclusion and exclusion criteria
P	Population	University or college students who are in good health. Reviews focusing on a subpopulation of university students, such as athletes, overweight or obese students, or students with eating disorders, were excluded. Reviews targeting young people in general, with <70% of their included studies implemented on university students, were excluded.
I	Intervention	Reviews including:
—	—	• Any type of dietary/nutrition, physical activity, or combined intervention aiming to improve dietary, activity, or weight-related outcomes implemented in a university/tertiary environment.
—	—	• Any type of weight gain prevention intervention implemented in a university/tertiary environment.
—	—	• Interventions targeting alcohol or aiming to treat a disease/clinical condition (e.g., obesity) were excluded.
C	Comparison	Reviews with trials with no comparison group or a comparison group that received no intervention or a comparison group that received a different type of intervention were included.
O	Outcomes	Reviews targeting:
—	—	• Dietary or nutrition-related outcomes including dietary intake, food habits, diet quality, nutrition knowledge/awareness/attitudes, cooking skills, food selection/purchase, and behavioral and cognitive skills toward dietary practices such as self-efficacy and self-regulation.
—	—	• Physical activity or exercise-related outcomes including fitness, intensity (moderate, vigorous), frequency (time/days spent), number of daily steps, physical activity knowledge/attitudes as well as cognitive and behavioral skills such as stage of change, self-efficacy, and goal setting toward exercise.
—	—	• Anthropometric and clinical data including body weight, BMI, body composition, and metabolic risk indicators.
—	—	• Weight gain prevention, prevention of chronic diseases, and improvement of overall quality of life.
S	Study design	Reviews conducted in a systematic way or meta-analyses including trials were eligible. Reviews including only descriptive/cross-sectional studies or where <70% of their studies involved a population other than university students were excluded.

[1] PICOS, Population, Intervention, Comparison, Outcomes, and Study Design.

It consists of the following 16 criteria: *1*) the application of PICOS, *2*) existence of a preregistered protocol, *3*) explanation of study design selection, *4*) search strategy, *5*) study selection in duplicate, *6*) data extraction in duplicate, *7*) list and justification of excluded studies, *8*) description of included studies, *9*) assessment of risk of bias of studies, *10*) reporting funding sources of studies, *11*) conducting a meta-analysis (if applicable), *12*) assessing the impact of risk of bias on the results of meta-analysis (if applicable), *13*) interpreting findings considering potential risk of bias, *14*) explaining heterogeneity of findings, *15*) investigating publication bias (if applicable), and *16*) declaring any conflict of interest. Responses to the criteria are in the form of yes/partial yes/no. The AMSTAR 2 does not calculate a quality score and the overall appraisal is based on methodological weaknesses in critical domains. For the purposes of this overview, the methodological conduct of each included review was examined against the 16 criteria using the AMSTAR 2 checklist available online at https://amstar.ca/amstar_checklist.php. The online checklist calculates an overall judgment based on responses to each criterion, including "high quality," "moderate quality," "low quality," and "critically low quality." The 2 reviewers independently assessed the quality criteria for the identified reviews and any disagreements were discussed and resolved between them.

Synthesis of findings across reviews.

In order to make an independent judgment of the effectiveness of interventions, all studies included in each review were read and the following data were extracted.

Types of interventions of studies. The interventions described by studies were classified as *1*) *environmental*, if changes were made to the food service environment of universities (e.g., canteens, vending machines); *2*) *face-to-face*, if educators and learners were present at the same place during the intervention (e.g., in-class courses); *3*) *e-interventions*, if interventions were facilitated through the World Wide Web or with the use of technology; and *4*) *combined*, if interventions included ≥2 of the above modes (environmental, face-to-face, e-intervention). Similar criteria to the above have been used before to group interventions (18).

Types of outcome measures of studies. The outcomes of studies were classified as *1*) *dietary*, including sales or purchases of foods/drinks/meals, intakes of foods/drinks/energy/nutrients, overall eating habits, diet quality, and cognitive variables toward dietary behavior; *2*) *physical activity*, including amount, length, frequency, and type of exercise, fitness level, sedentary behavior, and cognitive variables related to exercise behavior; and *3*) *weight-related*, including body composition measures (e.g., weight, BMI, body fat, lean mass, waist circumference, waist-to-hip ratio), prevention of weight gain, and related cognitive variables (e.g., body satisfaction).

Data synthesis and overall effect of studies. The results of the original studies from each review were categorized according to intervention (environmental, face-to-face, e-interventions, and combinations) and similar outcomes were summarized.

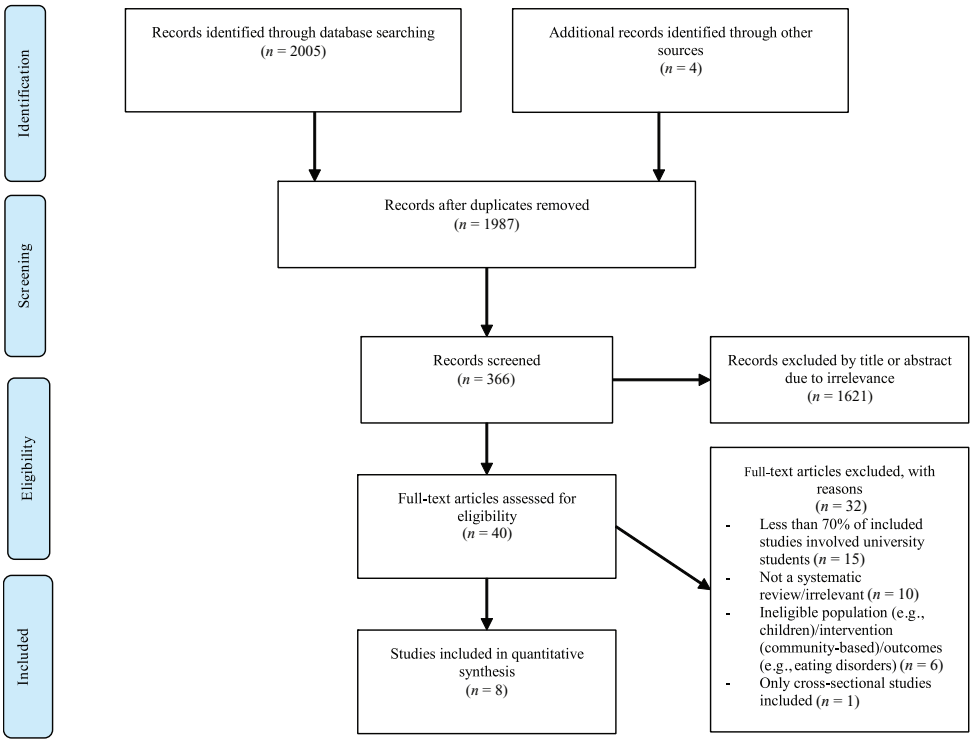

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart of database searches and selection of reviews. Reproduced from reference (15) with permission.

To estimate the overall effect of each type of intervention, we calculated the total number of outcomes suggesting a positive effect of each type of intervention out of the total number of outcomes reported. A judgment of a positive effect was based on the direction of effect as many studies did not report the statistical significance or effect size of changes in outcomes. To determine the level of effectiveness (no effect, low, moderate, high), the following criteria were used:

- 0% of outcomes favor the intervention = no effect;
- 1–33% of outcomes favor the intervention = low effect;
- 34–66% of outcomes favor the intervention = moderate effect;
- 67–100% of outcomes favor the intervention = high effect.

A similar decision rule has been used in other overviews (19). These results were then compared with the effects reported by individual reviews.

The data were presented in a narrative synthesis because, owing to the diversity of interventions identified and outcome measures reported, it was not possible to undertake a meta-analysis.

Results

The search strategy and selection process for eligible reviews are presented in **Figure 1**. Eight reviews were identified and included in the final analysis.

Summary of characteristics of the identified reviews

A summary of the main characteristics of the identified reviews is presented in **Table 2**.

Two reviews (20, 21) focused on the impact of environmental interventions on food choices/purchases, whereas the remainder investigated the impact of all types of intervention on diet (18, 22, 23), PA (24), body composition (25), or all the foregoing outcomes (26). Within reviews, the number of databases searched ranged from 2 (22) to 7 (21); 2 reviews limited their search to studies carried out in the United States and/or Canada (22, 25). Among reviews that focused on environmental interventions, one identified 22 studies (20) and one 15 studies (21). Among reviews targeting dietary behavior, 1 identified 20 studies (18) and 2 identified 14 studies (22, 23). One review targeted only PA and identified 27 studies (24) and 1 included all types of outcomes and identified 41 studies of which 24 targeted diet, 29 PA, and 12 WR outcomes (26). Finally, 1 review targeted weight gain prevention and identified 10 studies of which 8 were implemented among university students (25). Except for 2 reviews (18, 24), the rest identified a higher number of nonrandomized than randomized controlled trials. With regards to the synthesis of results, 4 reviews presented their findings according to the different types of interventions (18, 21, 22, 25), 2 according to the different outcomes reported (20, 26), and 2 (23, 24) did not use a specific method. A meta-analysis was undertaken only in 2 reviews (20, 26). The review by Laska et al. (25) included a group of 28 studies

TABLE 2 Main characteristics and quality rating of the identified systematic reviews including interventions targeting improvements in dietary, PA, and weight-related outcomes among university students[1]

			Characteristics of identified studies				Results			
Review	Main objective	Search methodology	Total number	Total number of participants	Quality rating of individual studies	Outcomes reported in studies	Synthesis/presentation of studies	Number of effective studies	Authors' conclusions	Methodological quality
Christoph and An (20)	To investigate the effect of nutrition label use on diet quality among university students.	4 databases were searched until 18 May, 2017 following the PRISMA guidelines. English-language limitation applied. No country limitation applied.	$n = 22$ (5 RCTs, 17 cohort or pre–post interventions)	~27,100	Risk of bias: high: $n = 1$; average: $n = 19$; low: $n = 2$. Assessment tool adapted from US National Heart, Lung, and Blood Institute.	Dietary intake, diet quality, and food choices.	Studies were presented in tables and categorized by the type of dietary outcome into: - Calories selected or consumed ($n = 13$) - Noncaloric measures ($n = 12$). A meta-analysis was conducted showing fewer calories ordered/consumed among pre–post interventions using nutrition labels vs. no labels (mean decrease of calories: 36.0; 95% CI: −60.2, −11.8, $P = 0.038$, $I^2 = 98.6$) and among studies using contextual vs. simple labels (mean decrease of calories: 66.9; 95% CI: −86.7, −47.2, $P = 0.002$, $I^2 = 86.4$). A meta-analysis on RCTs showed no difference.	Overall: 16 of 21 (76%). Assessing caloric selection/intake: 8 of 13 (62%). Assessing macronutrient selection/intake (diet quality): 9 of 12 (75%).	Nutrition labeling had a moderate but positive effect on dietary intake among university students.	Moderate
Maselli et al. (24)	To conduct a systematic review of interventions designed to improve PA among university students.	5 databases were searched until November, 2016 following PRISMA guidelines. English-language limitation applied. No country or other limitation applied.	$n = 27$ (24 RCTs, 3 non-RCTs)	11,376	Risk of bias: high: $n = 27$; average: $n = 7$; low: $n = 3$. Assessment tool: Cochrane Collaboration Tool.	All PA outcomes.	Studies were presented in tables. A specific approach was not used. A meta-analysis was not conducted.	Overall: 16 of 27 (59%).	Personalized approaches and PA sessions seem promising parts of an intervention. High risk of bias of studies limits the strength of conclusions with regards to effectiveness.	Moderate
Deliens et al. (18)	To provide an overview of interventions aiming to improve dietary intake among university students.	4 databases searched from January, 2000 until December, 2014 following the PRISMA guidelines. English-language limitation applied. No country limitations applied.	$n = 20$ (12 RCTs, 1 non- RCT, 7 pre–post without control group).	13,578	Risk of bias: high: $n = 1$; average: $n = 19$. Assessment tool: The Academy of Nutrition and Dietetics Quality Criteria.	Dietary habits, nutrient intakes, consumption of foods/fluids/beverages, and food or drinks sales/purchases.	Studies were presented in tables and categorized by the type of intervention into: - Media/web-based intrapersonal ($n = 6$); - Non-media–based intrapersonal ($n = 6$); - Combined intrapersonal ($n = 1$); - Environmental ($n = 7$). A meta-analysis was not conducted.	Overall: 13 of 20 (65%). According to type of intervention: - Web/media-based: 5 of 6 (83%); - Intrapersonal: 2 of 6 (33%); - Combined intrapersonal: 1 of 1 (100%); - Environmental: 5 of 7 (71%).	Nutrition education, with self-regulation, provided through technology and POP message strategies, may improve dietary intakes in the short term.	Moderate

(*Continued*)

TABLE 2 (*Continued*)

Review	Main objective	Search methodology	Characteristics of identified studies			Outcomes reported in studies	Results		Authors' conclusions	Methodological quality
			Total number	Total number of participants	Quality rating of individual studies		Synthesis/presentation of studies	Number of effective studies		
Roy et al. (21)	To evaluate food environment interventions targeting young adults in university settings.	7 databases searched from 1998 until December, 2014. The PRISMA guidelines were used. English-language limitation applied. No country limitation applied.	$n = 15$ (3 RCTs, 2 pre–post interventions, 6 quasi-experimental, and 4 cross-sectional).	~3753	Risk of bias: high: $n = 3$; average: $n = 7$; low: $n = 5$. Assessment tool: The Academy of Nutrition and Dietetics Quality Criteria.	Food choices, nutrition knowledge, and/or food/drink sales.	Studies were presented in tables and categorized by the type of intervention into: - Information about healthy foods through signage and labels ($n = 10$); - Availability of healthy foods through changing catering practices and portion sizes ($n = 3$); - Nutrition information with incentives (e.g., price reductions and availability of healthy foods) ($n = 2$). A meta-analysis was not conducted.	Overall: 13 of 15 (87%). According to type of intervention: - Information through signage and labels: 8 of 10 (80%); - Availability/portion size (assessing dietary intakes): 3 of 3 (100%); - Nutrition information with incentives: 2 of 2 (100%).	Nutrition information, healthy options, and decreased portion sizes as well as price reductions and increased availability of healthy options seem useful interventions to help improve dietary habits.	Moderate
Plotnikoff et al. (26)	To examine the effectiveness of interventions aimed at improving PA, diet, and/or weight-related behaviors among university students.	5 databases searched following the PRISMA guidelines from January, 1970 until April, 2014. English-language limitation applied. No country limitations applied.	$n = 41$ (16 RCTs, 12 non-RCTs, 13 pre–post with no control group).	19,589	Risk of bias: high: $n = 8$; average: $n = 30$; low: $n = 4$. Assessment tool: The Academy of Nutrition and Dietetics Quality Criteria.	Dietary intakes, diet quality, and related behavioral aspects (self-efficacy etc.). PA outcomes and related behavioral aspects (perceived barriers etc.). Changes in body weight and body composition.	Studies were presented in tables and categorized based on the outcomes of interest into: - Studies assessing dietary outcomes ($n = 24$); - Studies assessing PA outcomes ($n = 29$); - Studies assessing weight-related outcomes ($n = 12$). A meta-analysis was conducted for total, moderate, and vigorous PA (vs. control conditions). A significantly higher level was found only for moderate PA (standardized mean difference: 0.18; 95% CI: 0.06, 0.30, $P = 0.005$, $I^2 = 0\%$).	Overall: 34 of 41 (83%). Assessing dietary outcomes: 12 of 24 (50%). Assessing PA outcomes: 18 of 29 (62%). Assessing weight outcomes: 4 of 12 (33%).	Interventions including university courses with frequent face-to-face contact and feedback to provide encouragement and support were effective at improving PA, dietary, and weight-related outcomes.	Moderate
Kelly et al. (22)	To review research literature evaluating nutrition and dietary interventions in university settings.	2 databases searched between January, 2001 and June, 2011 following the Institute of Medicine Guidelines. English-language limitation and country limitation (US only) applied.	$n = 14$ (6 RCTs, 1 quasi-experimental, 7 non-experimental).	~2691	N/A	Intakes of foods/drinks/nutrients, healthy eating rating, food sales, and other aspects of dietary behavior (cooking skills, goal setting, etc.).	Studies were presented in tables and categorized by the type of intervention into: - In-person ($n = 6$); - Online ($n = 5$); - Environmental ($n = 3$). A meta-analysis was not conducted.	Overall: 11 of 14 (79%). According to type of intervention: - In-person: 5 of 6 (83%); - Online: 3 of 5 (60%); - Environmental: 3 of 3 (100%).	In-person strategies including self-regulation, self-monitoring, and goal setting were promising in improving students' dietary behavior, whereas environmental strategies could promote sales of healthy foods.	Critically low

(*Continued*)

TABLE 2 (*Continued*)

Review	Main objective	Search methodology	Characteristics of identified studies			Outcomes reported in studies	Results		Authors' conclusions	Methodological quality
			Total number	Total number of participants	Quality rating of individual studies		Synthesis/presentation of studies	Number of effective studies		
Lua and Wan (23)	To summarize studies on the effectiveness of nutrition educational interventions used by university students.	4 databases were searched from 1990 until 2011; no specific guidelines were mentioned. English-language limitation applied. No country limitations applied.	$n = 14$ (4 RCTs, 9 longitudinal, 1 cross-sectional).	1536	N/A	Dietary intake, aspects of dietary behavior (self-efficacy etc.), body weight, and body composition.	Studies were presented in tables. A specific approach was not used. A meta-analysis was not conducted.	Overall: 13 of 14 (93%).	Nutrition education with dietary supplements appeared the best methods for improving diet and promoting health.	Critically low
Laska et al. (25)	To review studies examining weight gain prevention interventions among young adults.	5 databases searched from 1985 until July, 2011 following a snowball strategy. No language limitation applied. Country limitations (United States and Canada only) applied.	$n = 8$ including university students (4 RCTs, 4 quasi-experimental).	877	N/A	Primary outcomes included changes in body weight and body composition.	Studies assessing weight-related outcomes were presented in tables and categorized by the type of intervention into: - University courses ($n = 6$); - Other strategies ($n = 2$). Studies addressing dietary intake ($n = 19$), PA ($n = 8$), or multiple health behaviors ($n = 1$) were briefly mentioned as text. A meta-analysis was not conducted.	Overall (assessing weight variables): 6 of 8 (75%). According to type of intervention: - University courses: 5 of 6 (83%); - Other strategies: 1 of 2 (50%).	University course-based interventions showed some promising results in preventing weight gain among postsecondary students.	Critically low

[1] N/A, not applicable; PA, physical activity; POP, point-of-purchase; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT, randomized controlled trial.

targeting dietary and/or PA outcomes, which were excluded from this analysis because the results were briefly mentioned in the text and not presented in detail.

Methodological quality of identified reviews

The results of the AMSTAR 2 assessment of the methodological quality of each review are presented in Table 2.

Methodological quality was moderate in 5 reviews (18, 20, 21, 24, 26) and critically low in 3 reviews (22, 23, 25) (**Supplemental Table 1**). Reviews published more recently had higher methodological quality than earlier reviews. Key omissions of moderate-quality reviews included failure to preregister the protocol, justify the selection of study design, and report sources of funding of included studies (18, 20, 21, 26). Among low-quality reviews, key omissions included all of the foregoing plus failure to apply the PICOS criteria (22, 23, 25), assess the risk of bias of studies, as well as report and justify the excluded studies (22, 23, 25). Also, low-quality reviews did not perform study selection (23, 25) and data extraction (22, 23, 25) in duplicate and failed to declare any conflicts of interest (22, 23).

Synthesis of findings across reviews

Types of intervention within individual studies.

The different types of intervention reported in studies across reviews are summarized and presented in **Table 3**. For each type of intervention, a number of subtypes of intervention were identified, giving a total of 14 different types of intervention within the 4 main groups.

Environmental interventions. Thirty-six studies using an environmental intervention were identified from the reviews (**Supplemental Table 2**). Twenty-eight provided nutrition information through labeling or other signage at point-of-purchase (POP). Examples include the studies by Turconi et al. (27) and Hoefkens et al. (28) who used posters, food pyramids, or a star rating system in the university cafeterias to encourage purchases of healthy foods, or the study by Bergen and Yeh (29) which used posters on vending machines to promote sales of healthy beverages (e.g., water). Four interventions provided price incentives including cash rebates (30), distributed free items (31), or reduced prices for healthy options (32, 33). Two studies reduced the portion size of unhealthy foods (e.g., snacks) (34, 35), 1 increased the availability of targeted foods in fairs (36), and 1 offered sample plates (37).

Face-to-face interventions. Fifty-one studies using a face-to-face intervention were identified from the reviews (**Supplemental Table 3**). Thirty-one used in-class interventions, including educational programs/courses or workshops and seminars. Most courses were delivered throughout 1 academic semester. The majority of interventions included lecturing, practice, group discussions, problem solving, and assigned homework with feedback. Examples are the studies by Claxton and Wells (8) and Pearce and Cross (38). Many courses were structured on behavior-change theories. For instance, the study by Ince (39) used social cognitive theory to increase self-regulation, social support, and perceived enjoyment toward PA, whereas the study by Schnoll and Zimmerman (40) used the same theory to improve knowledge and perceived confidence in following a dietary behavior. Eight studies used tailored interventions based on individuals' requirements, beliefs, and current practices, followed by personal feedback. For instance, Brinberg et al. (41) used tailored messages based on participants' baseline information, Martens et al. (42) used one-to-one brief motivational consultations, whereas Bowden et al. (43) provided each participant tailored dietary and activity prescriptions. Five studies used peer-training, where qualified students (peers) provided education and guidance to participating students. Examples include the studies by King et al. (44) and White et al. (45). Two studies used both peer and in-class education (13, 46), whereas others used cooking classes (47), activities within residence buildings (48), and motivational/instructional brochures (49).

E-interventions. Thirty studies using an e-intervention were identified from the reviews (**Supplemental Table 4**). Twenty-three delivered educational programs through the World Wide Web. Examples include the studies by Epton et al. (50) and Franko et al. (51) where students received access to online educational resources (text, links, videos), theory-based messages, rating assignments, and tailored feedback. Other e-interventions used e-mail messages with tailored feedback (52), online cooking programs (11), support through social media (53), and e-counselling (54). Many e-interventions were also structured on behavior-change theories. Examples include the study by Parrott et al. (55), who used the theory of planned behavior, including positive/negative framed messages, and the study by Kattelmann et al. (56), who used a theoretical Model of Instructional Design to structure their online lessons. Seven interventions used technology equipment: 1 sent behavior-directed motivational text messages via mobile phones (57) and 6 provided a device (usually a pedometer) to track daily steps, such as in the studies by Jackson and Howton (58) and Tully and Cupples (59).

Combined interventions. Five studies using a combination of the above modes of interventions were identified from the reviews (**Supplemental Table 5**). One used 2 peers working together and online logbooks to track behavior (60), 1 performed in-person meetings with counsellors enhanced by giving students access to online materials and a pedometer to track steps (61), and 1 used tailored motivational consultations followed by e-mail messages and access to online resources (62). Two studies used an environmental approach by modifying the calories of the cafeteria menu or providing POP information, together with group and/or peer education (63, 64) accompanied by supplemental online materials in 1 study (63).

TABLE 3 Classification of types and subtypes of interventions of studies in identified reviews aiming to improve dietary, physical activity, and weight-related outcomes in university students

Type of intervention (*n*, number of studies)	Brief description of intervention subtypes (*n*, number of studies)
Environmental interventions ($n = 36$)	*1*) Nutrition information through labeling or other signage (e.g., posters, pyramids) at point-of-purchase in university cafeterias or other food places ($n = 28$)
—	*2*) Price incentives (e.g., cash rebate, free items, or reduced price) for healthy food/meal options ($n = 4$)
—	*3*) Reduced portion size of unhealthy foods/meals ($n = 2$)
—	*4*) Increased availability of targeted healthy foods for sale ($n = 2$)
Face-to-face interventions ($n = 51$)	*1*) Educational programs/courses, workshops, or group seminars delivered in-class ($n = 31$)
—	*2*) Tailored motivational consultations or prescriptions ($n = 8$)
—	*3*) Peer-training, i.e., qualified students (peers) providing education and guidance to participating students ($n = 5$)
—	4) Mixed (peer plus in-class education) ($n = 2$)/other approaches (cooking classes, activities within residence buildings, motivational/instructional brochures/leaflets) ($n = 5$)
E-interventions ($n = 30$)	*1*) Educational programs delivered through the World Wide Web ($n = 23$)
—	*2*) Technology-based interventions using mobile phones, pedometers, accelerometers, etc. ($n = 7$)
Combined modes of interventions ($n = 5$)	*1*) Peer-education plus online tools ($n = 1$)
—	*2*) Tailored consultation plus online education ($n = 2$)
—	*3*) Environmental approach plus group and/or peer education ($n = 1$)
—	*4*) Environmental plus peer education plus online materials ($n = 1$)

Types of outcomes within individual studies.
Six main types of outcome were identified within the different types of interventions and are summarized in **Table 4**. PA behavior-related outcomes were the most frequently reported (112 of 384 outcomes) (29%) and dietary intake outcomes the second most reported (94 of 384 outcomes) (24%), with cognitive variables of dietary behavior being the least frequently reported outcomes (25 of 384 outcomes) (7%). Food sales (61 outcomes) were outcomes of interest only in environmental approaches. Environmental interventions also targeted dietary intakes with only 1 study assessing dietary cognitive variables (customers' intention to repurchase and rating of food quality) and 1 study assessing body weight changes.

Overall effect of individual studies according to the types of intervention.

Environmental interventions. The effect of environmental interventions overall and according to subtypes is presented in **Table 5**. For all environmental interventions identified in this overview, the sum of improved outcomes for food sales was 32 of 61 (53%) and for dietary intakes it was 22 of 47 (47%), representing a moderate effect (Supplemental Table 2). Comparing these findings with those of individual reviews (Table 2), Deliens et al. (18) reported that 5 out of 7 environmental interventions (71%) improved dietary intakes, whereas Roy et al. (21) and Kelly et al. (22) found that 13 out of 15 (87%) and all (3 of 3) environmental interventions, respectively, were effective at improving various dietary outcomes.

Examining the effect of intervention subtypes, this overview found that environmental interventions that provided POP information through food labeling or other signage had a moderate effect on both food sales (46% of outcomes improved) and dietary intakes (44% of outcomes improved). These rates were lower than the ones reported by Christoph and An (20) as well as Roy et al. (21), who found that 16 out of 21 (76%) and 8 out of 10 (80%) POP interventions, respectively, were effective at improving food sales or dietary intakes. Findings of this overview also suggest that overall interventions that increased availability, controlled portion size, or provided price incentives had a high effect on sales of specific foods/drinks/meals by improving 89% of outcomes, and a moderate effect on dietary intakes by improving half of outcomes (55%). Again, these rates were lower than those reported by Roy et al. (21), who found that all (3 of 3) studies that increased availability or reduced portion size improved dietary intakes. The overview also found that 1 environmental (POP) intervention had a positive impact on weight gain prevention and another on participants' rating of food quality and intention to repurchase; however, owing to the limited number of identified studies, no reliable conclusions could be drawn for these outcomes.

Face-to-face interventions. The effect of face-to-face interventions overall and according to subtypes is presented in Table 5. Examining all face-to-face interventions identified in this overview together, the sum of improved dietary intake outcomes was 28 of 65 (43%) and it was 15 of 18 (83%) for the related cognitive variables (Supplemental Table 3). Comparing these findings with those of individual reviews (Table 2), Deliens et al. (18) reported that 2 out of 6 (33%) face-to-face (i.e., interpersonal) interventions were effective at improving dietary intakes, whereas Kelly et al. (22) and Lua and Wan (23) found that 5 out of 6 (83%) and 13 out of 14 (93%), respectively, improved a mix of cognitive and behavioral dietary outcomes. In relation to PA, the sum of improved outcomes in this overview was 22 of 69 (32%) for behavior, 2 of 14 (14%) for cognitive outcomes, and 11 of

TABLE 4 Types of outcomes used to assess effectiveness of interventions in studies from identified reviews aiming to improve dietary, physical activity, and weight-related outcomes in university students

Outcomes (*n*, total number of outcomes)	Brief description of desired outcomes	Types and number of interventions targeting the outcomes
Food sales ($n = 61$)	Increases in sales of healthy foods/meals/drinks or decreases in sales of unhealthy foods/meals/drinks.	Environmental: $n = 20$
Dietary intakes ($n = 94$)	Increases in intakes of foods/nutrients beneficial to health or decreases in intakes of foods/nutrients harmful to health when consumed in excess amounts as well as improved overall eating habits and diet quality.	Environmental: $n = 15$ Face-to-face: $n = 21$ E-interventions: $n = 10$ Combined: $n = 2$
Cognitive variables toward dietary behavior ($n = 25$)	Increases in perceived skills (e.g., self-efficacy, goal setting), knowledge, attitudes, and social support or decreases in perceived barriers toward healthy eating behavior. Also, positive ratings on food quality and intention to repurchase.	Environmental: $n = 1$ Face-to-face: $n = 7$ E-interventions: $n = 6$ Combined: $n = 1$
Physical activity behavior ($n = 112$)	Increases in frequency, duration, intensity, and energy expenditure of activity; fitness level; or specific types of activities; decreases in sedentary behavior.	Face-to-face: $n = 21$ E-interventions: $n = 20$ Combined: $n = 1$
Cognitive variables toward activity behavior ($n = 59$)	Increases in perceived skills (e.g., stage of change, coping, outcome expectations), social support, and knowledge/attitudes or decreases in perceived barriers toward activity goals.	Face-to-face: $n = 6$ E-interventions: $n = 15$
Weight-related ($n = 33$)	Favorable changes in BMI and/or body composition variables (body mass, body fat, waist circumference, waist-to-hip ratio) or prevention of weight gain.	Environmental: $n = 1$ Face-to-face: $n = 9$ E-interventions: $n = 8$ Combined: $n = 1$

18 (61%) for WR outcomes. Comparisons with individual reviews could not be made because none investigated the impact of any type of intervention on PA.

Within the subtypes of face-to-face interventions, the findings of this overview suggest that interventions delivered in-class had a moderate effect on dietary and PA behavior (55% and 34% of outcomes improved, respectively), a high effect on dietary cognitive and WR outcomes (100% and 75% of outcomes improved, respectively), but no effect on PA cognitive outcomes (none of the outcomes improved). In comparison with findings of individual reviews (Table 2), Laska et al. (25) also found a high effect on WR outcomes by reporting that 5 out of 6 (83%) class-based courses were effective.

This overview also suggests that interventions including tailored consultations had a low effect on dietary intakes (8% of outcomes improved), a moderate effect on PA behavior (35% of outcomes improved), and a high effect on WR outcomes (67% of outcomes improved). Interventions using peers as educators were generally ineffective toward all types of outcomes, whereas the use of integrated face-to-face approaches had a moderate to high effect on all outcomes except PA behavior (low effect). However, the interpretation of results of peer-training or mixed face-to-face approaches on WR outcomes should be made with caution owing to the limited number of reported outcomes. Comparisons with individual reviews cannot be made, because none investigated the effectiveness of these subtypes (tailored or peer-training) of face-to-face interventions.

E-interventions. The overall effect of e-interventions is presented in Table 5. For all e-interventions identified in this overview, the sum of improved outcomes was 8 of 24 (33%) for dietary intakes, 11 of 16 (69%) for dietary cognitive variables, 10 of 43 (23%) for PA behavior, 13 of 45 (29%) for PA cognitive outcomes, and 4 of 13 (30%) for WR outcomes (Supplemental Table 4). Within e-interventions, those delivered through the World Wide Web had a high effect on dietary cognitive outcomes (79% of outcomes improved), a moderate effect on dietary intakes (35% of outcomes improved) and WR outcomes (57% of outcomes improved), and a low effect on PA outcomes (both behavioral and cognitive) (20–24% of outcomes improved). In comparison with findings of the individual reviews (Table 2), Deliens et al. (18) reported that 5 out of 6 (83%) web-based interventions improved dietary intakes, whereas Kelly et al. (22) found that 3 out of 5 (60%) online interventions improved a mix of dietary outcomes. This overview also found that using technology was generally ineffective, except for PA cognitive outcomes by improving 3 of 4 (75%) outcomes. Owing to the limited number of technology-based studies and reported outcomes, interpretation of these results should be made with caution. No individual reviews were found to have reported the effectiveness of technology-based e-interventions to make comparisons.

Combined interventions. The overall effect of combined interventions is presented in Table 5. The findings of this overview suggest that interventions that used a combination of the above approaches improved 3 out of 4 dietary intake and 1 out of 2 dietary cognitive outcomes (Supplemental Table 5). Owing to the limited number of studies and reported outcomes, interpretation of these results should be made with caution.

TABLE 5 Overall effect of environmental, face-to-face, e-interventions, and combined modes of interventions of studies identified from reviews targeting dietary, physical activity, and weight-related outcomes in university students

	Sum of improved outcomes out of the sum of outcomes reported (%)[1]											
	Environmental interventions			Face-to-face interventions					E-interventions			Combined modes of interventions
Outcomes	All environmental interventions	Information through labeling and other signage	Increasing availability/ control portion size/price incentives	All face-to-face interventions	In-class	Tailored	Peer-training	Mixed/other	All e-interventions	Delivered through the World Wide Web	Using technology	All combined interventions
Food sales	32 of 61 (52.5)	24 of 52 (46.2)	8 of 9 (88.9)	—	—	—	—	—	—	—	—	—
Dietary intakes	22 of 47 (46.8)	16 of 36 (44.4)	6 of 11 (54.5)	28 of 65 (43.1)	23 of 42 (54.8)	1 of 12 (8.3)	1 of 7 (14.3)	3 of 4 (75.0)	8 of 24 (33.3)	7 of 20 (35.0)	1 of 4 (25.0)	3 of 4 (75.0)
Cognitive variables toward dietary behavior	2 of 2 (100)	2 of 2 (100)	—	15 of 18 (83.3)	11 of 11 (100)	—	1 of 4 (25)	3 of 3 (100)	11 of 16 (68.8)	11 of 14 (78.6)	0 of 2 (0.0)	1 of 2 (50.0)
Physical activity behavior	—	—	—	22 of 69 (31.9)	12 of 35 (34.3)	6 of 17 (35.3)	0 of 4 (0.0)	4 of 13 (30.8)	10 of 43 (23.3)	6 of 30 (20.0)	4 of 13 (30.8)	—
Cognitive variables toward activity behavior	—	—	—	2 of 14 (14.3)	0 of 5 (0.0)	—	1 of 7 (14.3)	1 of 2 (50.0)	13 of 45 (28.9)	10 of 41 (24.4)	3 of 4 (75.0)	—
Weight-related outcomes	1 of 1 (100)	1 of 1 (100)	—	11 of 18 (61.1)	6 of 8 (75.0)	4 of 6 (66.7)	0 of 2 (0.0)	1 of 2 (50.0)	4 of 13 (30.1)	4 of 7 (57.1)	0 of 6 (0.0)	0 of 1 (0.0)

[1]The sum of improved outcomes suggesting a positive effect out of the sum of all outcomes.

Discussion

Identified interventions and outcomes

The aim of this overview was to identify systematic reviews of studies aiming to improve dietary, PA, or WR outcomes in university students, to identify the different types of interventions used and outcomes assessed, and to estimate the overall effect of the different types of intervention. Eight reviews were identified of which 2 focused on food purchases/choices, 3 on diet, 1 on PA, 1 on body composition, and 1 targeted all types of outcomes. The reviews included 122 studies in total, most of which had moderate quality, as judged by review authors. The types of interventions identified across all studies were grouped into face-to-face ($n = 51$), environmental ($n = 36$), e-interventions ($n = 30$), or combined approaches ($n = 5$). The types of outcomes reported across individual studies were food sales ($n = 61$), dietary intakes (including overall eating habits and diet quality) ($n = 94$), cognitive dietary behavior variables ($n = 25$), PA behaviors ($n = 112$), cognitive variables toward PA behavior ($n = 59$), and WR outcomes ($n = 33$).

In-class lecturing with interactive learning remains the most common teaching method used for educational purposes (65), which could explain the high number of such interventions identified in this overview (31 of 51 studies of face-to-face interventions). Environmental interventions require modifications to the university settings as well as the involvement and collaboration of the food catering services, which could be challenging for economic reasons. The use of technology and the World Wide Web in higher education has increased over the last few decades; however, they are mainly used to complement traditional educational methods (66). As expected, changing dietary and PA habits were the outcomes with the highest levels of reporting, as literature has shown the long-term benefits in health of the adoption and maintenance of a healthy diet and activity pattern in early adulthood (1). Many studies also aimed to improve mediators of dietary and activity behavior in an attempt to improve understanding (40) or enhance the impact of cognitive changes on behavior (44). Food sales were outcomes of interest only in environmental interventions. These interventions also targeted dietary intakes, but no environmental interventions were identified that targeted PA and only 1 targeted body weight (67). A large number of studies focused on weight gain prevention as was expected, considering the evidence showing that many students gain on average 3.85 kg during their first year in college (68). The majority of interventions had a short duration, lasting from a couple of minutes (69) to several weeks or months with very few continuing for >2 y to assess long-term outcomes (data not shown) (63, 70). The use of short-term outcomes acts as a surrogate for longer-term ones, but the high amount of time and cost taken to implement long-term studies can justify the relatively low number of studies identified.

Overall effect of studies

Environmental interventions, in particular POP interventions, had a moderate effect on dietary intake and food sales (~45%). The reviews by Christoph and An (20) and Roy et al. (21) found an overall effect of 75% and 80% for food labeling, respectively. These rates are 1.7 times higher than the ones found in this overview. This is partially explained by the different methodology followed by reviewers to estimate effectiveness (i.e., reviewers reported as effective any intervention that favorably changed ≥1 of the outcomes of interest) but also by the fact that both reviews identified a lower number of studies than the number of individual studies analyzed in this overview, which might have resulted from failings in the searching and study identification stages of each review. An interrupted time series design was followed by most environmental interventions, with many lacking randomization and specification of sample size; moreover, the reliability of results is highly dependent on the method used to analyze the data (71). In addition, counting food sales might be inaccurate, as purchasing food/drinks does not necessarily result in their consumption or indeed their consumption by the buyer (72).

Face-to-face interventions, particularly in-class courses, had a moderate effect on dietary intakes (43–55%) and a high effect on related cognitive variables such as knowledge, attitude, and self-efficacy (83–100%). When comparing with results of reviews that investigated face-to-face interventions, Deliens et al. (18) reported a low effect on dietary intakes (33%), whereas Kelly et al. (22) and Lua and Wan (23) reported a high effect (83% and 93%, respectively) on dietary outcomes (both intakes and cognitive). The review by Deliens et al. (18) identified only 6 interventions, whereas in this overview 21 studies were analyzed, suggesting that Deliens et al. (18) failed to identify studies which were included in other reviews, which may have contributed to bias in the conclusions drawn. The fact that Kelly et al. (22) and Lua and Wan (23) drew conclusions by assessing dietary intake and cognitive outcomes together could explain the high effect found, because cognitive variables skewed the results toward higher rates. One should also consider that methodological quality was found to be critically low in both reviews.

With regards to e-interventions, the findings of this overview suggest a moderate effect on dietary intakes (33–35%) and a high effect on related cognitive variables (69–79%). The review by Deliens et al. (18) found that almost all Web-based studies were effective (83%), whereas Kelly et al. (22) found a moderate effect (60%). Both reviews identified a lower number of Web-based studies than this overview, where 10 studies assessing dietary intakes [compared with $n = 5$ in Deliens et al. (18)] and 16 studies assessing both dietary intakes and cognitive variables [compared with $n = 6$ in Kelly et al. (22)] were included in the analysis.

Both face-to-face and e-interventions had a low effect on PA behavior (32% and 23%, respectively) and related cognitive variables (14% and 29%, respectively). Interestingly though, the use of technological equipment such as accelerometers and pedometers improved awareness and other cognitive mediators toward exercise (effect rate: 75%). The reviews by Maselli et al. (24) and Plotnikoff et al. (26) found a moderate impact of interventions on PA (~60%); however, they did not present their results by the type of intervention or separate cognitive from behavioral aspects, thus, direct comparisons cannot be made with the findings of this overview.

Regarding body composition, both face-to-face and e-interventions had a low to moderate effect (30–60%). The review by Plotnikoff et al. (26) also reported a low number of effective studies (33%), in contrast to Laska et al. (25) who found a high effect (75%). The critically low methodological quality in addition to the country limits at the study selection stage applied by Laska et al. (25) could somehow explain the results found by the reviewer. Many studies, presumably for increasing the ease of data collection, used self-reported measures of body weight and BMI (38–41), decreasing the accuracy of overall conclusions.

In general, the findings of this overview suggest that the interventions identified had a higher effect on cognitive outcomes than on behavioral outcomes. Despite our findings, improvements in cognitive skills are known to be significant precursors of behavior change, and evidence from similar health interventions has shown that cognitive skills such as self-efficacy and action planning were positively correlated with improved dietary (73) and activity (48) behaviors. In addition, interventions that are structured according to behavioral theory techniques seem to have a higher effect on behavior change than interventions with little use of such techniques (74). Our findings might be explained by the fact that assessment of behavior is more challenging than the assessment of cognitive skills. In most studies, cognitive variables were measured by Likert scales and ratings were solely based on individual perceptions, whereas dietary and PA behavior were usually assessed by questionnaires, which are susceptible to literacy and recall bias (75). In addition, dietary and PA behavior in students are influenced by a cluster of other factors, including individual (taste, time, convenience, stress), social (family, peers, friends), environmental (availability, accessibility, cost), and media (advertising) factors (76, 77). These factors might diminish the beneficial influence of cognitive mediators on behavior change. Also, most studies lasted for a couple of weeks or months, which might not be enough time to engage and maintain a behavior.

Quality of reviews

The application of AMSTAR 2 criteria resulted in 5 reviews being of moderate quality and 3 reviews being of critically low quality. As some of the results in this overview were based on results reported by reviewers, the methodological quality of reviews had a direct impact on the findings of this overview. Almost all reviews limited their search to

English-language articles and did not extend their search to grey literature; moreover, data selection and extraction in 2 reviews were conducted by 1 reviewer. Thus, studies might have been omitted by reviews, and, although it was outside of the scope of this overview, we noticed that reviews with apparently similar eligibility criteria had a high number of uncommon studies. In addition, none of the reviewers assessed publication bias. Empirical evidence suggests that journals or researchers tend to underreport manuscripts with null or unfavorable results (78). Absence of studies with negative results or null findings from reviews may result in the findings seeming overly favorable. Assessment of the risk of bias of studies was performed by 5 out of 8 reviews, whereas risk of bias was not considered in reviews that pooled results in a meta-analysis. It is not clear to what extent the quality affects the outcome of a study; nevertheless, assessing risk of bias of studies is vital for interpreting the results and making strong recommendations (79).

Assessment of heterogeneity and pooled analysis of data was performed in only 2 reviews, with many reviews being unclear whether an attempt was made to assess heterogeneity and perform a meta-analysis. Many reviews failed to report conflicts of interest or state the potential funding bias of their included studies. Although research studies are nonprofitable in nature, the funding sources should always be reported and taken into consideration. Finally, a relation seems to emerge between the number of effective studies found by reviews and their methodological quality because the 3 reviews that scored very low (22, 23, 25) identified almost exclusively effective studies (>75%).

Strengths and limitations of the overview process

The review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines with no restrictions applied with regards to publication status, date, or language. However, there was no preregistered protocol. Two reviewers worked independently to assess the eligibility of, and extract data from, full-text identified reviews, reducing potential bias in the overview process. Reviews with a pooled and narrative synthesis were eligible for inclusion with many reviews choosing not to report the effect size or statistical significance of changed outcomes. Some reviews were focused only on behavioral outcomes, whereas others investigated a mix of cognitive and behavioral variables, making the synthesis of results in a meta-analysis very difficult. When a pooled synthesis of findings cannot be conducted, a method of last resort suggested by *The Cochrane Handbook* is vote counting (80). Vote counting reports the direction of effect (positive, negative, or no change) of a reported outcome but cannot draw any conclusion about the effect size or statistical significance of the changed outcome (19). In this overview, vote counting was used to derive an estimate of the overall effect of studies by calculating the sum of outcomes improved out of the total number of outcomes reported. There are weaknesses inherent in this method in that it can be difficult to judge whether the results of a study are positive or negative and decisions are subjective. Despite this limitation, this method is likely more objective than the one used by individual reviewers, who reported as effective any study with favorable improvements in ≥1 of the outcomes of interest, a method likely to introduce selective reporting bias. An additional weakness of the vote counting method is that, unlike meta-analysis, it fails to take into account the weighting of individual studies and this is a weakness of this synthesis.

In this overview, behavioral and cognitive variables were analyzed separately when estimating overall effect, increasing the reliability of overall findings. Also, new (sub)groups of the main modes of interventions were introduced and their overall effect on the various outcomes was calculated. However, the methods and units used to assess the outcomes in studies as well as the methodological quality of reviews were not considered in data synthesis and analysis, introducing potential bias in the overview process and findings.

Conclusion and Implications for Future Research

The findings of this overview suggest that there is scope for research to investigate the impact of interventions that modify university settings to improve PA and body composition outcomes. Combining different modes of interventions also seems promising to improve health outcomes in university students. Despite difficulties, research should aim to conduct more long-term interventions. Mixed-methods research should be considered for future studies not only to assess the impact of interventions but also capture the views of students on acceptability and feasibility of the interventions and explain the variation observed across studies. When conducting reviews, it is advised that authors investigate specific outcomes and types of interventions to eliminate variation and contribute toward combinable findings. Finally, it would be interesting to explore the potential reasons for the very low effect of all types of interventions toward PA outcomes in order to design more successful interventions in the future.

Researchers could use the findings of this overview when planning environmental, face-to-face, and e-interventions that aim to improve cognitive or behavioral variables in relation to diet or exercise as well as body composition among university students. There is need in the field for more long-term well-designed randomized controlled trials, qualitative studies, and studies that use combined modes of interventions. Despite the challenges, researchers should aim to perform high-quality systematic reviews including specific types of interventions and attempt to synthesize findings to get a pooled estimate of changes.

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on the manuscript, and read and approved the final manuscript.

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