Literature Review

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Promoting Physical Activity Among University Students: A Systematic Review of Controlled Trials

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Abstract

Objective: University study is often accompanied by a decline in physical activity (PA) levels but can offer the opportunity to promote a lifelong active lifestyle. This review aims to summarize controlled trials of interventions promoting PA among university students, describing the quality of the evidence, effective strategies, and deficiencies in the interventions employed, to provide directions for future research and for practical implementations.

Data Source: PubMed, PsychINFO, Cochrane Library, Education Source, and SPORTDiscus.

Study Inclusion Criteria: Randomized or nonrandomized controlled trial, describing an intervention to promote PA in university students, where PA was one of the outcomes and results were published in English.

Data Extraction: Country, study design, participants' inclusion criteria, participation rate and characteristics, randomization, blinding, theoretical framework, intervention characteristics, participant retention rate and withdrawal reasons, measures employed, data analysis, PA results, and findings regarding PA correlates.

Data Synthesis: Data were synthetized considering study characteristics, strategies used, and outcomes.

Results: Two thousand five hundred eighty-five articles were identified. Twenty-seven studies met the inclusion criteria. Sixteen studies reported an increase in PA levels.

Conclusion: Physical Activity promotion interventions should address a range of behavioral determinants. Personalized approaches and PA sessions should be considered in future studies. The high risk of bias of many studies (mainly due to attrition and poor reporting) and missing information about intervention components limit the strength of conclusions about the most effective strategies and the evidence of effectiveness, highlighting the need for further high-quality studies.

Keywords

physical activity, university, college, health promotion, health education

Introduction

Regular physical activity (PA) has been recognized as fundamental to the prevention of many chronic diseases and to the improvement and maintenance of both physical and psychological functioning.[1,2] Nevertheless, it is estimated that the 31% of adults worldwide are physically inactive (a proportion that can reach more than 50% in some countries), leading to increased risk for the development of noncommunicable diseases and reduced life expectancy.[3,4] The promotion of PA and the reduction in sedentary behavior has become one of the key priorities for international health agencies.[5]

Despite the fact that health-related physical education (focused on establishing lifelong active lifestyles) is part of most educational systems,[6] and many school-based interventions on PA have been found to be effective in the transition from secondary school to university, there is a significant decline in PA levels.[7-10] Therefore, promoting PA in university students is a priority that also provides an opportunity to help people establish lifelong active habits. University students are at a stage in life where they begin to take autonomous decision about their future, and this can include adopting an active lifestyle.[11] In addition, universities may allocate resources to PA

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promotion, expanding the reach of a potential intervention strategy. A recent systematic review and meta-analysis reviewed interventions targeting PA, nutrition, and healthy weight in university students, including 11 interventions targeting PA. This review focused primarily on the outcomes of the interventions, with less focus on strategies employed in delivering the interventions.[12]

The aim of the present study was to conduct a systematic review of interventions designed to promote PA among university students, assessing the quality of the evidence, identifying, and discussing effective strategies, methodologies, and deficiencies in the interventions employed. This should provide directions for future research and deployment of effective PA promotion strategies in tertiary education settings.

Methods

The review protocol was registered with PROSPERO register of systematic review (CRD42016036781).

Data Sources

We conducted a search of the literature using online bibliographic databases (PubMed, PsychINFO, Cochrane Library, Education Source, and SPORTDiscus) up to and including March 2016. A search update was undertaken up to and including November 2016. The search strategy included terms referring to 3 main concepts: PA (eg, "physical activity"), population (eg, "university"), and type of intervention (eg, "promotion" and "education"). We used filters provided by databases (eg, MeSH in PubMed) to narrow the search (eg, controlled trials). The complete search strategy is available on request to the corresponding author. After the elimination of duplicates, 2 independent reviewers conducted an initial selection of the articles to include in the review.

Inclusion and Exclusion Criteria

Inclusion criteria were randomized controlled trial (RCT) or non-RCT (NRCT), describing an intervention to promote PA in university students, PA was one of the outcomes reported as a quantitative measure, and results published in English. We included only RCTs and NRCTs, as they represent the strongest evidence of generalizable effectiveness.[13] We excluded uncontrolled studies because of the high risk of confounding factors to impact results in the absence of a control group.

Data Extraction

Data extraction included country, study design, participant inclusion criteria and rate of participation, randomization procedure, sample characteristics, blinding of outcome assessors, baseline conditions, theoretical framework informing the intervention, intervention characteristics and duration, participant retention and follow-up, dropout/withdrawal reasons, measurement instruments, data analysis procedure, PA results, and results about dimensions related to PA. The follow-up period was defined as the period between the cessation of any treatment and outcome assessment. We did not consider outcome assessments undertaken during the intervention period. The percentage of participants lost to follow-up was defined as the portion of those participants randomized or assigned to experimental conditions who dropped out, did not provide data, or excluded from the study by researchers. Data extraction was carried out by 2 reviewers. Disagreements were resolved by discussion.

Risk of Bias Assessment

Assessment of the risk of bias of the studies was made using the domains described in the Cochrane Collaboration tool for assessing risk of bias[14]: selection bias, performance bias, attrition bias, detection bias, and reporting bias. Since the tool was designed to assess risk of bias in RCTs, for NRCTS we used the criteria proposed in the Methods Guide for Effectiveness and Comparative Effectiveness Reviews (Supplementary Table 1).[15] It can be difficult to blind participants and study personnel; therefore, participant and personnel blinding was not considered in evaluating performance bias.[13,16] Blinding of outcome assessors was still taken into account in evaluating detection bias. Each domain was rated either at "high risk" or at "low risk" of bias based on whether bias was likely to have had a notable impact on the results of the trial. "Unclear risk" rating was used when insufficient information was reported.[14] A summary assessment of the risk of bias for each study was conducted following the guidelines provided by the Cochrane Handbook for Systematic Reviews of Interventions.[14] To rate attrition bias, in relation to an equal attrition between the groups, "high risk" was defined as those studies with an attrition rate higher than 20%, following the threshold for strong quality rating proposed in the quality assessment tool for quantitative studies.[17] Risk of bias was assessed by 2 reviewers independently. In case of disagreements, agreement was reached by discussion. Risk of bias was used to interpret the results of the review and in the narrative discussion of the results.

Data Synthesis

Strength of the evidence was rated taking into account the risk of bias of the studies, the number of the studies, the outcomes, and the consistency observed in the body of evidence. Data were synthetized in relation to study characteristics, the strategies used in the interventions, and the outcomes.

Results

We identified 2567 articles from online databases. We added 17 articles as a result of a previous pilot search, while 1 article was identified by citation in an article identified in the search that reported short-term outcomes of that study. Two thousand four hundred twenty articles remained after removing

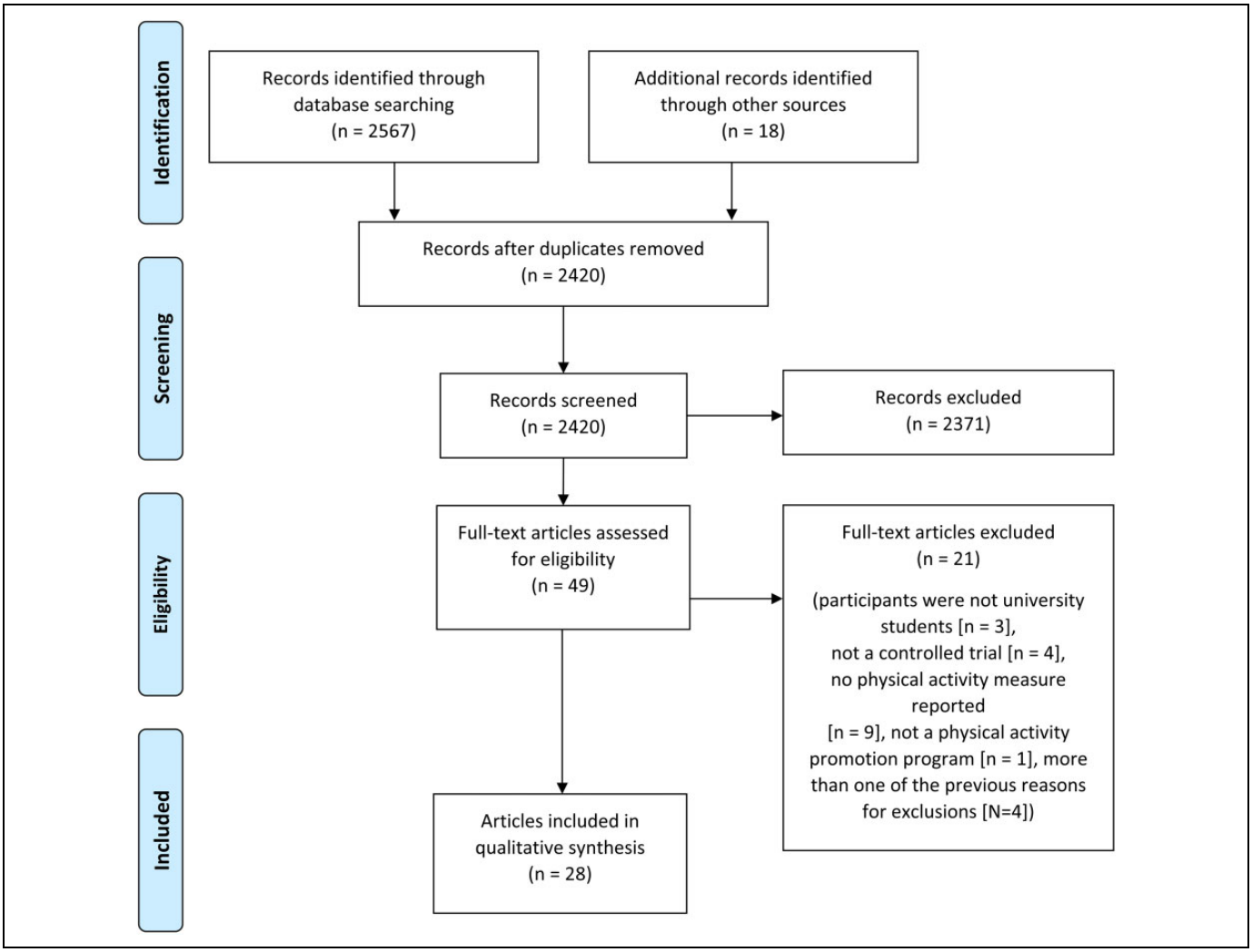

Figure 1. Search and screening process flow diagram.

duplicates, and abstracts were screened. After screening, we retrieved the full text of 49 articles that were assessed for eligibility. Twenty-eight articles, representing 27 studies, met the inclusion criteria and were included in the review. Figure 1 reports the flow diagram for articles included in the review. Supplementary Table 2 displays the characteristics and results of the included studies. Supplementary Table 3 reports the levels of statistical significance for differences between the intervention and the control group, and the standardized mean differences between the changes in intervention groups and the changes in the control groups, calculated using the equation suggested by Morris.[18]

We considered 2 articles by Werch et al[19,20] as a single study, since they reported the 3-month and 12-month follow-up outcomes of the same cohort. The article by Hall and Fong[21] reported 2 studies; for the purpose of the review, only the second will be considered, since the initial study served as a pilot study. Priebe and Spink[22] reported 2 studies; we included only the second one, since the first was not conducted with university students.

Risk of Bias Assessment

Three studies were rated as at low risk of bias,[23-25] 17 as at high risk of bias,[21,22,26-40] and 7 as at unclear risk of bias.[19,20,41-46] Selection bias included elective participant allocation (2 studies[26,28]), poor/missing reporting of randomization procedures (13 studies[19-22,27,29-31,33,34,36,40,42,45]), unequal and uncontrolled baseline groups conditions (4 studies[28,30,36,43]), different or unclear recruiting/allocation strategies across groups (2 studies[35,36]), and lack of allocation blinding (1 study[44]). Performance bias included lack of control for intervention fidelity (1 study[28]), influence on control group behavior (1 study[33]), and differences in monetary rewards between the groups (2 studies[33,39]). Attrition bias included significant difference in attrition between groups (1 study[29]), high attrition rates (average percentage of participants lost to follow-up of 39.7%) not handled with intention-to-treat analyses (11 studies[21,22,27,28,30-32,35,37,40,41]), participant dropout reasons, or rate not specified (3 studies[28,32,35] and 1 study[26], respectively). Detection bias comprised use of imprecise PA

measures (9 studies[22,30,33-35,39,43,44,46]), improper scoring of questionnaires (4 studies[27,34,44,46]), missing of outcome assessors blinding (2 studies[21,45]), and measuring PA only in part of the sample or in different subsets of the sample between time points (4 studies[21,37,38,43]). Reporting bias included selective reporting (4 studies[21,30,34,36]) and not reporting PA data or statistical analysis results (6 studies[22,33,34,43-45]). Supplementary Table 4 reports risk of bias assessment, with reasons for the ratings.

Country

Nineteen studies were conducted in the United States,[19-23,25,26,29-34,37,38,40,42-45] 3 in Canada,[27,27,28] 2 in the United Kingdom,[41,46] 1 in Hong Kong,[35] 1 in Japan,[36] and 1 in Thailand.[39]

Study Design

Twenty-four studies were RCTs,[21-25,27,29-34,36-46] while 3 were NRCTs.[26,28,35] Sixteen studies assessed the outcome of the interventions at the end of the intervention period,[22,24-26,28-30,32-36,38,40,42,45] while 5 reported post follow-up measures.[21,23,31,39,44] Five studies described brief single-session interventions,[19,20,37,41,43,46] and 1 intervention only comprised print material;[27] as such, these studies only obtained measures after a follow-up period.

Theoretical Framework Informing the Interventions

Twelve studies used Bandura's Social–Cognitive Theory to inform the intervention,[23,26-28,31,34-36,39,40,42,45] 4 used the Transtheoretical Model of behavior change,[31,32,37,45] 3 used the Theory of Planned Behavior,[41,44,46] 2 used Dick and Carey's Model of Instructional Design,[31,32] 1 used Keller's Instructional Motivational Model,[31] 1 used Time Perspective Theory,[21] 1 used Prospect Theory,[25] 1 used the Health Belief Model,[36] 1 used the Theory of Normative Conduct,[22] 1 used the Elaboration Likelihood Model,[37] 1 used Self-Affirmation Theory,[41] and 1 used the Behavior-Image Model.[19,20] Two studies focused on the role of social support.[29,38] Six studies used more than one theory to inform the intervention design,[31,32,36,37,41,45] while 3 did not specify a theoretical framework.[24,30,33]

Seventeen studies evaluated changes in psychological or behavioral constructs targeted by the interventions, which could mediate engagement in PA. These comprised self-efficacy, perceived behavioral control, outcome expectations, perceived social support, intention, self-regulation, perceived barriers, subjective norms, instrumental attitude, long-term thinking, and stage of change. Six studies reported no significant changes in PA levels and in psychological/behavioral constructs.[29,32,35,40,41,46] In 5 studies, effects obtained for PA were not accompanied by changes in the measured mediators.[21,27,34,37,42] In 1 study, the changes in the measured PA mediators did not impact PA.[23] In 2 studies, there was congruence between the changes in all the psychological/behavioral constructs measured and improvements in PA,[39,45] while in 3 studies there was only partial congruence.[28,36,44]

Characteristics of the Interventions

Nineteen studies specifically targeted PA,[21,22,25-27,29,30,33-36,38-40,42-46] while 8 studies targeted multiple behaviors.[19,20,23,24,28,31,32,37,41] Eleven studies reported Web-based interventions,[22,23,29,31,32,34,36,37,40,41,42] while 5 interventions were partially delivered online.[26,33,38,39,42] Twelve interventions required participants to attend in person for group or individual activities.[19-21,24-26,28,30,33,42,43,45] Six interventions were course based.[21,26,30,35,36,45] Three studies included practical physical activities.[28,35,45] Interventions included educational components as well as cognitive and behavioral strategies to promote behavioral change. The most commonly used method to promote PA was providing information about benefits of PA and risks of sedentary lifestyle to raise consciousness and increase expectancies about PA (20 studies[19-25,27,28,31-36,39-42,44,45]). Twelve studies provided information about the effects of different types of exercise and how to perform them.[23,24,26,28,31,32,34-36,39,40,45] Ten provided information about PA recommendations, and[19,20,27,28,31-33,37,39,43,45] 11 provided suggestions to start engaging in PA, maintain it in daily routine, and prevent relapses.[23,24,27,31-33,40-43,45] Many interventions provided participants with self-regulatory techniques, including goal-setting (17 studies[19-21,23,24,26,28,29,31,32,34-36,39,40,42,43,45]), planning (14 studies[19,20,26-28,31,34,36,37,41,42,45,46]), self-monitoring (11 studies[24,28-31,33,34,36,39,40,42]), identifying barriers to PA and coping strategies (eight studies[28,34,35,37,40,42,43,46]), enlisting social support (8 studies[28,29,34,35,38,40,42,45]), time management (4 studies[28,35,40,45]), decisional balance (3 studies[21,43,45]), and self-rewarding (2 studies[28,34]). In 5 interventions, participants were required to keep PA logs.[30,34,36,39,42] Other strategies were providing feedback on reported PA (8 studies[23,26,31,36,37,39,42,43]), providing models of active lifestyles (7 studies[22,24,26,27,35,37,39]), prompting reflection on emotions/perceptions associated with PA (eg, enjoyment; 5 studies[31,32,34,35,45]), and verbal persuasion (4 studies[26,35,39,42]). Seven studies provided participants with the support of an expert, a tutor, or a PA counselor, for individual PA counseling/tutoring,[19,20,26,42,43] to lead group lessons, workshops, or practical activities,[28,45] or to answer to participants' questions online.[40] Most of the interventions included standardized components for all participants. Only 4 studies described fully or partially individually tailored interventions.[19,20,26,42,43] Three studies included some components tailored to the stage of change (Transtheoretical Model of behavior change) of each participant.[32,37,45]

Effectiveness of the Interventions

Seventeen studies compared an intervention to a no-treatment condition or to minimal PA intervention.[19,20,23,24,27,28,31-36,39,40,42,43,45] Ten of these studies reported effects on PA. Bray et al[27] provided freshmen students with a brochure containing

information about PA benefits, recommendations, training, planning, and strategies to include PA in daily routine. The intervention group reported a smaller reduction in moderate and vigorous PA (MVPA) from the preuniversity period to the first semester than control group. Brown et al[28] described a 20-week residence-based intervention comprising seminars (dealing with PA benefits, recommendations, planning, and strategies for an active lifestyle), practical physical activities, and workshops with a counselor. The intervention had a significant effect, in comparison to controls, on MVPA. Four interventions[31,34,36,39] provided information to participants via Web sites and e-mails. Common topics were PA benefits, types of exercises/training, and goal setting. Other topics were PA reccommendations,[31,34,39] self-efficacy,[34,39] role models,[31,39] PA logs,[31,34] planning, and self-monitoring.[34,36] In Greene et al,[31] enjoyment and safety were also addressed. In this study, the intervention group showed a smaller decline in MVPA compared to the control group. Magoc et al[34] also dealt with barriers and social support and gave participants weekly assignments. Results of this study were ambiguous. The intervention group showed an increase in both days/week of moderate PA (MPA) and in days/week of vigorous PA (VPA). However, there were no significant changes in minutes/week of MPA and VPA. The Web site used in Okazaki et al[36] also provided students with interactive quizzes and energy expenditure calculations. At posttest, an effect on PA was observed only among those participants who at baseline did not engage in university sports. The intervention described in Sriramatr et al[39] also included use of a pedometer. At posttest, the intervention group reported more steps/day and self-reported PA than control group.

Mailey et al[42] used a blended approach, including a Web site and bimonthly counseling meetings. Topics addressed were PA benefits, exercise safety, self-monitoring, self-efficacy, outcome expectations, goal setting, overcoming barriers to PA, and suggestions for maintaining PA. Participants also wore a pedometer and received feedback. The intervention group showed a greater increase in PA compared to the control group, considered statistically significant by the authors, although not reaching the usual cut off for statistical significance ($P = .08$). Martens et al[43] undertook an intervention consisting of a one-on-one motivational interviewing session, including discussion on the decisional balance, personalized feedback, barriers to PA, goal setting, and tips for increasing PA. After 1 month, intervention group participants reported more days/week of 20+ minutes and minutes/week of VPA than controls. Sallis et al[45] evaluated a 14-week university course comprising lectures and laboratories. Lectures dealt with PA benefits, recommendations, injuries, scheduling, goal setting, social support, self-talk, and exercise. Some topics were stage tailored. Participants received a reference book. Laboratories taught different types of exercise, and self-management techniques. Two types of laboratories (adoption or maintenance of PA) were available according to participants' stage of change. The intervention had significant effects on female participants as regards minutes/week of strength and flexibility exercise. "Active" females increased their weekly energy expenditure, contrary to those in the control group. Werch et al[19,20] delivered a single one-on-one consultation to participants, providing tailored content addressing health behaviors, in relation to salient image achievement. Participants were provided with a goal plan and recommendations reflecting participant's aspirations. After 3 months, intervention group participants increased 30-day MPA, contrary to control group. At 12 months, the intervention group reported a smaller decrease in 30-day MPA than the control group.

Ten studies evaluated the effect of a specific intervention component[21,22,25,26,29,37,38,44,46]; therefore, only the targeted intervention components were considered in this review. Three of these studies[37,44,46] also had a no-treatment control group, allowing the evaluation of the efficacy of the intervention compared to the control group. In this group of studies, 7 reported significant effects on PA. Three studies[21,26,30] investigated the effect of an additional intervention for students enrolled in health courses promoting PA. Boyle et al[26] evaluated the effect of individual peer-tutoring aimed at building outcome expectations and self-efficacy. After 1 semester, an effect on PA levels, in comparison to control, was observed only among participants who were inactive at baseline and for females. Hall and Fong[21] showed that helping students focus on PA benefits and implementing goal setting has greater effect than only attending a health course, but they found no differences in focusing on short-term rather than on long-term benefits of PA. Claxton and Wells[30] obtained small and equivocal results when investigating the effect of PA logs as homework. The PA logs led to increased weight-managing exercises only, whereas students attending the course without completing logs increased flexibility exercises. Kozak et al[25] studied the effect of gain versus loss-framed messages among normal-weight and overweight students. Gain-framed messages improved exercise behavior among overweight students, while results were mixed for normal-weight students. Similarly, Parrot et al[44] evaluated the effect of positive versus negative-framed messages about PA and found efficacy only for positive-framed messages in increasing PA after a 2-week intervention. In the study by Quintiliani et al,[37] 2 experimental groups received the same intervention. Participants in one group received the intervention by their own choice and showed no significant improvements, while the participants of the other group received the intervention because prior screening revealed they did not meet PA recommendations; they increased their PA levels in comparison to controls. Therefore, the results do not clearly indicate that the intervention was effective. Two studies[29,38] investigated the role of social support via social network in Web-based interventions, reporting contrasting findings.

Sustainability of the Results Over Time

Ten studies evaluated the effect of the intervention after a follow-up period, ranging between 1 week and 12 months.[19-21,23,27,31,37,39,40,43,44,46] Of these, 7 reported sustained intervention effects on PA.[19,20,27,31,37,39,43,44] Among

the studies reporting intervention effect at the follow-up, 4 studies had a follow-up lasting from 1 to 6 weeks,[27,37,43,44] while 3 had follow-up periods lasting from 3 to 12 months.[19,20,34,39]

Discussion

The aim of the present article was to review existing RCTs and NRCTs of intervention to promote PA among university students, identifying effective strategies and limitations, to provide directions for research and practical implementations of interventions.

Among the 20 studies that evaluated an intervention in its entirety, 12 reported statistically significant effects on participant PA levels. As shown by results, different typologies of intervention are present. In order to give directions for the implementations of future PA promotion programs, we analyzed effective interventions to identify common elements that could constitute a framework for intervention planning. The majority of the effective interventions (except for 1 study[44]) were multicomponent, addressing different features of human behavior and agency: the motives of an action (e.g. desired outcomes), the knowledge of the link between the desired outcome and the actions needed to achieve it (outcome expectations), the perceived or actual ability/skills to perform intended actions and to achieve intended results through them, and techniques people use to self-regulate their own behavior.[47] The results of the reviewed studies suggest that addressing all of these dimensions helped PA promotion.

Motives to engage in PA were provided informing participants about the benefits of an active lifestyle and the risks of a sedentary life, in order to help them understand the importance of being physically active. Two studies[25,44] suggested that information about benefits of PA could have greater effects on university students when positively framed. Outcome expectations were addressed informing participants about the recommended levels of PA necessary to maintain/improve health, and the specific effects of different types of exercises (eg, endurance, aerobic, and flexibility exercise). As regards skills to perform PA, the majority of the intervention merely provided students with information, with few cases of practical PA learning experiences.[28,45] Suggestions were given to students about how to adopt and maintain PA, opportunities to being physically active, and how to overcome barriers to PA as well as information on how to perform different types of exercises and how to schedule PA. Self-regulation techniques mainly comprised setting goals, making a PA plan to achieve them, and monitoring one's PA to verify goal attainment. Self-monitoring comprised both being aware of the quality and quantity of PA performed (eg, heart-rate monitoring) and regularly keeping track of PA (eg, with a PA log).

However, the overall evidence of effectiveness is limited, mainly due to the numerous bias violations. Seven of these effective studies are at high risk of bias, and the other 5 have unclear risk of bias. Moreover, some of these studies reported ambiguous outcomes [31,34,37] or limited effectiveness in a subset of the total sample.[36,45] In addition, the 2 studies at low risk of bias that evaluated the effect of a whole intervention against a control group reported no significant intervention effects.[23,24] Similarly, evidence for sustainability of PA outcomes over time is limited, considering the duration of the follow-up periods, and the risk of bias of the studies reporting intervention effects at follow-up (4 were at high risk of bias,[27,31,39,44] while in the other 3 studies the risk of bias is unclear[19,20,37,43]).

Risk of Bias

The high risk of bias in the majority (63%) of the included studies limits the potential to draw strong conclusions about evidence of effectiveness. Source of bias is present in study protocols (eg, recruitment/allocation strategies, rewards for participants, measurement instruments chosen), during the study execution (eg, participants dropout), and in the research reporting (eg, randomization not described and selective reporting). Future studies should improve all these elements of research quality. For example, participant dropout should be minimized by implementing strategies to increase the retention of participants (eg, motivating participants' learning and interest), and using intention-to-treat analysis in order to account for missing data. The PA measures employed in some studies were imprecise or improperly used. A questionnaire asking for how many days in a week a person has engaged in at least 15 minutes of PA, even if validated, would be unable to discriminate between a 15-minute long PA session and a 30-minute long (or longer) PA session, assigning an identical PA score to participants engaging in different amounts of PA. As an example, the ambiguity of the results in 1 study[34] may reflect inappropriate continuous scoring of the questionnaire used to measure PA (the International Physical Activity Questionnaire) that was designed to be scored as MET $\times$ minutes/week of PA (and not as days/week). Moreover, the authors did not specify what criterion was used to define a valid day of PA (eg, minimum amount of minutes/day).

Country

The majority (70%) of the studies were conducted in the United States. Considering that physical inactivity is a major global public health concern,[2] programs to improve PA levels in university students should be developed and evaluated in countries with different university systems, for example, in terms of courses/classes organization, university life routines, or as regards facilities and resources available to students. As an example, course-based interventions would not be feasible in countries where the university system does not provide the opportunity to select elective courses that are outside the scope of the normal curriculum.

Use of Theory

In the studies that described using 1 or more theory or model to inform the intervention, the link between the theory and the intervention components is apparent. However, the results of the majority of studies that measured constructs linked to the theory often showed no congruence between changes in PA mediators and PA levels, suggesting that the theoretical constructs were

unable to explain the changes in PA, and, in other cases, the interventions failed to impact the targeted PA mediators. This could reflect the fact that the majority of interventions were standardized, using a top-down approach, and did not assess the needs of participants before implementing the intervention strategy. For example, targeting mainly self-efficacy in a group of people for whom lack of PA-related self-efficacy was not the reason for physical inactivity is likely to result in little change in PA levels. Future studies should investigate the individual needs of participants in order to identify the PA mediators that most need to be targeted by the PA promotion intervention. It is interesting to note that the interventions based on Bandura's Social Cognitive Theory (the most used theory overall, and among effective studies) focused on outcome expectations, self-efficacy, and self-regulation techniques but neglected the importance that the theory attributes to self-reflectiveness about personal values and life pursuit meaning.[47] The mere knowledge of the effects of PA does not necessarily imply that these effects have become valued and meaningful for a person. This should be the subject of future investigation.

Strategies and Behavior Change Techniques Used in the Interventions

Although we identified some strategies common to effective interventions, it is unclear which of the specific intervention components, or their combinations, were the most effective in promoting PA. Besides the high risk of bias of the studies that described effective interventions, 4 additional factors make it difficult to define the characteristics that differed between effective and ineffective interventions. First, most of the components used in the interventions were common to both effective and ineffective interventions, and both effective and ineffective interventions shared similar combinations of behavior change techniques. Second, the same techniques were implemented in different ways in different studies. As an example, self-regulation strategies in some studies were just presented to participants through written text or lectures, while in other studies these strategies were taught through laboratories, interactive activities, or seminars; in other studies, participants were provided with online interactive tools for goal setting and self-monitoring; finally, in some studies, participants were directly assisted by an expert in implementing such strategies. The way a behavior change technique is implemented can have a considerable impact on its effectiveness and on the volitional/motivational dimensions related to the learning process.[48] Third, the majority of the studies do not specify the content of the information (eg, about benefits of PA, suggestions to adopt and maintain PA) provided to participants. Therefore, we cannot assume that specific intervention components had the same value in different studies because they may have differed in content and in the pedagogical approach used. For these reasons, a quantitative analysis and synthesis (eg, meta-regression) of PA outcomes would not be informative. Also, missing data in many studies hindered the possibility of a quantitative analysis (see Supplementary Table 3). Fourth, the lack of qualitative data does not allow a proper process evaluation. Only 1 study[35] included qualitative data, referring only to 3% of the participants. Qualitative data can bring useful insights about how the interventions were delivered and about the experience of the participants during the intervention, including which of the behavior change techniques used have been found most helpful/meaningful by participants and are key to improving knowledge about health-promoting interventions.[13,49] Future studies should use mixed methods to provide information that can be used in the improvement of existing PA promotion interventions and in the development of new interventions.

From a social–ecological perspective, all the included studies, except for Brown et al,[28] described interventions targeting individual and interpersonal levels, without considering environmental components. The absence of environmental strategies probably reflects that controlled trials were the focus of this review; environmental changes (eg, policies, facilities, and accessibility) would also affect the control group participants, resulting in contamination bias.

The use of the Internet was common to many studies as an easy and relatively inexpensive way to deliver information, communicate with participants, and provide online support (eg, online utilities for goal setting, planning, and keep track of one's PA). However, among the 11 solely Web-based interventions, only 5 had effects on PA.[31,34,36,37,44] Considering the risk of bias of these studies, and the ambiguity of the results in 2 studies,[34,37] as previously discussed, solely Web-based intervention seems to be ineffective in promoting PA among universities students, and therefore in-person or blended interventions seem preferable. This is consistent with the findings of previous reviews of literature and meta-analyses that outlined how face-to-face lifestyle modification interventions have greater effects than Web-based interventions.[50-53] Moreover, some of the solely Web-based interventions[29,31,32,40,41,46] reported that many participants did not actually engage with the intervention components, suggesting that online-focused interventions with university students risk low adherence. These results could reflect the fact that university students seem to prefer face-to-face learning when it concerns the acquisition of skills or learning to apply knowledge to solve problems and that cognitive and emotional engagement is higher for university students attending face-to-face courses than for those enrolled in Web-based courses.[54,55]

Although individual tailoring is an important component in interventions for the promotion of PA,[56-58] only 4 studies included in this review used a totally[9,20,43] or partially[26,42] individually tailored intervention. All of these interventions were effective in promoting PA (with some limitations[26,42]). Individual tailoring takes into account participant's personal characteristics, past experiences, needs, aspirations, expectations, goals, and barriers toward PA. Considering the importance of tailoring in health behavior change programs, the positive results of these studies, but also the limitations due to the risk of bias, and the small number of studies available, individual tailoring requires further consideration in future research.

Involving participants in practical PA sessions was an underused strategy. Promoting PA differs from other types of health

behavior change interventions, as it concerns helping people to adopt a healthy behavior rather than abstaining from a harmful one (eg, smoking and excessive alcohol consumption). Therefore, it is important to teach people how to perform the desired behavior, in this case PA and exercise. Educational, instructional, and experiential practical PA sessions are fundamental to the process of learning how to exercise, as they allow the learner to practice and learn from observation and experience, guided by an expert. The PA sessions can also be important in supporting other behavioral change techniques. As an example, during exercise sessions, some barriers to PA (eg, unpleasant physiological responses to exercise, insufficient level of ability in performing a particular exercise) may become evident which otherwise may have not been detected. During exercise sessions, these barriers can be overcome with the help of an expert. Twelve interventions in this review provided participants with information about exercise types and training methods, but only 3 of these included practical PA sessions.[28,35,45] The PA research that ignores practice can often lead to misleading outcomes. As an example from a clinical setting, an RCT reported by Chalder et al[59] concluded that facilitated PA was ineffective in reducing depressive symptoms, whereas a recent meta-analysis found strong evidence for the effectiveness of PA in reducing depressive symptoms.[60] The ineffectiveness of the intervention implemented by Chalder and colleagues may have arisen due to the use of telephone counseling, without any practical PA sessions. In light of these considerations, future studies should integrate theoretical/knowledge-based components of interventions with guided exercise sessions.

Limitations

The present systematic review was conducted following the PRISMA checklist[61] in order to guarantee accuracy in the reporting of the review protocol. However, there are some limitations. First, although we extended the search to 5 different databases, using broad search terms, it is possible that some studies were not retrieved because they were not listed or lacked one of the search terms. Second, only articles written in English were included, which could have limited the geographical regions where the majority of the studies were conducted.

Conclusions

The present systematic review examined controlled trials that tested the efficacy of PA promotion interventions in university students. Some examples of effective interventions were found, and these suggested that it is important to address the motives for adopting an active lifestyle, outcome expectations, skills necessary to perform PA, and behavioral self-regulation. However, the overall level of evidence regarding both the immediate and the longer term effects of the interventions is limited. This is due in first place to the risk of bias of the studies and to the short follow-up periods in majority of the studies reviewed. In addition, due to the lack of detailed information about the content of some components of the interventions, overlapping of the behavior change techniques used (in both effective and not-effective interventions), and their different implementation in different studies, it was not possible to determine which intervention components were the most effective in promoting PA or what distinguished effective and ineffective interventions. Similarly, the results were sometimes conflicting, since very similar interventions led to significant improvements or to no changes in PA. Solely Web-based interventions resulted in minimal effects on PA with low adherence and participant engagement. Individually tailored/personalized interventions and the use of practical PA sessions, despite of their importance, were strategies that were infrequently employed and should be a focus of further investigation in future studies.

This review revealed some gaps in the existing literature, and the need for further research in this field. Higher quality studies are needed in order to reduce the risk of bias. More studies with longer follow-up periods are necessary to verify the sustainability of the changes in PA behavior. Better reporting of strategies used, with more details about the contents and the methodology, is necessary for a better understanding of the interventions. The integration of quantitative outcomes with a qualitative evaluation of the process will enhance understanding of key factors that need to be considered in implementation. Assessing individual needs and characteristics of the participants, using a bottom-up approach, could allow a better use of theory, resulting in increased efficacy of the intervention.

SO WHAT?

The present study offers an overview of interventions to promote physical activity (PA) among university students, revealing some limitations but also offering suggestions for future studies, that can also be useful to PA promotion in different types of populations and settings.

The reviewed effective studies suggested that PA promotion interventions should target motives to engage in regular PA, outcome expectations, skills necessary to perform PA, and self-regulatory techniques. However, the level of evidence regarding the immediate and the long-term effects of interventions to promote PA among university students is limited, mainly due to the high risk of bias of many studies. More high-quality studies, with longer follow-up period, are needed to increase the quality of the overall body of evidence. Future studies should report detailed information about how the intervention components were implemented, and qualitative data from participants were collected to facilitate the understanding and the identification of the most efficient components.

Solely Web-based interventions risk results in low engagement rate and in having minimal effect on PA. Personalized approaches, based on participants' needs and characteristics, and the use of practical PA sessions should be a focus of further investigation in future studies.

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Supplementary Material

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