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1 **Title:** Types of interventions targeting dietary, physical activity and weight-related outcomes
2 among university students- A systematic review of systematic reviews¹

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17

18 **Short Running head:** Interventions among university students: overview

19 **List of abbreviations**

20 AMSTAR: A MeaSurement Tool to Assess systematic Reviews

21 PA: Physical Activity.

22 PICOS: Population, Intervention, Comparison, Outcomes, and Study design

23 POP: Point Of Purchase

¹Supplemental search strategy for one database, Supplemental Tables 1-4 and Supplemental References are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at <https://academic.oup.com/advances/>

- 24 PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
- 25 RCT: Randomized Controlled Trial
- 26 WC: Waist Circumference
- 27 WHR: Waist-to-Hip Ratio
- 28 WR: Weight-Related

29 **ABSTRACT**

30

31 A plethora of studies aiming to improve dietary, physical activity (PA) and weight-related
32 (WR) outcomes among university students have been implemented and summarized in a series
33 of systematic reviews, with unclear conclusions regarding their effectiveness. This overview
34 aims to identify systematic reviews and meta-analyses of studies aiming to improve health
35 outcomes in university students, to assess their methodological quality, to identify the different
36 types of interventions used and outcomes assessed and estimate their overall effect. Four
37 electronic databases were searched until 19th March 2018 following the PRISMA guidelines.
38 The identified reviews were described, and their methodological quality was rated. The studies
39 of reviews were investigated to identify the different types of interventions used, and outcomes
40 assessed. Effectiveness was assessed by measuring the overall number of improved outcomes
41 out of the total number of outcomes reported. As a result, eight reviews were identified
42 targeting food sales (n=2), dietary (n=3), PA (n=1), WR (n=1) or all outcomes (n=1).
43 Methodological quality of reviews was moderate (n=5) to low (n=3). All reviews included 122
44 studies, of which 36 used an environmental, 51 a face-to-face, 30 an e-intervention and 5 a
45 combined approach. Environmental interventions improved a moderate number of food sales
46 (32/61) and dietary intake (22/47) outcomes. Face-to-face interventions improved a high
47 number of dietary cognitive outcomes (15/18), a moderate number of dietary intake (28/65)
48 and WR (11/18) outcomes and a low number of PA behavioral (22/69) and cognitive (2/14)
49 outcomes. E-interventions improved a high number of dietary cognitive variables (11/16) but
50 had a low effect ($\leq 33\%$) on the rest types of outcomes. In conclusion, face-to-face and e-
51 interventions improved cognitive variables towards diet or PA but were less effective in
52 changing the actual behavior. Environmental interventions favorably changed food sales. Face-
53 to-face and e-interventions moderately impact WR outcomes. Future research should focus on
54 long-term studies.

55 Key words/ Medical Subject Headings (MeSH): nutrition, diet, food habits, physical
56 activity, exercise, weight gain, interventions, university, college, systematic review

57 **INTRODUCTION**

58 Studying at university is often characterised by unhealthy changes in dietary and
59 physical activity (PA)² habits and consequent weight gain (1). The large prospective CARDIA
60 study in the United States showed that young people, aged 18-30 years, who followed a healthy
61 lifestyle had a 5% reduced cardiovascular risk in the subsequent twenty-years (2). Analysis of
62 the same dataset found that frequent visitors of fast-food outlets gained an extra of 4,5 kg and
63 had a two-fold greater increase in insulin resistance in the following fifteen years (3).

64 Many interventions aimed at improving lifestyle habits of university students have been
65 implemented and there exists a plethora of studies, summarised in systematic reviews. Despite
66 the general increase in numbers of systematic reviews and meta-analyses, only 3% are
67 recognised as being of good quality and enhancing the knowledge needed for evidence-based
68 practice (4). An additional issue when synthesising studies aimed at improving health of
69 university students, is that the outcomes and interventions of these studies vary considerably,
70 making the synthesis of results challenging. The main outcomes with regards to diet are food
71 intakes (5), sales of foods (6) or cognitive variables reflecting dietary behavior (e.g. self-
72 efficacy) (7). Physical activity interventions vary in terms of the types of exercise prescribed
73 (aerobic, flexibility, resistance) and variations in intensity (light, moderate, vigorous) (8) and
74 outcomes are often cognitive, reflecting exercise intentions and self-efficacy towards exercise
75 behavior (9). Weight gain and changes in body composition are also outcomes of poor dietary
76 habits and low activity levels reported in some studies (10). A variety of interventions have
77 been used with examples including online programss (11), in-class courses (12), education
78 delivered by peers (13) and nutrition labelling on food items available in university canteens

² AMSTAR: A MeaSurement Tool to Assess systematic Reviews. PA: Physical Activity. PICOS: Population, Intervention, Comparison, Outcomes, and Study design. POP: Point Of Purchase. PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses. RCT: Randomized Controlled Trial. WC: Waist Circumference. WHR: Waist-to-Hip Ratio. WR: Weight-Related

79 (6). Therefore, the way authors conduct a systematic review of this literature in terms of
80 framing the question, search criteria, outcomes of interest, and methods of assessing and
81 analysing the results might lead to different conclusions and difficulties in comparing
82 apparently similar systematic reviews and meta-analyses (4).

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

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

93

94 **METHODS**

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

99

100 **Eligibility criteria**

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

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

107

108 **Search methods for identification of reviews**

109 We searched the following four electronic databases; Pubmed, Medical Literature Analysis and
110 Retrieval Systems Online (MEDLINE) OvidSP, Cochrane Database of Systematic Reviews
111 (*The Cochrane Library*) and Google Scholar for systematic reviews from their inception dates
112 until 7th June 2016 and updated in 19th March 2018.

113 The reference lists of included reviews were searched, and reviews identified from the ‘similar
114 articles’ feature in Pubmed were assessed against the inclusion criteria. In addition, the
115 database WorldCat and the libraries of two universities for dissertations, conference
116 proceedings and press articles were searched. The authors of the included reviews were
117 contacted to enquire about their knowledge of other relevant reviews in the field. All searching
118 was undertaken by one author.

119 Keywords and Medical Subject Heading [MeSH] terms such as intervention, nutrition, diet,
120 food habits, physical activity, exercise and university were used to run the search in each
121 database. Searching was limited to ‘systematic reviews’ or ‘reviews’ and no language
122 limitation was applied (Supplementary Data).

123

124 **Selection and extraction of reviews**

125 Titles and abstracts were examined on the screen against the inclusion and exclusion criteria
126 by one author and relevant articles were retrieved based on their title or abstract. After
127 removing duplicates and excluding irrelevant reviews by abstract, two reviewers worked

128 independently to assess eligibility of the full text articles and any inconsistencies were resolved
129 by discussion between them.

130

131 **Synthesis of findings**

132 *Summary of characteristics of identified reviews*

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

140

141 *Methodological quality of reviews*

142 Quality appraisal of the identified reviews was based on the AMSTAR 2 (A MeaSurement
143 Tool to Assess systematic Reviews) criteria (17). The AMSTAR 2 tool is suitable for assessing
144 methodological issues in reviews including both randomized and non-randomized healthcare
145 interventions. It consists of the following 16 criteria 1) the application of PICO, 2) existence
146 of a pre-registered protocol, 3) explanation of study design selection, 4) search strategy, 5)
147 study selection in duplicate, 6) data extraction in duplicate, 7) list and justification of excluded
148 studies, 8) description of included studies, 9) assessment of risk of bias of studies, 10) reporting
149 funding sources of studies, 11) conducting a meta-analysis (if applicable), 12) assessing the
150 impact of risk of bias on the results of meta-analysis (if applicable), 13) interpreting findings
151 considering potential risk of bias, 14) explaining heterogeneity of findings, 15) investigating
152 publication bias (if applicable), and 16) declaring any conflict of interest. Responses to the

153 criteria are in the form of- yes/ partial yes/ no. The AMSTAR 2 does not calculate a quality
154 score and the overall appraisal is based on methodological weaknesses in critical domains. For
155 the purposes of this overview, the methodological conduct of each included review was
156 examined against the 16 criteria using the AMSTAR 2 checklist available online at
157 https://amstar.ca/Amstar_Checklist.php. The online checklist calculates an overall judgement
158 based on responses to each criteria, including “high quality”, “moderate quality”, “low quality”
159 and “critically low quality”. The two reviewers independently assessed the quality criteria for
160 the identified reviews and any disagreements were discussed and resolved between them.

161

162 *Synthesis of findings across reviews*

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

165 i. Types of interventions of studies

166 The intervention described by studies were classified as a) *environmental*, if changes were
167 made to the food service environment of universities (e.g. canteens, vending machines), b)
168 *face-to-face*, if educators and learners were present at the same place during the
169 intervention (e.g. in-class courses), c) *e- interventions*, if interventions were facilitated
170 through the World Wide Web or with the use of technology and d) *combined*, if
171 interventions included two or more of the above modes (environmental, face-to-face, e-
172 intervention). Similar criteria to the above have been used before to group interventions
173 (18).

174

175 ii. Types of outcome measures of studies

176 The outcomes of studies were classified as a) *dietary*, including sales or purchases of
177 foods/drinks/meals, intakes of foods/drinks/energy/nutrients, overall eating habits, diet

178 quality as well as cognitive variables toward dietary behavior, b) *physical activity*,
179 including amount, length, frequency, type of exercise, fitness level, sedentary behavior, as
180 well as cognitive variables related to exercise behavior, and c) *weight-related*, including
181 body composition measures [e.g. weight, BMI, body fat, lean mass, waist circumference
182 (WC), waist-to-hip ratio (WHR)], prevention of weight gain and related cognitive
183 variables (e.g. body satisfaction).

184

185 iii. Data synthesis and overall effect of studies

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

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

- 195 • 0% of outcomes favor intervention = no effect;
- 196 • 1% to 33% of outcomes favor intervention = low effect;
- 197 • 34% to 66% of outcomes favor intervention = moderate effect;
- 198 • 67% to 100% outcomes favor intervention = high effect.

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

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

204

205 **RESULTS**

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

208

209 **Summary of characteristics of identified reviews**

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

211 Two reviews (20, 21) focused on the impact of environmental interventions on food
212 choices/purchases while the remainder investigated the impact of all types of intervention on
213 diet (18, 22, 23), physical activity (24), body composition (25) or all the above outcomes (26).

214 Within reviews, the number of databases searched ranged from two (22) to seven (21) while
215 two reviews limited their search to studies carried out in the USA and/or Canada (22, 23).

216 Among reviews that focused on environmental interventions, one identified 22 studies (20) and
217 one 15 studies (21). Among reviews targeting dietary behavior, one identified 20 studies (18),

218 and two identified 14 studies (22, 23). One review targeted only PA and identified 27 studies
219 (24) and one included all types of outcomes and identified 41 studies of which 24 targeted diet,

220 29 PA and 12 WR outcomes (26). Finally, one review targeted weight gain prevention and
221 identified 10 studies of which 8 were implemented among university students (25). Except two

222 reviews (18, 24), the rest identified a higher number of non-randomized than randomized
223 controlled trials. With regards to the synthesis of results, four reviews presented their findings

224 according to the different types of interventions (18, 21, 22, 25), two according to the different
225 outcomes reported (20, 26) and two (23, 24) did not use a specific method. A meta-analysis

226 was undertaken only in two reviews (20, 26). The review by Laska et al. (25) included a group
227 of 28 studies targeting dietary and/or PA outcomes, which have been excluded from this
228 analysis because the results were briefly mentioned in text and not presented in detail.

229

230 **Methodological quality of identified reviews**

231 The results of the AMSTAR 2 assessment of the methodological quality of each review are
232 presented in **table 2**.

233 Methodological quality was moderate in five reviews (18, 20, 21, 24, 26) and critically low in
234 three reviews (22, 23, 25) (Supplementary Table 1). Reviews published more recently had
235 higher methodological quality than earlier reviews. Key omissions of moderate quality reviews
236 included failure to pre-register the protocol, justify the selection of study design and report
237 sources of funding of included studies (18, 20, 21, 26). Among low quality reviews, key
238 omissions included all the previous plus failure to apply the PICO criteria (22, 23, 25), assess
239 the risk of bias of studies as well as report and justify the excluded studies (22,23,25). Also,
240 low quality reviews did not perform study selection (25, 25) and data extraction (22, 23, 25) in
241 duplicate and failed to declare any conflicts of interest (22, 23).

242

243 **Synthesis of findings across reviews**

244

245 **Types of intervention within individual studies**

246 The different types of intervention reported in studies across reviews are summarized and
247 presented in **table 3**. For each type of intervention, a number of sub-types of intervention were
248 identified, giving a total of fourteen different types of intervention, within the four main groups.

249

250 *Enviromental interventions*

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

261

262 *Face-to-face interventions*

263 Fifty-one studies using a face-to-face intervention were identified from the reviews
264 (Supplemental Table 3). Thirty-one used in-class interventions, including educational
265 programs/courses or workshops and seminars. Most courses were delivered throughout one
266 academic semester. The majority of interventions included lecturing, practice, group
267 discussions, problem solving and assigned homework with feedback. Examples are the studies
268 by Claxton and Wells (8) and Pearce and Cross (38). Many courses were structured on
269 behavior-change theories. For instance the study by Ince (39) used social cognitive theory to
270 increase self-regulation, social-support and perceived enjoyment toward PA while the study by
271 Schnoll R & Zimmerman (40) used the same theory to improve knowledge and perceived
272 confidence in following a dietary behaviour. Eight studies used tailored interventions based on
273 individual's requirements, beliefs and current practices, followed by personal feedback. For
274 instance, Brinberg et al. (41) used tailored messages based on participants' baseline
275 information, Martens et al. (42) used one-to-one brief motivational consultations while

276 Bowden et al. (43) provided each participant tailored dietary and activity prescriptions. Five
277 studies used peer-training, where qualified students (peers) provided education and guidance
278 to participating students. Examples include the studies by King et al. (44) and White et al. (45).
279 Two studies used both peer and in-class education (13, 46) while others used cooking classes
280 (47), activities within residence buildings (48) and motivational/instructional brochures (49).

281

282 *E-interventions*

283 Thirty studies using an e-intervention were identified from the reviews (Supplemental Table 4).
284 Twenty-three delivered educational programs through the world wide web. Examples include
285 the studies by Epton et al. (50) and Franko et al. (51) where students received access to online
286 educational resources (text, links, videos), theory-based messages, rating assignments and
287 tailored feedback. Other e-interventions used e-mail messages with tailored feedback (52),
288 online cooking programs (11), support through social media (53) and e-counselling (54). Many
289 e-interventions were also structured on behavior-change theories. Examples include the study
290 by Parrot (55), who used the theory of planned behavior, including positive/negative framed
291 messages and the study by Kattelman (56), who used a theoretical Model of Instructional
292 Design to structure their online lessons. Seven interventions used technology equipment, one
293 sent behavior-directed motivational text messages via mobile phones (57) and six provided a
294 device (usually a pedometer) to track daily steps such as in the studies by Jackson and Howton
295 (58) and Tully and Cupples (59).

296

297 *Combined interventions*

298 Five studies using a combination of the above modes of interventions were identified from the
299 reviews (Supplemental Table 5). One used two peers working together and online logbooks to
300 track behavior (60), one performed in-person meetings with counsellors enhanced by giving

301 students access to online materials and a pedometer to track steps (61), and one used tailored
302 motivational consultations followed by email messages and access to online resources (62).
303 Two studies used an environmental approach by modifying the calories of the cafeteria menu
304 or providing POP information, together with group and/or peer education (63, 64) accompanied
305 by supplemental online materials in one study (63).

306

307 **Types of outcomes within individual studies**

308 Six main types of outcome were identified within the different types of interventions and are
309 summarized in **table 4**. Physical activity behavior-related outcomes were the most frequently
310 reported (112 of 384 outcomes) (29%) and dietary intake outcomes the second most reported
311 (94 of 384 outcomes) (24%), with cognitive variables of dietary behavior being the least
312 frequently reported outcomes (25 of 384 outcomes) (7%). Food sales (61 outcomes) were
313 outcomes of interest only in environmental approaches. Environmental interventions also
314 targeted dietary intakes with only one study assessing dietary cognitive variables (customers'
315 intention to repurchase and rating of food quality) and one study assessing body weight
316 changes.

317

318 **Overall effect of individual studies according to the types of intervention**

319 *Environmental interventions*

320 The overall effect of environmental interventions and according to subtypes is presented in
321 **table 5**. For all environmental interventions identified in this overview, the sum of improved
322 outcomes for food sales was 32/61 (53%) and 22/47 (47%) for dietary intakes, representing a
323 moderate effect (Supplemental Table 2). Comparing these findings to those of individual
324 reviews (table 2), Deliëns et al. (18) reported that 5 out of 7 environmental interventions (71%)
325 improved dietary intakes while Roy et al. (21) and Kelly et al. (22) found that 13 out of 15

326 (87%) and all (3/3) environmental interventions respectively, were effective at improving
327 various dietary outcomes.

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

343

344 *Face-to-face interventions*

345 The overall effect of face-to-face intervention and according to subtypes is presented in **table**
346 **5**. Examining all face-to-face interventions identified in this overview together, the sum of
347 improved dietary intake outcomes was 28/65 (43%) and 15/18 (83%) for the related cognitive
348 variables (Supplemental Table 3). Comparing these findings to those of individual reviews
349 (table 2), Deliens et al. (18) reported that 2 out of 6 (33%) face-to-face (=intrapersonal)
350 interventions were effective at improving dietary intakes while Kelly et al. (23) and Lua and

351 Wan (23) found that 5 out of 6 (83%) and 13 out of 14 (93%) respectively, improved a mix of
352 cognitive and behavioral dietary outcomes. In relation to PA, the sum of improved outcomes
353 in the this overview was 22/69 (32%) for behavior 2/14 (14%) for cognitive outcomes and
354 11/18 (61%) for WR outcomes. Comparisons with individual reviews could not be made as
355 none investigated the impact of any type of intervention on PA.

356 Within the subtypes of face-to-face interventions, the findings of this overview suggest that
357 interventions delivered in-class had a moderate effect on dietary and PA behavior (55% and
358 34% of outcomes improved), a high effect on dietary cognitive and WR outcomes (100% and
359 75% of outcomes improved) but no effect on PA cognitive outcomes (none of the outcomes
360 improved). In comparison to findings of individual reviews (table 2), Laska et al. (25) also
361 found a high effect on WR outcomes by reporting that 5 out of 6 (83%) class-based courses
362 were effective.

363 This overview also suggests that interventions including tailored consultations had a low effect
364 on dietary intakes (8% of outcomes improved), a moderate effect on PA behavior (35% of
365 outcomes improved), and a high effect on WR outcomes (67% of outcomes improved).
366 Interventions using peers as educators were generally ineffective towards all types of outcomes
367 while the use of integrated face-to-face approaches had a moderate to high effect on all
368 outcomes, except PA behavior (low effect). However, the interpretation of results of peer-
369 training or mixed face-to-face approaches on WR outcomes should be made with caution due
370 to the limited number of reported outcomes. Comparisons with individuals reviews cannot be
371 made, as none investigated the effectiveness of these subtypes (tailored or peer-training) of
372 face-to-face interventions.

373

374 *E-interventions*

375 The overall effect of e-interventions is presented in **table 5**. For all e-interventions identified
376 in this overview, the sum of improved outcomes was 8/24 (33%) for dietary intakes, 11/16
377 (69%) for dietary cognitive variables, 10/43 (23%) for PA behavior, 13/45 (29%) for PA
378 cognitive outcomes and 4/13 (30%) for WR outcomes (Supplemental Table 4). Within e-
379 interventions, those delivered through the world wide web had a high effect on dietary
380 cognitive outcomes (79% of outcomes improved), a moderate effect on dietary intakes (35%
381 of outcomes improved) and WR outcomes (57% of outcomes improved) and a low effect on
382 PA outcomes (both behavioral and cognitive) (20-24% of outcomes improved). In comparison
383 to findings of the individual reviews (table 2), Deliens et al. (18) reported that 5 out of 6 (83%)
384 web-based interventions improved dietary intakes while Kelly et al. (22) found that 3 out of 5
385 (60%) online interventions improved a mix of dietary outcomes. This overview also found that
386 using technology was generally ineffective, except for PA cognitive outcomes by improving
387 3/4 (75%) outcomes. Due to the limited number of technology-based studies and reported
388 outcomes, interpretation of results should be made with caution. No individual reviews were
389 found to have reported the effectiveness of technology-based e-interventions to make
390 comparisons.

391

392 *Combined interventions*

393 The overall effect of combined interventions is presented in **table 5**. The findings of this
394 overview suggest that interventions that used a combination of the above approaches improved
395 3 out of 4 dietary intake and 1 out of 2 dietary cognitive outcomes (Supplemental Table 5).
396 Due to the limited number of studies and reported outcomes, interpretation of results should be
397 made with caution.

398

399 **DISCUSSION**

400 **Identified interventions and outcomes**

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

413 In-class lecturing with interactive learning remains the most common teaching method
414 used for educational purposes (65), which could explain the high number of this type of
415 intervention identified in this overview (31 of 51 studies of face-to-face interventions).
416 Environmental interventions require modifications to the university settings as well as the
417 involvement and collaboration of the food catering services, which could be challenging for
418 profit reasons. The use of technology and the world wide web in higher education has increased
419 the last decades, however, it is mainly used to complement traditional educational methods
420 (66). As expected, changing dietary and physical activity habits were the outcomes with the
421 highest levels of reporting, as literature has shown the long-term benefits in health by the
422 adoption and maintenance of a healthy diet and activity pattern in early adulthood (1). Many
423 studies also aimed to improve mediators of dietary and activity behavior in an attempt to
424 improve understanding (40) or enhance the impact of cognitive changes on behavior (44). Food

425 sales were outcomes of interest only in environmental interventions. These interventions also
426 targeted dietary intakes, but no environmental interventions were identified that targeted
427 physical activity and only one targeted body weight (67). A large number of studies focused
428 on weight gain prevention as was expected, considering the evidence showing that many
429 students gain on average 3,85 kg during their first year in college (68). The majority of
430 interventions had a short duration, lasting from a couple of minutes (69) to several weeks or
431 months with very few continuing for more than two years to assess long term outcomes (data
432 not shown) (63,70). The use of short-term outcomes act as surrogates for the longer-term ones,
433 but the high amount of time and cost taken to implement long term studies can justify the
434 relatively low number of studies identified.

435

436 **Overall effect of studies**

437 Environmental interventions, in particular POP interventions, had a moderate effect on
438 dietary intake and food sales (~45%). The reviews by Christoph and An (20) and Roy et al.
439 (21) found an overall effect of 75% and 80% for food labelling, respectively. These rates are
440 1.7 times higher than the ones found in this overview. This is partially explained by the different
441 methodology followed by reviewers to estimate effectiveness (i.e. reviewers reported as
442 effective any intervention that favourably changed at least one of the outcomes of interest) but
443 also by the fact that both reviews identified a lower number of studies than the number of
444 individual studies analyzed in this overview, which might have resulted from failings in the
445 searching and study identification stages of each review. An interrupted time series design was
446 followed by most environmental interventions, with many lacking randomization and
447 specification of sample size, whilst the reliability of results is highly dependant on the method
448 used to analyse the data (71). In addition, counting food sales might be inaccurate, as

449 purchasing food/drinks does not necessarily result in their consumption or indeed their
450 consumption by the buyer (72).

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

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

470 Both face-to-face and e-interventions had a low effect on PA behavior (32% and 23%,
471 respectively) and related cognitive variables (14% and 29%, respectively). Interestingly
472 though, the use of technological equipment such as accelerometers and pedometers improved
473 awareness and other cognitive mediators towards exercise (effect rate 75%). The reviews by

474 Maselli et al. (24) and Plotnikoff et al. (26) found a moderate impact of interventions on
475 physical activity (~60%), however, they did not present their results by the type of intervention
476 or separate cognitive from behavioral aspects thus, direct comparisons cannot be made with
477 the findings of this overview.

478 Regarding body composition, both face-to-face and e-interventions had a low to
479 moderate effect (30-60%). The review by Plotnikoff et al. (26) also reported a low number of
480 effective studies (33%) opposite to Laska (2012), which found a high effect (75%). The
481 critically low methodological quality in addition to the country limits at the study selection
482 stage applied by Laska et al. (25) could somehow explain the results found by the reviewer.
483 Many studies, presumably for increasing the ease of data collection, used self-reported
484 measures of body weight and BMI (38-41) decreasing the accuracy of overall conclusions.

485 In general, the findings of this overview suggest that the interventions identified had a
486 higher effect on cognitive outcomes than on behavioral outcomes. Despite our findings,
487 improvements in cognitive skills are known to be significant precursors of behavior change,
488 and evidence from similar health interventions has shown that cognitive skills such as self-
489 efficacy and action planning were positively correlated with improved dietary (73) and activity
490 (48) behaviors. Additionally, interventions that are structured according to behavioral theory
491 techniques seem to have a higher effect on behavior change compared to interventions with
492 little use of such techniques (74). Our findings might be explained by the fact that assessment
493 of behavior is more challenging than the assessment of cognitive skills. In most studies,
494 cognitive variables were measured by Likert scales, and ratings were solely based on individual
495 perceptions while dietary and PA behavior were usually assessed by questionnaires, which are
496 susceptible to literacy and recall bias (75). In addition, dietary and PA behavior in students is
497 influenced by a cluster of other factors, including individual (taste, time, convenience, stress),
498 social (family, peers, friends), environmental (availability, accessibility, cost) and media

499 (advertising) factors (76-77). These factors might diminish the beneficial influence of cognitive
500 mediators on behavior change. Also, most studies lasted for a couple of weeks or months,
501 which might not be enough time to engage and maintain a behavior.

502

503 **Quality of reviews**

504 The application of AMSTAR 2 criteria resulted in five reviews being of moderate
505 quality and three reviews being of critically low quality. As some of the results in this overview
506 were based on results reported by reviewers, the methodological quality of reviews had a direct
507 impact on the findings of this overview. All reviews limited their search to English language
508 articles and did not extend their search to grey literature while data selection and extraction in
509 two reviews was conducted by one reviewer. Thus, studies might have been omitted by
510 reviews, and, although it was out of the scope of this overview, we noticed that reviews with
511 apparently similar eligibility criteria had a high number of uncommon studies. Additionally,
512 none of the reviewers assessed publication bias. Empirical evidence suggests that journals or
513 researchers tend to underreport manuscripts with null or unfavorable results (78). Absence of
514 studies with negative results or null findings from reviews may result in the findings seeming
515 overably favorable. Assessment of the risk of bias of studies was performed by five out of eight
516 reviews while risk of bias was not considered in reviews that pooled results in a meta-analysis.
517 It is not clear at which extend the quality impacts the outcome of a study, nevertheless,
518 assessing risk of bias of studies is vital for interpreting the results and making strong
519 recommendations (79).

520 Assessment of heterogeneity and pooled analysis of data was performed in only two
521 reviews, with many reviews being unclear whether an attempt was made to assess
522 heterogeneity and perform a meta-analysis. Many reviews failed to report conflict of interest
523 or state the potential funding bias of their included studies. Although the nature of research of

524 studies is non-profitable, the funding sources should always be reported and taken into
525 consideration. Finally, a relationship seems to emerge between the number of effective studies
526 found by reviews and their methodological quality as the three reviews that scored very low
527 (22, 23, 25) identified almost exclusively effective studies (>75%).

528

529 **Strengths and limitations of the overview process**

530 The review was conducted following the PRISMA guidelines with no restrictions
531 applied with regards to publication status, date or language. However, there was no pre-
532 registered protocol. Two reviewers worked independently to assess eligibility and extract data
533 from full-text identified reviews, reducing potential bias in the overview process. Reviews with
534 a pooled and narrative synthesis were eligible for inclusion with many reviews choosing not to
535 report effect size or statistical significance of changed outcomes. Some reviews were focused
536 only on behavioral outcomes while others investigated a mix of cognitive and behavioral
537 variables, making the synthesis of results in a meta-analysis very difficult. When a pooled
538 synthesis of findings cannot be conducted, a least preferable method suggested by The
539 Cochrane Handbook is vote counting (80). Vote counting reports the direction of effect
540 (positive, negative or no change) of a reported outcome but cannot draw any conclusion about
541 the effect size or statistical significance of the changed outcome (19). In this overview, vote
542 counting was used to derive an estimate of the overall effect of studies by calculating the sum
543 of outcomes improved out of the total number of outcomes reported. There are weaknesses
544 inherent in this method in that it can be difficult to judge whether the results of a study are
545 positive or negative and decisions are subjective. Despite this limitation, this method is likely
546 more objective than the one used by individual reviewers, who reported as effective any study
547 with favourable improvements in at least one of the outcome(s) of interest, a method likely to
548 introduce selective reporting bias. An additional weakness of the vote counting method is that,

549 unlike meta-analysis, it fails to take into account the weighting of individual studies and this is
550 a weakness of this synthesis.

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

557

558 **Conclusion and implications for future research**

559 The findings of this overview suggest that there is scope for research to investigate the
560 impact of interventions that modify university settings to improve physical activity and body
561 composition outcomes. Combining different modes of interventions also seems promising to
562 improve health outcomes in university students. Despite difficulties, research should aim in
563 conducting more long-term interventions. A mixed methods research should be considered for
564 future studies not only to assess the impact of interventions but also capture the views of
565 students on acceptability and feasibility of the interventions and explain the variation observed
566 across studies. When conducting reviews, it is advised that authors investigate specific
567 outcomes and types of interventions to eliminate variation and contribute towards combinable
568 findings. Finally, it is interesting to explore the potential reasons for the very low effect of all
569 types of interventions towards physical activity outcomes in order to design more successful
570 interventions in the future.

571 Researchers could use the findings of this overview when planning environmental,
572 face-to-face and e-interventions that aim to improve cognitive or behavioral variables in
573 relation to diet or exercise as well as body composition among university students. There is

574 need in the field for more long-term well-designed RCTs, qualitative studies and studies that
575 use combined modes of interventions. Despite the challenges, researchers should aim to
576 perform high quality systematic reviews including specific types of interventions and attempt
577 to synthesize findings to get a pooled estimate of changes.

578

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581 The authors' responsibilities were as follows- KB applied the literature search and undertook the initial
582 screening. KB and CB designed the overview; extracted data; tabulated results; wrote and made critical
583 comments on the manuscript. All authors have read and approved the final manuscript.

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Figure Legends

Figure 1. PRISMA flow chart of database searches and selection of reviews [Reproduced with permission from (15)]

Table 1. The PICOS criteria for inclusion of reviews³

Acronym	Category	Inclusion and exclusion criteria
P	Population	University or college students who are in good health. Reviews focusing on a sub-population of university students, such as athletes, or overweight/obese students or students with eating disorders were excluded. Reviews targeting young people in general, with less than 70% of their included studies implemented on university students, were excluded.
I	Intervention	Reviews including: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Dietary or nutrition related outcomes including dietary intake, food habits, diet quality, nutrition knowledge/awareness/attitudes, cooking skills, food selection/purchase, behavioural and cognitive skills towards dietary practices such as self-efficacy and self-regulation. • Physical activity or exercise related outcomes including fitness, intensity (moderate, vigorous) and frequency (time/days spent), number of daily steps, physical activity knowledge/attitudes as well as cognitive and behavioural skills such as stage of change, self-efficacy and goal setting towards exercise. • Anthropometric and clinical data including body weight, BML, body composition and metabolic risk indicators; • Weight gain prevention, prevention of chronic diseases and improvement of overall quality of life.
S	Study types	Reviews conducted in a systematic way or meta-analyses including trials were eligible. Reviews including only descriptive/cross-sectional studies or where less than 70% of their studies involved a population other than university students were excluded.

³PICO: Population, Intervention, Comparison, Outcomes, and Study Design

Table 2. Main characteristics and quality rating of the identified systematic reviews including interventions targeting improvements in dietary, physical activity and weight-related outcomes among university students⁴

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
Christoph & An (20)	To investigate the effect of nutrition label use on diet quality among university students	4 databases were searched until 18 th of 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 to: - Calories selected or consumed (n=13) - Non-caloric measures (n=12) A meta-analysis was conducted showing fewer calories ordered/consumed among pre-post intervention using nutrition labels vs no labels [mean decreased 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: 16/21 (76%). Assessing caloric selection/intake: 8/13 (62%) Assessing macronutrient selection/intake (diet quality): 9/12 (75%)	Nutrition labelling 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	All physical activity outcomes.	Studies were presented in tables. A specific approach was not used. <i>A meta-analysis was not conducted.</i>	Overall: 16/27 (59%)	Personalized approaches and PA sessions seems promising parts of an interventions. High risk of bias of studies limit the strength of conclusions with regards to effectiveness.	Moderate

⁴ N/A: not applicable; POP: Point-of-Purchase; PA: Physical Activity; RCT: randomised controlled trials

					Collaboration Tool.					
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 to: <ul style="list-style-type: none">- Media/web-based intrapersonal (n=6)- Non-media based intrapersonal (n=6)- Combined intrapersonal (n=1)- Environmental (n=7). <i>A meta-analysis was not conducted.</i>	Overall: 13/20 (65%). According to type of intervention: <ul style="list-style-type: none">- Web/ media-based: 5/6 (83%)- Intrapersonal: 2/6 (33%)- Combined intrapersonal: 1/1 (100%)- Environmental: 5/7 (71%)	Nutrition education, with self-regulation, provided through technology and POP message strategies, may improve dietary intakes in short-term.	Moderate
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. No language or country limitation applied.	n=15 (3 RCTs, 2 pre-post interventions, 6 quasi-experimental and 4 cross-sectional).	≈3,753	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 to: <ul style="list-style-type: none">- 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). <i>A meta-analysis was not conducted.</i>	Overall: 13/15 (87%). According to type of intervention: <ul style="list-style-type: none">- Information through signage and labels: 8/10 (80%)- Availability/portion size (assessing dietary intakes): 3/3 (100%)- Nutrition information with incentives: 2/2 (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 improving dietary habits.	Moderate
Plotnikoff et al. (26)	To examine effectiveness of interventions aimed at improving physical activity, diet, and/or weight-related behaviors amongst	5 databases searched following 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	Dietary intakes, diet quality and related behavioral aspects (self-efficacy, etc.) Physical activity outcomes and related behavioral aspects	Studies were presented in tables and categorized based on the outcomes of interest to: <ul style="list-style-type: none">- Studies assessing dietary outcomes (n=24)- Studies assessing physical activity outcomes (n=29)- Studies assessing weight-related outcomes (n=12). <i>A meta-analysis was conducted for total, moderate and</i>	Overall: 34/41 (83%) Assessing dietary outcomes: 12/24 (50%) Assessing physical activity outcomes: 18/29 (62%)	Interventions including university courses with frequent face-to-face contact and feedback to provide encouragement and support were effective at improving physical activity, dietary and	Moderate

	university students.				Dietetics Quality Criteria.	(perceived barriers, etc.). Changes in body weight and body composition.	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), $P=0.005$, $I^2=0\%$].	Assessing weight outcomes: 4/12 (33%)	weight-related outcomes.	
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).	≈2,691	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 to: - In-person (n=6), - Online (n=5), - Environmental (n=3). <i>A meta-analysis was not conducted.</i>	Overall: 11/14 (79%) According to type of intervention: - In-person: 5/6 (83%) - Online: 3/5 (60%) - Environmental: 3/3 (100%)	In-person strategies including self-regulation, self-monitoring and goal setting were promising in improving students' dietary behavior while environmental strategies could promote sales of healthy foods.	Critically Low
Lua & 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).	1,536	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. <i>A meta-analysis was not conducted.</i>	Overall: 13/14 (93%)	Nutrition education with dietary supplement 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 (US 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 to: - 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. <i>A meta-analysis was not conducted.</i>	Overall (assessing weight variables): 6/8 (75%) According to type of intervention: - University courses: 5/6 (83%) - Other strategies: 1/2 (50%)	University course-based interventions showed some promising results in preventing weight gain among post-secondary students.	Critically Low

Table 3. Classification of types and sub-types 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)	<ol style="list-style-type: none"> 1. Nutrition information through labelling or other signage (e.g. posters, pyramids) at point-of-purchase points at university cafeterias or other food places (n=28) 2. Price incentives (e.g. cash rebate, free items or reduced price) for healthy food/meals 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)	<ol style="list-style-type: none"> 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)	<ol style="list-style-type: none"> 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)	<ol style="list-style-type: none"> 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)

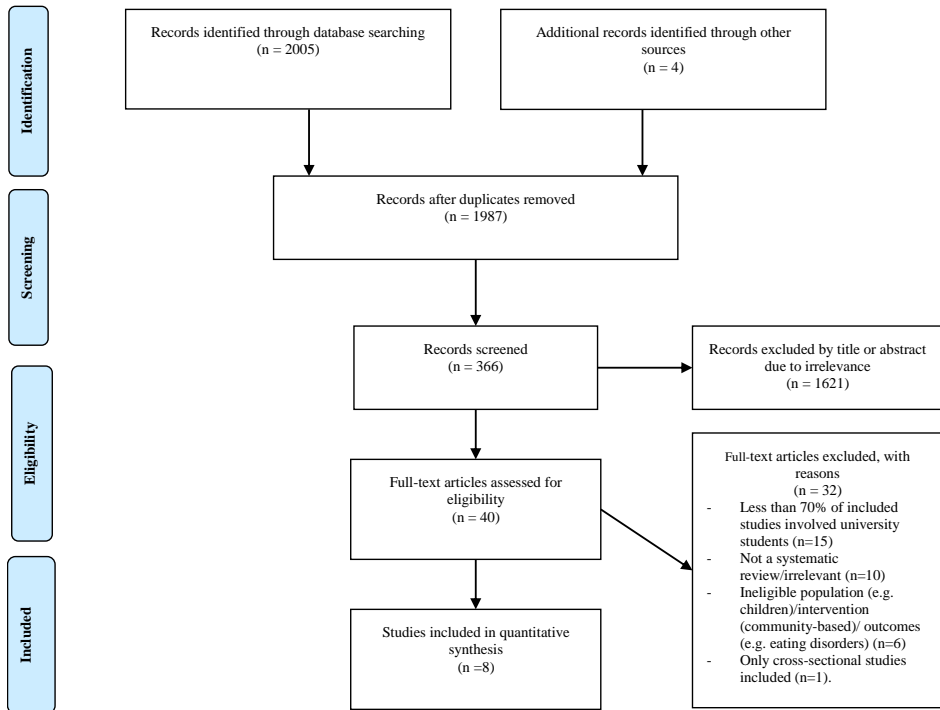
Table 4. Types of outcomes used to assess effectiveness of interventions in studies from identified reviews aiming to improve dietary, physical activity and weight-related outcomes in university students

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 towards dietary behavior (n=25)	Increases in perceived skills (e.g. self-efficacy, goal setting), knowledge, attitudes, social support or decreases in perceived barriers towards 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, energy expenditure of activity, fitness level or specific types of activities or decreases in sedentary behavior	Face-to-face: n=21 E-interventions: n=20 Combined: n=1
Cognitive variables towards activity behavior (n=59)	Increases in perceived skills (e.g. stage of change, coping, outcome expectations), social support, knowledge/attitudes or decreases in perceived barriers towards activity goals.	Face-to-face: n=6 E-interventions: n=15
Weight-related (n=33)	Favorable changes in BMI or/and 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

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, a/A (%) ⁵											
	Environmental interventions			Face-to-face interventions				E-interventions		Combined modes of interventions		
	All environmental interventions	Information through labelling 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
Outcomes												
Food sales	32/61 (52.5)	24/52 (46.2)	8/9 (88.9)	-	-	-	-	-	-	-	-	-
Dietary intakes	22/47 (46.8)	16/36 (44.4)	6/11 (54.5)	28/65 (43.1)	23/42 (54.8)	1/12 (8.3)	1/7 (14.3)	3/4 (75.0)	8/24 (33.3)	7/20 (35.0)	1/4 (25.0)	3/4 (75.0)
Cognitive variables toward dietary behavior	2/2 (100)	2/2 (100)	-	15/18 (83.3)	11/11 (100)	-	1/4 (25)	3/3 (100)	11/16 (68.8)	11/14 (78.6)	0/2 (0.0)	1/2 (50.0)
Physical activity behavior	-	-	-	22/69 (31.9)	12/35 (34.3)	6/17 (35.3)	0/4 (0.0)	4/13 (30.8)	10/43 (23.3)	6/30 (20.0)	4/13 (30.8)	-
Cognitive variables toward activity behavior	-	-	-	2/14 (14.3)	0/5 (0.0)	-	1/7 (14.3)	1/2 (50.0)	13/45 (28.9)	10/41 (24.4)	3/4 (75.0)	-
Weight-related outcomes	1/1 (100)	1/1 (100)	-	11/18 (61.1)	6/8 (75.0)	4/6 (66.7)	0/2 (0.0)	1/2 (50.0)	4/13 (30.1)	4/7 (57.1)	0/6 (0.0)	0/1 (0.0)

⁵The sum of improved outcomes out of the sum of all outcomes suggesting a positive effect



Supplementary Data

Search Strategy in Pubmed

((((intervention?[Text Word] OR intervention*[Other Term]) AND (((((((((((((((nutrition[MeSH Terms] OR ((nutrition[Text Word] OR nutrition[Other Term])) OR diet[MeSH Terms] OR ((diet?[Text Word] OR diet*[Other Term])) OR (((((((food habits[Text Word] OR food habits[Other Term] OR dietary habits[Text Word] OR dietary habits[Other Term] OR eating habits[Text Word] OR eating habits[Other Term] OR dietary intake?[Text Word] OR dietary intake*[Other Term])) OR physical activity[MeSH Terms] OR exercise[MeSH Terms] OR (((physical activity[Text Word] OR physical activity[Other Term] OR exercise[Text Word] OR exercise[Other Term])) AND university[MeSH Terms] OR (((university[Text Word] OR university[Other Term] OR college[Text Word] OR college[Other Term])) AND ((Review[ptyp] OR systematic[sb])))) NOT patients[Title/Abstract] NOT hospital[Title/Abstract] AND ((Review[ptyp] OR systematic[sb])))) NOT children[MeSH Terms] AND ((Review[ptyp] OR systematic[sb])))) AND ((Review[ptyp] OR systematic[sb])))) AND ((Review[ptyp] OR systematic[sb])))) AND English[Language] Filters: Review; Systematic ReviewsFilters: Review, Systematic Reviews.

Supplementary Data

Supplementary Table 1. Application of the AMSTAR 2 methodological quality criteria on the identified reviews targeting dietary, physical activity and weight-related outcomes in university students

Systematic Reviews	Christoph & An (20)	Maselli et al. (24)	Deliens et al. (18)	Roy et al. (21)	Plotnikoff et al. (26)	Kelly et al. (22)	Lua & Wan (23)	Laska et al. (25)
AMSTAR 2 Criteria								
1. Did the research questions and inclusion criteria for the review include the components of PICO?	Yes	No	Yes	Yes	Yes	No	No	No
2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?	No	Partial Yes	No	No	No	No	No	No
3. Did the review authors explain their selection of the study designs for inclusion in the review?	No	Yes	No	No	No	Yes	No	No
4. Did the review authors use a comprehensive literature search strategy?	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes
5. Did the review authors perform study selection in duplicate?	No	Yes	Yes	Yes	Yes	Yes	No	No
6. Did the review authors perform data extraction in duplicate?	No	Yes	Yes	Yes	Yes	No	No	No
7. Did the review authors provide a list of excluded studies and justify the exclusions?	Yes	Yes	No	Yes	No	Yes	No	No
8. Did the review authors describe the included studies in adequate detail?	Yes	Yes	Partial Yes	Yes	Yes	No	Partial Yes	Yes
9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?	Yes	Yes	Yes	Yes	Yes	No	No	No
10. Did the review authors report on the sources of funding for the studies included in the review?	No	No	Yes	Yes	Yes	No	No	No
11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?	Yes	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	Yes	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted
12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?	No	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted
13. Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?	Yes	Yes	Yes	Yes	Yes	No	No	No
14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?	No	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted	No	No meta-analysis conducted	No meta-analysis conducted	No meta-analysis conducted

Supplementary Data

16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?	Yes	Yes	No	Yes	Yes	No	No	Yes
Overall quality assessment	Moderate	Moderate	Moderate	Moderate	Moderate	Critically Low	Critically Low	Critically Low

Supplementary Data

Supplemental table 2. Brief description of environmental interventions targeting dietary and weight-related outcomes in university students, reviews including them and number of improved/not improved outcomes as appear in reviews¹

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Food sales (n=number of outcomes)		Other outcomes (n=number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Information through labelling and other signage						
Aaron et al. (S1)	Christoph & An (20)	POP information through nutrition labelling			Intakes: n=2 (total energy and fat intake increased)	
Bergen & Yeh (S2)	Lua & Wan (23) Roy et al. (21)	Nutrition information through labelling and posters on vending machines	Sales: n=2 (lower growth rate sales of sugary-beverages; increased sales of all beverages, mostly of water)			
Buscher et al. (2 studies) (S3)	Deliens et al. (18) Roy et al. (21) Kelly et al. (22)	POP information through posters and other signage	Sales: n=4 (increased sales of yogurt, pretzels, whole fruit, packaged salads)		Sales: n=3 (not increases in sales of fruit baskets and vegetables baskets; increases in sales of candy)	
Chu et al. (S4)	Christoph & An (20) Roy et al. (21)	POP information through nutrition labelling	Sales: n=1 (reduced average energy content of entrées sold)		Sales: n=1 (not change in total number of entrées sold)	
Cioffi et al. (S5)	Christoph & An (20)	POP information through nutrition labelling	Sales: n=4 (decreased mean energy and fat content of items sold; sales of low calorie-foods increased; sales of high-fat foods decreased)			
Cranage et al. (S6)	Roy et al. (21)	POP nutrition information on laminated cards	Sales: n=2 (decreases in sales of high-fat/high-calorie entrées; increases in sales of low-fat/ low-calorie entrées)			Other: n=2 (higher rating of food quality satisfaction; higher intention to repurchase)

¹ FVI: Fruit and Vegetable Intake; NC: information Not Clear; POP: Point-of-Purchase

Supplementary Data

Davis-Chervin et al. S(7)	Christoph & An (20)	POP nutrition information displayed on posters and cards	Sales: n=2 (low calorie entrees; low-cholesterol entrees)	Sales: n=1 (low-fat entrees not increased)
Dingman et al. (S8)	Christoph & An (20)	Nutrition information on labels/posters on vending machines		Sales: n=2 (average calories per snack, proportion of targeted snacks sold)
Driskell et al. (S9)	Roy et al. (21)	POP information through nutrition labelling	NC	
Christoph & Ellison (S10)	Christoph & An (20)	Nutrition information signage (caloric content, traffic lights) on specific menus	Sales: n=2 (medium and low-calorie entrees increased; high-calorie items decreased)	
Freedman (S11)	Christoph & An (20)	POP information through nutrition labelling, laminated signs, and photos	Sales: n=1 (% of students choosing large portions of French fries decreased)	Sales: n=2 (% of students choosing salad dressing and French fries did not decrease)
Freedman & Connors (S12)	Christoph & An (20) Deliens et al. (18) Roy et al. (21) Kelly et al. (22)	POP information through nutrition labelling		Sales: n=4 (cereal, soup, cracker and bread not increased)
Hammond et al. (S13)	Christoph & An (20)	POP information through nutrition labelling	Intakes: n=2 (calories ordered and consumed decreased)	
Hoefkens et al. (S14)	Christoph & An (20) Roy et al. (21)	POP nutrition information through signage (star rating point system, posters)	Intakes: n=1 (increased vegetable intake)	Sales: n=1 (targeted meals not increased) Intakes: n=4 (energy, fat, saturated fat, and sodium intakes not decreased)
Hoerr & Loudon (S15)	Christoph & An (20)	Nutrition information using posters on vending machines		Sales: n=3 (low-nutrient density snacks not decreased; moderate and high-nutrient density snacks not increased)
James et al. (S16)	Christoph & An (20)	Labels with nutrition and exercise information on specific menus	Sales: n=1 (fewer calories ordered) Intakes: n=2 (energy and fat intake decreased)	
Kolodinsky et al. (S17)	Plotnikoff et al. (26)	POP information through nutrition labelling	NC	NC

Supplementary Data

Larson-Brown (S18)	Christoph & An (20)	Information through nutrition labelling on vending machines	Sales: n=1 (sales of more-nutritious food increased)	Sales: n=1 (sales of less-nutritious foods not decreased)	
Lillico et al. (S19)	Christoph & An (20)	POP information through nutrition labelling		Intakes: n=1 (calorie intake not decreased)	
Nikolaou et al. (S20)	Christoph & An (20) Roy et al. (21)	POP information through nutrition labelling and posters	Intakes: n=3 (calories, fat and saturated fat content of selected meals decreased)	Intakes: n=3 (vitamin C, iron and calcium did not increase)	Other: n=1 (prevention of weight gain)
Nikolaou et al. (S21)	Christoph & An (20)	POP information through nutrition labelling	Sales: n=2 (sales of high-calorie and high-fat sandwiches decreased)	Sales: n=2 (sales of low-calorie and low-fat sandwiches decreased)	
Peterson et al. (S22)	Deliens et al. (18) Roy et al. (21) <u>Plotnikoff</u> et al. (26) Kelly et al. (22)	POP nutrition information through signage (indicators, signs, table tents, flyers, photographs)	Intakes: n=3 (increased intakes of cottage cheese, low-fat salad dressing; decreased intake of deli sandwiches)	Intakes: n=7 (not increased intakes of grilled chicken breast, tossed salad, steamed vegetables, fresh fruits, yoghurt, skim milk, whole grain bread)	
Reed et al. (S23)	Deliens et al. (18) <u>Plotnikoff</u> et al. (26)	POP nutrition information using PowerPoint slides	Intakes: n=1 (increased fruit intake)	Intakes: n=1 (no reduction in cookie intake)	
Roy et al. (S24)	Christoph & An (20)	POP information through nutrition labelling	Sales: n=2 (sales of two targeted items changed favorably)	Sales: n=7 (sales of seven targeted items did not change)	
Schwartz et al. (S25)	Christoph & An (20)	POP information through nutrition labelling		Sales: n=1 (calories ordered did not decrease)	
Temple et al. (S26)	Christoph & An (20)	POP information through nutrition labelling plus educational video before lunchtime	Intakes: n=2 (energy intake reduced; not increases in intake of high-energy-dense foods)	Intakes: n=1 (control group increased intake of low-energy-density foods)	
Temple et al. (2 studies) (S27)	Christoph & An (20)	Nutrition labelling on menus	Intakes: n=2 [increased intake of green (healthier) foods; decreased intake of red (less healthy) foods]	Intakes: n=1 (energy intake did not decrease)	
Turconi et al. (S28)	Roy et al. (21)	POP nutrition information through pyramid figures	NC	NC	
<i>Total number of outcomes</i>			Total: 40 Food sales: 24	Total: 48 Food sales: 28	Total: 3

Supplementary Data

			Dietary intakes: 16	Dietary intakes: 20
Increasing availability of targeted items, controlling portion size or providing price incentives				
Cardenas et al. (S29)	Deliens et al. (18)	Three phases: 1) POP information, 2) POP information plus health and price information, 3) POP information plus price reduction		Sales: n=1 (no increased fruit sales)
Cinciripini (S30)	Christoph & An (20)	Cash rebate, caloric feedback of food selections, nutrition information (labels, flyer distribution)	Sales: n=6 (starchy carbohydrates; red meat; regular dairy; high fat dessert/sauces decreased. Salad; and non-starchy vegetable/soup/fruit/low-fat dairy increased for subgroups)	
Freedman & Brochado (S31)	Roy et al. (21)	Portion control (reduce portion size)	Intakes: n=1 (reduced intakes of French fries)	
McClain et al. (S32)	Deliens et al. (18)	Marketing campaign (sample plates, signage, table tents, flyers, photographs)	Intakes: n=2 (decreases in high-fat meat and junk food intakes)	Intakes: n=2 (no increases in FVI, no reductions in high-fat dairy intakes)
Michels et al. (S33)	Roy et al. (21)	POP information (nutrition labels) and price reductions	Sales: n=2 (increases in sales of healthy foods; decreases in sales of less-healthy foods)	
Lachat et al. (S34)	Roy et al. (21)	Free distribution of targeted items (fruit and vegetables)	Intakes: n=1 (Increased FVI)	Intakes: n=3 (no reduced energy, fat, and sodium intake) NC
Shive & Morris (S35)	Roy et al. (21) Laska et al. (25)	Increased availability of targeted foods plus information (nutrition labels, fairs)	Intakes: n=1 (increased fruit intake)	
Stroebele et al. (S36)	Roy et al. (21)	Portion control (reduce portion of snacks)	Intakes: n=1 (decreased snack intake)	
<i>Total number of outcomes</i>			Total: 14 Food sales: 8 Dietary intakes: 6	Total: 6 Food sales: 1 Dietary intakes: 5
Overall number of outcomes of all interventions			Overall: 54 Foods sales: 32 Dietary intakes: 22	Overall: 54 Food sales: 29 Dietary intakes: 25 Other: 3

Supplementary Data

Supplemental table 3. Brief description of face-to-face interventions targeting dietary, physical activity and weight-related outcomes in university students, reviews including them, and number of improved/not improved outcomes appear in reviews²

Study	Reviews including the study	Brief description of intervention	Dietary intakes/ Diet cognitive (n= number of outcomes)		Physical activity behavior/PA cognitive (n= number of outcomes)		Weight-related (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
<i>In-class interventions</i>								
Abood et al. (S37)	Lua & Wan (23)	In-class educational sessions with activities	Intakes: n=1 (overall number of positive dietary changes increased) C-diet: n=2 (nutrition knowledge and self-efficacy increased)					
Abu-Moghli et al. (S38)	Plotnikoff et al. (26)	Educational workshops	Intakes: n=2 (type of diet score increased; overall dietary habits scored increased) NC			PA behavior: n=1 (activity score of did not increase)		
Afifi Soweid et al (S39)	Plotnikoff et al. (26)	In class-educational course with activities			NC			NC
Alpar et al. (S40)	Plotnikoff et al. (26)	Educational (nursing) program		Intake: n=1 (frequency of healthy eating score did not increase)		PA behavior: n=1 (frequency of exercise score increased)		
Calfas et al. (S41)	Laska et al. (25)	In-class educational course					NC	
Cardinal et al. (S42)	Plotnikoff et al. (26) Laska et al. (25)	In-class educational course and lab activities				NC		

²C-diet: Cognitive Dietary outcomes; C-PA: Cognitive Physical Activity outcomes; FVI: Fruit and Vegetable Intake; MET: Metabolic Task Equivalent; MPA: Moderate Physical Activity; NC: information Not Clear; PA: Physical Activity; VPA: Vigorous Physical Activity; WHR: Waist-to-Hip Ratio; WR: Weight-related outcomes

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Chen et al. (S43)	Plotnikoff et al. (26)	In-class educational course with activities	NC		
Claxton et al. (S44)	Maselli et al. (24) Plotnikoff et al. (26) Laska et al. (25)	In-class course with homework		PA behavior: n=1 (days of activity for weight management increased)	PA behavior: n= 4 (MPA; VPA; strength/endurance activity; flexibility activity not increased)
DeVahl et al. (S45)	Laska et al. (25)	In-class course with activities plus course bonus award			WR: n=1 (body fat not decreased)
Endevelt et al. (S46)	Lua & Wan (23)	In-class workshop with interactive activities	NC		
Finckenor & Byrd-bredbenner (S47)	Laska et al. (25)	Group-based short course	NC		
Ince (S48)	Plotnikoff et al. (26)	In-class educational course with activities plus exercise at the gym	Intakes: n=1 (nutrition behavior score increased)	PA behavior: n=4 [exercise score increased; MPA, VPA and total PA (MET-min/week) increased]	PA behavior: n=1 [walking (MET-min/week) did not increase]
Jung & Heald (S49)	Laska et al. (25)	In-class instructor-delivered lecture involving high-intender/ low-intender discriminate beliefs			NC
Hall & Fong (S50)	Maselli et al. (24)	Educational fitness classes with or no goal setting		PA behavior: n=1 (weekly VPA increased at post-test but did not maintain at follow-up)	PA behavior: n=5 (monthly VPA did not increase; weekly minutes of MPA, very hard PA, strength and flexibility activity did not increase)
Gieck & Olsen (S51)	Plotnikoff et al. (26)	In-class educational course			C-PA: n=2 (knowledge and self-efficacy of physical

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Gray et al. (S52)	Plotnikoff et al. (26)	In-class educational course		NC			wellness did not increase)
Ha et al. (S53)	Kelly et al. (22) Lua & Wan (23) Laska et al. (25)	In-class educational course with interactive activities	Intakes: n=3 (soft-drinks reduced; fat-free milk increased; whole-milk decreased)	Intakes: n=1 (low-fat milk decreased)			
Ha & Caine-Bish N (S54)	Plotnikoff et al. (26) Kelly et al. (22) Lua & Wan (23) Laska et al. (25)	In-class educational course with interactive activities	Intakes: n=5 (total & fresh vegetable increased; total & fresh fruit increased; French fries decreased)	Intakes: n= 4 (starchy vegetables; vegetable juice; fruit juice; canned fruits not increased)			
Ha & Caine-Bish (S55)	Kelly et al. (22) Lua & Wan (23) Laska et al. (25)	In-class educational course with interactive activities	Intakes: n=1 (whole grains increased) C-diet: n=1 (whole-grain knowledge increased)				
Hager et al. (S56)	Plotnikoff et al. (26)	In-class (vs the same online) educational course with assignments	Intakes: n=3 (fruit & vegetable; bran/wholegrain cereals; brown rice/ whole wheat foods increased)	Intakes: n=1 (green salad did not increase)	PA behavior: n=4 (days of MPA; minutes of MPA; overall PA and VO ₂ max increased)	PA behavior: n=2 (frequency and length of VPA did not increase)	WR: n=2 (BMI and body mass did not improve)
Hekler et al. (S57)	Plotnikoff et al. (26) Kelly et al. (22) Laska et al. (25)	Group-based educational course with interactive activities	Intakes: n=2 (vegetables increased; high-fat dairy decreased)	Intakes: n=4 (fruit did not increase; high-fat meats, sweets, processed foods did not decrease)			
Hivert et al. (S58)	Maselli et al. (24) Laska et al. (25)	Group-based educational seminars				PA behavior: n=1 (total PA did not increase)	WR: n=2 (BMI and body mass decreased)
Kozak et al. (S59)	Masselli et al. (24)	Group-based informative and exercise				PA behavior: n=2	

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Matvienko et al. (S60)	<p>Deliens et al. (18)</p> <p>Lua & Wan (23)</p> <p>Laska et al. (25)</p>	<p>instructive sessions with framed messages</p> <p>In-class educational course</p>		<p>Intakes: n=4 (energy and fat intake did not decrease; protein and carbohydrate intake did not change)</p>		<p>(MVPA and strength activity did not increase)</p>	<p>WR: n= 2 (body mass and BMI did not change)</p>
Mitchell (S61)	Laska et al. (25)	In-class educational course	NC				
Ng et al. (S62)	Masselli et al. (24)	In-class educational course with activities				<p>PA behavior: n=3 (no increase in weekly minutes of LPA, MPA and VPA)</p> <p>C-PA: n=3 (perceived self-efficacy, motives and barriers toward exercise did not improve)</p>	
Pearce & Cross (S63)	Plotnikoff et al. (26)	In-class educational course with activities	<p>C-diet: n=5 (knowledge of dietary recommendations, sources of nutrients, healthy food choices, diet-disease relationships and overall score increased)</p>				
Pearman et al. (S64)	Plotnikoff et al. (26)	In-class educational course	<p>Intakes: n= 5 (energy, fat, sodium, and cholesterol intakes decreased; carbohydrate intake increased)</p>	<p>Intakes: n=4 (protein, calcium, iron, fiber did not change)</p>	<p>PA behavior: n=1 (frequency of jogging/running increased)</p>	<p>PA behavior: n=4 (frequency of doing sports; physical exercise; swimming/walking; gardening/fishing/hunting did not increase)</p>	
Schnoll & Zimmerman (S65)	Kelly et al. (22)	In-class course with different assignments (goal setting vs self-monitoring)	<p>C-diet: n=3 (knowledge, goal-setting and self-monitoring of fiber intake increased)</p>				

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Skinner (S66)	Laska et al. (25)	In-class educational course	NC						
Stice et al. (S67)	Laska et al. (25)	Group-based psycho-educational seminars with assignments							WR: n= 1 (BMI remained unchanged in contrast to control group)
<i>Total number of outcomes</i>			Total: 34 Dietary intakes: 23 C-diet: 11	Total: 19 Dietary intakes: 19 C-diet: -	Total: 12 PA behavior: 12 C-PA: -	Total: 28 PA behavior: 23 C-PA: 5		Total WR: 6	Total WR: 2
Tailored interventions									
Bowden et al. (S68)	Plotnikoff et al. (26)	Tailored diet and activity prescription			Intakes: n=1 (systemic glucose level did not reduce)				
Brinberg et al. (S69)	Laska et al. (25)	Tailored (vs general) motivational messages with feedback	NC						
Buscemi et al. (S70)	Plotnikoff et al. (26)	Tailored brief motivational consultation plus boost phone call			Intakes: n=5 (fruit, vegetables did not increase; sweets, fast-food and sugary beverages did not decrease)		PA behavior: n=2 (VPA and MPA did not increase)		WR: n=2 (BMI and body mass did not decrease)
Martens et al. (S71)	Maselli et al. (24) Plotnikoff et al. (26)	Tailored Brief Motivational Consultation				PA behavior: n=2 (weekly days and minutes of VPA increased)	PA behavior: n=2 (weekly days and minutes of MPA did not increase)		
Werch et al. (S72)	Plotnikoff et al. (26)	Tailored consultation plus contract with calendar log	Intakes: n=1 (foods with healthy fats increased)	Intakes: n=2 (FVI and foods with healthy carbohydrates did not increase)	PA behavior: n=3 (length of exercise; monthly and weekly MPA)		PA behavior: n=2 (monthly VPA and weekly strenuous activity did not increase)		
Werch et al. (S73)	Maselli et al. (24) Deliens et al. (18) Plotnikoff et al. (26) Kelly et al. (22)	Tailored brief image-based multiple-behavior intervention		Intakes: n=3 (FVI; foods with healthy carbohydrates and foods with healthy-fats did not increase)			PA behavior: n=5 (length of exercise; monthly VPA; monthly MPA; weekly strenuous PA; weekly MPA did not increase)		
Werch et al. (follow-up study) (S74)	Maselli et al. (24)	Tailored brief image-based				PA behavior: n=1 (smaller decrease in monthly MPA)			

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You et al. (S75)	Lua & Wan (23)	multiple-behavior intervention Tailored prescriptions plus supplement plus educational program			compared to control group)		WR: n=4 (body mass, BMI, body fat and WHR reduced) Total WR: 4	Total WR: 2
<i>Total number of outcomes</i>			Total: 1 Dietary intakes: 1 C-diet: -	Total: 11 Dietary intakes: 11 C-diet: -	Total: 6 PA behavior: 6 C-PA: -	Total: 11 PA behavior: 11 C-PA: -		
Peer-training interventions								
Fischer & Bryant (S76)	Plotnikoff et al. (26)	Peer training (personal training provided by certified students)				C-PA: n=5 (cognitive and behavioral process of change; decisional balance; coping, scheduling, and task self-efficacy did not improve)		
King et al. (S77)	Plotnikoff et al. (26)	Peer-training	Intakes: n=1 (FVI increased) C-diet: n= 1 (perceived FVI planning increased)	C-diet: n=1 (perceived health benefits of FVI did not increase)	C-PA: n=1 (perceived exercise barriers decreased)	PA behavior: n=1 (sedentary behavior decreased) C-PA: n=1 (perceived health benefits of exercise increased)		
Topp et al. (S78)	Deliens et al. (18)	Peer-education		Intakes: n=5 (energy, fat, sugars and salt did not decrease; fiber did not increase)				
White et al. (S79)	Lua & Wan (23)	Peer-education		Intakes: n=1 (overall healthy eating behavior did not improve) C-diet: n=2 (knowledge and attitudes of healthy eating did not improve)				
Yakusheva et al. (S80)	Plotnikoff et al. (26)	Effect of peers' (roommates) weight management behaviors on				PA behavior: n=3 (frequency of exercising; use the gym, exercise outside decreased)		WR: n=2 (body mass increased; proportion of participants trying

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Total number of outcomes			participants' weight	Total: 2 Dietary intakes: 1 C-diet: 1	Total: 9 Dietary intakes: 6 C-diet: 3	Total: 1 PA behavior: - C-PA: 1	Total: 10 PA behavior: 4 C-PA: 6	Total WR: -	to lose weight decrease) Total WR: 2
Mixed/Other face-to-face interventions									
Boyle et al. (S81)	Masselli (2018) Plotnikoff et al. (26) Laska et al. (25)	In-class educational course plus peer education					PA behavior: n=6 (total PA; energy expenditure; VO2max; flexibility; chest press repetitions; leg press repetitions did not increase)	WR: n=1 (WHR decreased only in women)	WR: n=1 (body fat did not decrease)
Bray & Born (S82)	Masselli et al. (24)	Action-planning brochure and Physical Activity Guide tailored to first year students					PA behavior: n=1 (weekly minutes of MVPA decreased)		
Brown et al. (S83)	Maselli et al. (24) Deliens et al. (18)	Interactive activities within student residence building		Intakes: n=1 (FVI did not increase)		PA behavior: n=1 (MVPA increased) C-PA: n=1 (action planning towards PA increased)	C-PA: n=1 (outcome expectations towards PA did not increase)		
Chapman et al. (S84)	Deliens et al. (18)	Intention-based intervention by pre-intervention instructions	Intakes: n=1 (FVI increased)						
Levy & Auld (S85)	Laska et al. (25) Lua & Wan (23)	Four sessions of cooking classes, and a supermarket tour	C-diet: n=3 (cooking attitudes, knowledge and behavior improved)						
Sallis et al. (S86)	Masselli et al. (24) Plotnikoff et al. (26) Laska et al. (25)	Class course plus peer-training				PA behavior: n=3 [total PA; strengthening activities; and flexibility activities increased (only for females)]	PA behavior: n=2 (VPA and MPA did not increase)		
Zhang & Cooke (S87)	Deliens et al. (18)	Motivation or/and volitional intervention including educational	Intakes: n=2 (FVI increased; fat decreased)						

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	leaflets and action and coping sheets						
<i>Total number of outcomes</i>		Total: 6 Dietary intakes: 3 C-diet: 3	Total: 1 Dietary intakes: 1 C-diet: -	Total: 5 PA behavior: 4 C-PA: 1	Total: 10 PA behavior: 9 C-PA: 1	Total WR: 1	Total WR: 1
Overall number of outcomes of all interventions		Total: 43 Dietary intakes: 28 C-diet: 15	Total: 40 Dietary intakes: 37 C-diet: 3	Total: 24 PA behavior: 22 C-PA: 2	Total: 59 PA behavior: 47 C-PA: 12	Total WR: 11	Total WR: 7

Supplementary Data

Supplemental table 4. Brief description of e-interventions targeting dietary, physical activity and weight-related outcomes in university students, reviews including them, and number of improved/not improved outcomes appear in reviews³

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Diet cognitive (n=number of outcomes)		Physical activity behavior/ PA cognitive (n=number of outcomes)		Weight-related (n=number of outcomes)	
			Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Interventions delivered through the world wide web								
Brown et al. (S88)	Plotnikoff et al. (26)	Online vegetable preparation videos and vegetable testing	Intakes: n=1 (intake of asparagus increased) C-diet: n=2 (stage of readiness to change behavior and self-efficacy for vegetable preparation increased)	Intakes: n=4 (total vegetables, onions, potatoes, and salad greens did not increase)				
Cavallo et al. (S89)	Maselli et al. (24) Plotnikoff et al. (26)	Educational website with self-monitoring tools plus online social group (Facebook) and prompting e-mail messages				PA behavior: n=4 (energy spent in total PA, moderate, heavy and light activities) C-PA: n=1 (perceived social support towards exercise did not increase)		
Clifford et al. (S90)	Deliens et al. (18) Kelly et al. (22) Laska et al. (25)	Online cooking program (4 sessions x15-min)	C-diet: n=4 (knowledge, motivation and self-efficacy for cooking increased; cooking barriers decreased)	Intakes: n=1 (FVI did not increase) C-diet: n=1 (cooking behavior did not improve)				

³C-diet: Cognitive Dietary outcomes; C-PA: Cognitive Physical Activity outcomes; FVI: Fruit and Vegetable Intake; MET: Metabolic Task Equivalent; MPA: Moderate Physical Activity; NC: information Not Clear; PA: Physical Activity; VPA: Vigorous Physical Activity; WHR: Waist-to-Hip Ratio; WR: Weight-related outcomes

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Epton et al. (S91)	Maselli et al. (24)	Website containing a profile page, theory-based messages and a planner with menus to implement goals.								PA behavior: n=1 (MVPA did not increase) C-PA: n= 7 (descriptive norm, injunctive norm, perceived control, self-efficacy, intention, plan, and attitude toward PA did not improve)
Franko et al. (S92)	Maselli et al. (24) Deliens et al. (18) Kelly et al. (22) Lua & Wan (23)	Online educational program with text-based and audio information, interactive activities, feedback and goal setting	Intakes: n=1 (FVI increased) C-diet: n=2 (perceived social support and self-efficacy for FVI increased)	Intakes: n=1 (fat intake did not decrease)	C-PA: n=2 (perceived barriers towards PA decreased; perceived beliefs on PA benefits increased)					PA behavior: n=1 [MVPA (MET min/week) did not increase]
Gow et al. (S93)	Plotnikoff et al. (26) Lua & Wan (23) Laska et al. (25)	Online educational program with behavior checklists and tailored feedback plus email messages		Intakes: n=3 (FVI and fibre intake did not increase; fat intake did not decrease)						PA behavior: n=4 (total PA, walking, MPA and VPA in MET-min did not increase) WR: n=1 (BMI decreased) WR: n=1 (body weight did not change)
Greene et al. (S94)	Maselli et al. (24) Deliens et al. (18)	Online educational program with activities, goal setting and feedback	Intakes: n=1 (FVI increased)							PA behavior: n=1 [MVPA (MET min/week) decreased]
Grim et al. (S95)	Plotnikoff et al. (26)	Online program including skill-building, assignments and activity log								PA behavior: n=1 (frequency of VPA increased) C-PA: n=2 (self-regulation and outcome expectancy value toward PA increased) PA behavior: n=1 (frequency of MPA did not increase) C-PA: n=2 (friend social support and self-efficacy toward PA did not increase)
Harvey-Berino et al. (S96)	Plotnikoff et al. (26)	Online weight management program with behavioral skill-building plus online chats with								WR: n=1 (body weight reduced)

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Huang et al. (S97)	Plotnikoff et al. (26)	facilitators, social groups, food logs, diet and exercise prescriptions Website with stage-matched messages			C-PA: n=1 (self-efficacy toward PA increased)	PA behavior: n=1 [total PA (MET-min) did not increase] C-PA: n=3 (knowledge of fitness, benefits and barriers to activity did not improve)	
Kattelman et al. (S98)	Maselli et al. (24) Deliens et al. (18)	Online educational lessons plus email messages	Intakes: n= 2 (FVI increased; fat intake decreased)	Intakes: n=2 (sugary beverages did not decrease; whole grains did not increase)		PA behavior: n=4 (MET min/week of total PA, walking, MPA and VPA did not increase) C-PA: n=1 (stage of readiness to change did not increase)	
LaChausse (S99)	Deliens et al. (18) Plotnikoff et al. (26)	Online program including educational information, rating assessments, and tailored feedback	Intakes: n=2 (Fruit and vegetable intake both increased) C-diet: n=1 (self-efficacy for FVI increased)		PA behavior: n=1 (frequency of aerobic activity increased)	C-PA: n=2 (attitude and self-efficacy towards exercise did not increase)	WR: n=1 (BMI did not decrease)
Levitsky et al. (2 studies) (S100)	Laska et al. (25)	Email messages with tailored feedback					WR: n=1 (body weight reduced)
Magoc et al. (S101)	Maselli et al. (24) Plotnikoff et al. (26)	Online educational program with assignments, goal-setting, social support and activity logs.			PA behavior: n=2 (frequency of MPA and VPA increased)	PA behavior: n=2 [MPA and VPA (min/week) did not increase] C-PA: n=5 (perceived self-efficacy, goals, plans, expectancies, family and friends social support did not increase)	
Morris & Merrill (S102)	Kelly et al. (22)	Online program to enter dietary		Intakes: n=1			

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Okazaki et al. (S103)	Maselli et al. (24)	intake and receive tailored feedback Website with information, goal-setting, quizzes, exercises and tailored advice.		(overall eating habits did not improve)		PA behavior: n=1 (energy spent on exercise increased only for those not engaged in regular PA at baseline) C-PA: n=1 (stage of change score toward PA increased)
Parrott et al. (S104)	Maselli et al. (24) Laska et al. (25)	Positive framed - email messages			PA behavior: n=1 (frequency of MVPA increased) C-PA: n=5 (intention, affective attitude, instrumental attitude, subjective norm, and perceived behavioral control increased)	
Poddar et al. (S105)	Kelly et al. (22) Laska et al. (25) Lua & Wan (23)	Website with posted information, behavior checklists, tailored feedback plus e-mail messages	C-diet: n=2 (self-regulation and self-efficacy for dairy intake increased)	Intakes: n=1 (intake of dairy did not increase) C-diet: n=2 (outcome expectations and social support for dairy intake did not increase)		
Priebe & Spink (S106)	Maselli et al. (24)	E-mail messages with motivational information				PA behavior: n=1 (frequency of total PA did not increase)
Quintiliani et al. (S107)	Maselli et al. (24)	Web-delivered messages with tailored planning and feedback.			PA behavior: n=1 [VPA (min/week) increased]	PA behavior: n=1 [MPA (min/week) did not increase] C-PA: n=4 (no improvements in intention, self-efficacy, goal commitment and goal difficulty toward PA at follow-up)

Supplementary Data

Jackson & Howton (S112)	Laska et al. (25)	Wearing a pedometer	restaurants did not improve)	NC			
LeCheminant et al. (S113)	Maselli et al. (24) Plotnikoff et al. (26)	Wearing a pedometer plus activity log with goal-setting and e-mail reminders				PA behavior: n=6 (VO2max, treadmill time and heart rate did not improve. Steps/day, frequency of MPA and VPA did not increase) C-PA: n=1 (rating of perceived exertion did not improve)	WR: n=3 (body weight, WC and body fat did not decrease)
Ornes & Ransdell (S114)	Laska et al. (25)	Online program with goal-setting plus wearing pedometers		NC			
Rote et al. (S115)	Maselli et al. (24)	Wearing a pedometer, PA logs and goal-setting plus Facebook social group or emails with tailored feedback			PA behavior: n=1 (daily steps increased in both groups)		
Sriramatr et al. (S116)	Maselli et al. (24)	Wearing a pedometer, educational website with goal-setting, plus email messages with advice and feedback			PA behavior: n=2 (daily steps and frequency of LPA increased) C-PA: n=3 (self-efficacy, outcome expectations and self-regulation toward PA increased)	PA behavior: n=2 (frequency of MPA and VPA did not increase)	
Tully & Cupples (S117)	Plotnikoff et al. (26)	Wearing a pedometer			PA behavior: n=1 (daily steps increased)	PA behavior: n=1 (VO2max did not improve)	WR: n= 3 (body weight, BMI, WHR did not decrease)
<i>Total number of outcomes</i>			Total: 1 Dietary intakes: 1	Total: 5 Dietary intakes: 3	Total: 7 PA behavior: 4	Total: 10 PA behavior: 9	Total WR: - Total WR: 6

Supplementary Data

	C-diet: -	C-diet: 2	C-PA: 3	C-PA: 1		
Overall number of outcomes of all interventions	Total: 19	Total: 21	Total: 23	Total: 65	Total WR: 4	Total WR: 9
	Dietary intakes: 8	Dietary intakes:	PA behavior: 10	PA behavior: 33		
	C-diet: 11	16	C-PA: 13	C-PA: 32		
		C-diet: 5				

Supplementary Data

Supplemental table 5. Brief description of combined modes of interventions targeting dietary and weight-related outcomes in university students, reviews including them, and number of improved/not improved outcomes appear in reviews⁴

Study	Reviews including the study	Brief description of intervention	Dietary intakes/Diet cognitive		Weight-related outcomes (n= number of outcomes)	
			Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved	Outcomes reported by reviewer(s) as improved	Reported by reviewer(s) as not improved
Cholewa & Irwin (S118)	Laska et al. (25)	"Buddy system" (working in pairs) vs online logbook for goal-setting and tracking progress				WR: n=1 (BMI did not decrease)
Evans & Mary (S119)	Plotnikoff et al. (26) Laska et al. (25)	Group-based education plus peer-education plus POP information, website, cafeteria tours, videos	Intakes: n=2 (FVI increased; fat intake decreased)	Intakes: n=1 (fruit juice consumption increased)		
Mailey et al. (S120)	<u>Maselli et al. (24)</u>	Accelerometer with tailored feedback, website, tailored feedback plus attendance of meeting with counsellors.		<i>The study targeted physical activity outcomes. Results were excluded from the table because the sample included only students with mental health disorders.</i>		
Musgrave & Thornbury (S121)	Plotnikoff et al. (26)	Caloric modification of regular menus in the canteen plus instruction and encouragement in weekly group meetings				NC
Richards et al. (S122)	Deliens et al. (18) Kelly et al. (22) Laska et al. (25)	Tailored newsletters, motivational interview, tailored e-mail messages plus educational website	Intakes: n=1 (FVI increased) C-diet: n=1 (self-efficacy for FVI increased)	C-diet: n=1 (perceived pros and cons for FVI did not improve)		
Overall number of outcomes			Total: 4 Dietary Intakes: 3 C-diet: 1	Total: 2 Dietary intakes: 1 C-diet: 1		WR: 1

⁴C-diet: Cognitive Dietary outcomes; FVI: Fruit and Vegetable Intake; NC: information Not Clear; WR: Weight-related outcomes

Supplementary Data

Supplemental References (reported as SR in tables, where R is the citation number)

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