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Review article

School-Based Physical Activity Interventions in Prevocational Adolescents: A Systematic Review and Meta-Analyses

Joannis H. van de Kop, M.Sc. [a,*], Willem G. van Kernebeek, M.Sc. [a], Rene H. J. Otten, M.Sc. [b], Huub M. Toussaint, Ph.D. [a], and Arnoud P. Verhoeff, Prof [c]

[a] *Faculty of Sports and Nutrition, Amsterdam University of Applied Sciences, Amsterdam, The Netherlands*
[b] *Vrije Universteit Amsterdam, Medical Library, Amsterdam, The Netherlands*
[c] *Faculty of Social and Behavioural Sciences, University of Amsterdam, Amsterdam, The Netherlands*

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A B S T R A C T

Purpose: Literature detailing the effectiveness of school-based physical activity promotion interventions in prevocational adolescents was reviewed to identify effective intervention characteristics.
Methods: The search strategy assessed studies against inclusion criteria study design, study population, school setting, language, and construct. The risk of bias of the included studies was assessed, and extractions were made of the physical activity (PA) level outcome measures and intervention characteristics regarding organizational, social, and content features. A meta-analysis was conducted to determine the overall effect of the interventions on the PA level. Identification of effective intervention characteristics was done by subgroup analyses. Meta-regression analysis was performed with PA level as dependent variable and intervention characteristics as covariates.
Results: A total of 40 eligible studies was included for meta-analyses. Among the included studies, the overall intervention effect on increasing the PA level of prevocational adolescents was weak (standardized mean difference [SMD] .19, 95% confidence interval [CI] .12–.27). Intervention characteristics that improve the effect size to a moderate level were intracurricular PA (SMD .43, 95% CI .19–.68), involving school staff in an intracurricular intervention (SMD .37, 95% CI .16–.58) and a tailored intracurricular intervention (SMD .35, 95% CI .13–.58). Meta-regression analysis confirmed PA as a positive predictor.
Conclusions: The effect of a school-based PA intervention was small to moderate. A sensible choice in the assembly of a multicomponent school-based PA intervention increases the effectiveness considerably. Physical education teachers, school administrators, and policy makers should consider organizational (intracurriculum, short and medium duration), personal (tailoring, participation), social (school staff) and content (PA) determinants.

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IMPLICATIONS AND CONTRIBUTION

Multicomponent school interventions are effective for enhancing physical activity levels of prevocational adolescents. Intervention characteristics that make multicomponent school interventions more successful are involvement of school staff and students, short or medium duration, intracurricular interventions that contain physical activities tailored to the target group.

Insufficient physical activity (PA) is one of the 10 leading risk factors for death worldwide, and it is a key risk factor for noncommunicable diseases [1]. The failure to spend 15–30 minutes a day in, for example, brisk walking increases the risk of cancer, heart disease, stroke, and diabetes by 20%–30% and shortens the lifespan by 3–5 years [2]. Globally, around 81% of adolescents

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* Address correspondence to: Joannis H. van de Kop, Faculty of Sports and Nutrition, Amsterdam University of Applied Sciences, Dr. Meurerlaan 8, Amsterdam 1067 SM, The Netherlands.
E-mail address: j.h.van.de.kop@hva.nl (J.H. van de Kop).

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aged 11–17 years were insufficiently physically active in 2010, especially those coming from a low socioeconomic background [3]. Girls were less active than boys, with 84% versus 78% not meeting WHO PA recommendations [4,5]. In the Netherlands, students in prevocational education show the largest decline in sports participation with accompanying increased inactivity [6]. Both on weekdays and days off, adolescents spend most of their time sitting or lying, exceeding inactivity levels for elderly of 65+ and even 75+ years of age [7]. Unlike most adults, children and adolescents have a limited ability to understand the long-term consequences of their behavior. Apparently, for these adolescents, some support for developing a healthy lifestyle may be necessary. In response to the growing burden of noncommunicable diseases, the World Health Assembly calls for the development and implementation of school policies and programs that promote healthy diets and increase PA levels [8]. The WHO specifically identifies schools as a target setting for the promotion of PA among children and youth. The key question is "what programs can be proposed in a school setting to encourage adolescents to be physically more active?" There is limited to strong evidence for the effectiveness of school-based interventions. Also, it is suggested that more effective programs can be made by further alignment of interventions to the targeted population [9–11]. Therefore, it is necessary to identify ingredients that make interventions more effective in encouraging adolescents to become more physically active [12].

The aim of this systematic review is to identify characteristics of interventions that are effective in elevating the PA level of prevocational adolescents. Therefore, literature is reviewed on the effectiveness of school-based PA promotion interventions. The results will be used in a Dutch trial to advise prevocational intervention schools in promoting their students to become physically more active.

Methods

Eligibility criteria

Studies published in between 2000 and 2018 were considered for inclusion if they were controlled trials and the target population was prevocational 12- to 17-year-old healthy adolescents. Each study should provide effects of a school-based PA or health promotion intervention with a duration of at least 6 weeks. At least one outcome measure of PA level was reported. Studies were not included if the study population was a specific sample that could be significantly different from the general population (e.g., overweight or obese subjects). The search was limited to publications in English.

Information sources and search

A systematic literature search was performed in the bibliographic databases PubMed, Embase.com, The Cochrane Library (via Wiley) and (via EBSCO) CINAHL, SPORTDiscus, PsycINFO, and ERIC from January 1, 2000, to November 28, 2018. Controlled terms (e.g., MeSH in PubMed and Emtree in Embase) as well as free-text terms were used in the search. Only free-text terms were used in The Cochrane Library. Search terms expressing PA in adolescents were used in "AND" combination with search terms comprising social or personal factors. Within these results, we searched for (1) a prevocational education level, (2) implementation, and (3) participation using controlled and free-text terms. The references of identified articles were searched for additional publications that met the eligibility criteria for inclusion.

Study selection

After removal of duplicate reports, the study selection process involved screening of titles and reading abstracts of the retrieved search results. Potentially relevant full-text reports were examined to verify whether they met the eligibility criteria. Two authors of this review evaluated eligibility of each report independently. Final decisions on study inclusion were made by consensus. The study selection process is summarized in a flow diagram in Figure 1.

Data collection process

Two authors of this review independently extracted post-test data on PA level–related outcomes and intervention characteristics. An assessment criterion form for a randomized controlled trial was used for extracting post-test data [13]. The use of the templates was refined after pilot testing a random selection of the included studies. Because of under-reporting and variation in follow-up time, retention test data were not used. If more than one effect measure was published, self-reported outcomes were used for analysis. Disagreements were resolved by discussion. The original researchers were contacted to provide incomplete data. Study protocol articles were consulted to derive additional information on intervention characteristics.

Data items

PA level outcome measures assessed by a direct or indirect method were derived from the articles. The measures included (1) total PA level; (2) moderate to vigorous PA (MVPA) level; (3) leisure time PA level; (4) number of days MVPA; (5) number of steps a day; (6) energy expenditure PA, or MVPA in physical education (PE) lessons. If possible, the data were split for boys and girls separately. Otherwise, the data for the total group were analyzed. Then the intervention characteristics were determined and extracted from the studies. Table 1 shows the description of seven dichotomous intervention characteristics and two categorical intervention characteristics (duration and intra- or extra-curriculum).

Risk of bias assessment

Cochrane Collaboration's Review Manager software version 5.3 (RevMan, The Nordic Cochrane Centre, Copenhagen, Denmark). was used by two authors for assessing risk of bias of the controlled trials. Nine items were used to assess selection bias (random sequence generation and allocation concealment), performance bias (blinding of participants and providers), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data intention-to-treat analysis), group similarity on baseline, incomplete data of dropouts, and the influence of cointerventions. Consensus by the authors was determined on the preliminary independent decision to distinguish low risk of bias (criterion satisfied and clearly described in the article) from high risk of bias (criterion not satisfied) or unclear risk of bias (insufficient information to permit judgment). Selection bias and incomplete data dropouts were used to determine a conclusive

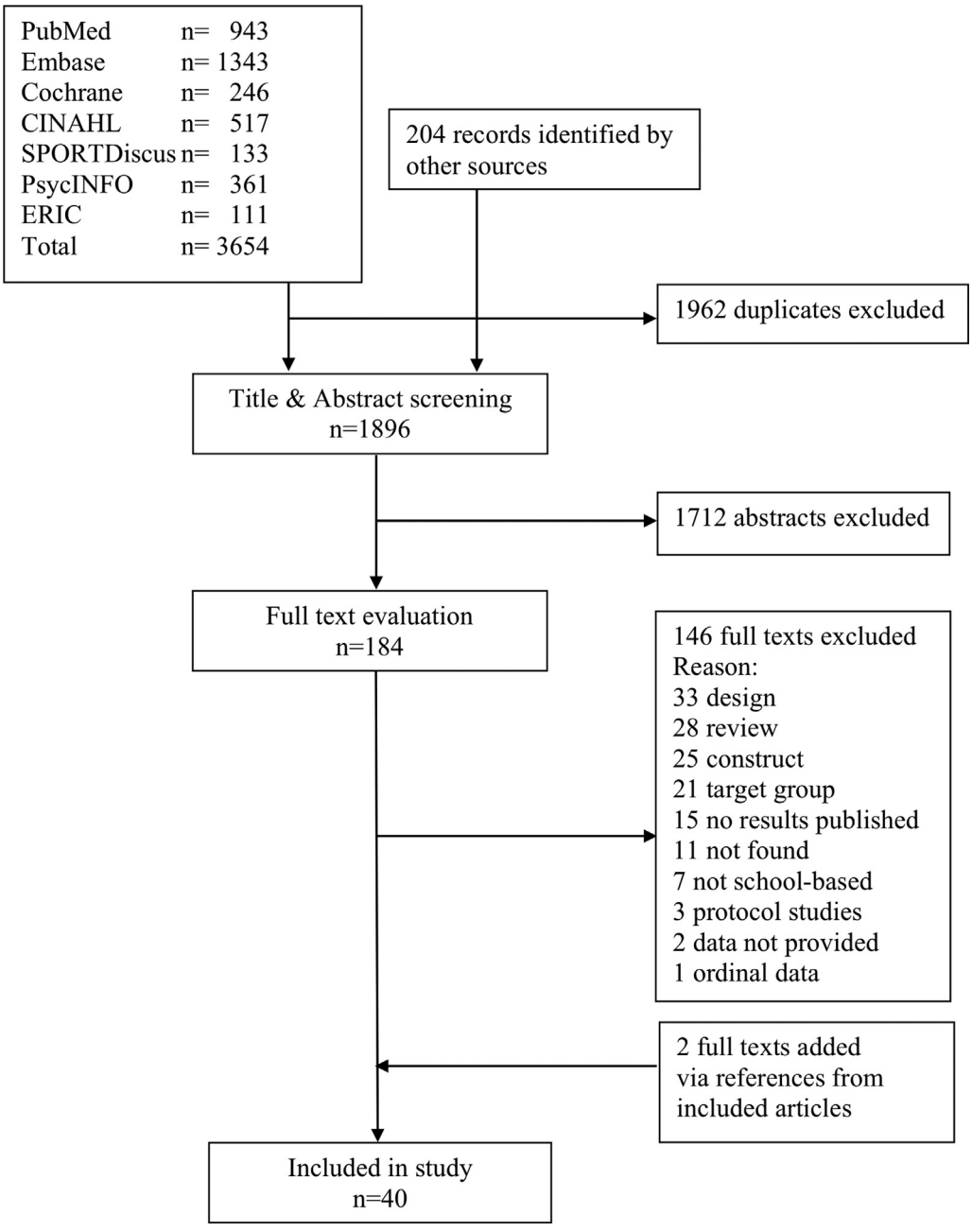

Figure 1. Flow of information during the selection process.

dichotomous quality assessment of a study. Appendix 1 presents the risk of bias assessment of the included studies.

Summary measures

Pre- and post-test means and standard deviations of the primary outcomes of interest were taken directly from the studies. A random effects model was used on the weighted standardized mean differences (SMDs) and its 95% confidence interval (CI) because the effect estimate varies within studies as well as between studies. Heterogeneity was assessed by the I^2 estimate [14]. Overall intervention effects were determined over the included studies. Subgroup analyses were performed to evaluate different intervention effects between boys and girls and between low risk and high risk of bias studies. To investigate whether the effect sizes were robust, sensitivity analyses were performed by omitting those studies, whose effects differed substantially and therefore contributed the most to the degree of heterogeneity [14]. To identify effective intervention characteristics, subgroup analyses determined the magnitude of the effect estimate (SMD), reflecting the importance of the intervention characteristic. For identification of a relevant characteristic, at least five studies had to be included in a subgroup, regardless if the intervention was effective or not. Subgroup analyses were

Table 1
Description of intervention characteristics

Intervention characteristic	Description	Example
Digital technology (DIGIT)	Information technology was used for promotion purposes	Providing health promotion by a computer program or Internet
Multicomponent (MULTI)	The intervention was aimed at more than one behavioral determinant (personal, physical environment, social environment)	Personal mentoring and providing sports equipment
Participatory approach (PARTIC)	The students were given responsibility by cocreating the intervention	Students were asked to create their own physical activity plan for the week to come
Parent involvement (PARENT)	Parents were included as a target group in the intervention	Parents received a leaflet with information about promoting health
Personnel involvement (STAFF)	School staff were (also) intervention providers	Extra lessons physical education by PE teacher
Tailored (TAIL)	The intervention was customized to the target group and/or the school environment	Different activities for boys and girls
Physical activities (PA)	Physical activities were part of the intervention	Playing basketball, hiking, cycling
Curriculum (CURR)	The intervention was intracurricular, extracurricular, or both	Intra: enhance intensity of PE lesson Extra: providing after school activities Intra + Extra: both examples
Duration	Short: 6–12 wk Medium: 13–26 wk Long: 27 wk or longer	

performed by a single intervention characteristic or a combination of two intervention characteristics. SMD is considered small (.2), moderate (.5), or large (.7) [15]. Statistically significant results were considered for the estimates with the 95% CI not including zero. RevMan software version 5.3 was used for meta-analyses. A meta-regression analysis was conducted with the PA level (SMD) as dependent variable and intervention characteristics as covariates. Dummies were made for the categorical variable intra- or extra-curricular intervention (or both). A backward stepwise elimination was performed with a .20 alpha level of removal. The variable with the largest p value for contribution to the model was dropped, and the regression was repeated. SPSS version 22 was used for meta-regression.

Results

Study selection

A total of 3,858 records were retrieved; 3,654 as a result of the electronic search and 204 from references of the included articles (Figure 1). After removal of 1,962 duplicates, 1,896 records were assessed on title and abstract resulting in 184 articles screened for full-text reading. Forty articles were considered eligible. Figure 1 summarizes the reasons for excluding the previously selected full texts. Three studies were excluded from the meta-analysis due to (1) data on ordinal scale and (2) data that were not provided after contacting the original researcher. Fourteen authors were contacted to provide missing data on number of participants, means, and standard deviations of effect measures. Appendix 2 gives an overview of the included studies with their study and intervention characteristics.

Study characteristics

The 40 articles included in this systematic review were published between 2002 and 2018. The studies were mainly performed in the North American and European continent. Four studies were Australian, two were from Hong Kong, one was South-African, and one was originally performed in Thailand. The study populations were mainly underserved, multiethnic prevocational adolescents aged 12–17 years old. Sample sizes ranged from 25 to 4,164. The total number of participants (♀ + ♂) was 32,696, with 17,593 individuals allocated to intervention (I) and 15,103 to control (C) groups. Thirty-five studies presented only data of the total sample of participants (I: 14,471 and C: 12,204). Five studies targeted only girls (I: 3,122 and C: 2,899). Eleven studies presented data of the total sample and boys (I: 2,498, C: 1,898) and girls separately (I: 2,497 and C: 2,178). A total number of 16 studies presented data of 10,696 girls (I: 5,619 and C: 5,077).

Risk of bias

Appendix 1 presents the risk of bias assessment of all included articles. Ten studies did not describe the method of randomization (25.0%). The highest risk of bias was found for the items blinding of participants (99.9%), blinding of the intervention providers (99.9%), and blinding of the outcome measure assessment (80%). This could be expected because of the nature of the intervention. Thirteen studies did not present intervention and control group similarity on baseline (32.5%), whereas twelve studies reported incomplete data of dropouts (30%). One study lacked outcome data of intention-to-treat analysis (.25%), and in seven studies (18%), cointerventions may have interfered.

Overall intervention effects

PA level of the total target group was significantly increased for the 40 included school-based PA promotion interventions studies with a mean effect estimate (SMD) of .19 (.12, .27; $I^2 = 91\%$). A forest plot (Figure 2) presents detailed information of the results for the 40 studies in this review and presents a synthesis of the results for the total group. Sensitivity analyses, where sequentially eight studies with substantially different outcomes were omitted, decreased the effect estimate to .11 (.06, .16; $I^2 = 70\%$; Table 2) [16–26]. Gender-specific meta-analyses showed nonsignificant increase of the PA level in 11 studies for boys .14 (−.06, .34; $I^2 = 86\%$; Table 2) [17,24–33]. Sensitivity analysis, omitting two studies with outcomes substantially different than others, resulted in a shift to a relevant effect of .14 (.02, .27; $I^2 = 63\%$; Table 2) [17,24]. The mean effect size in 16

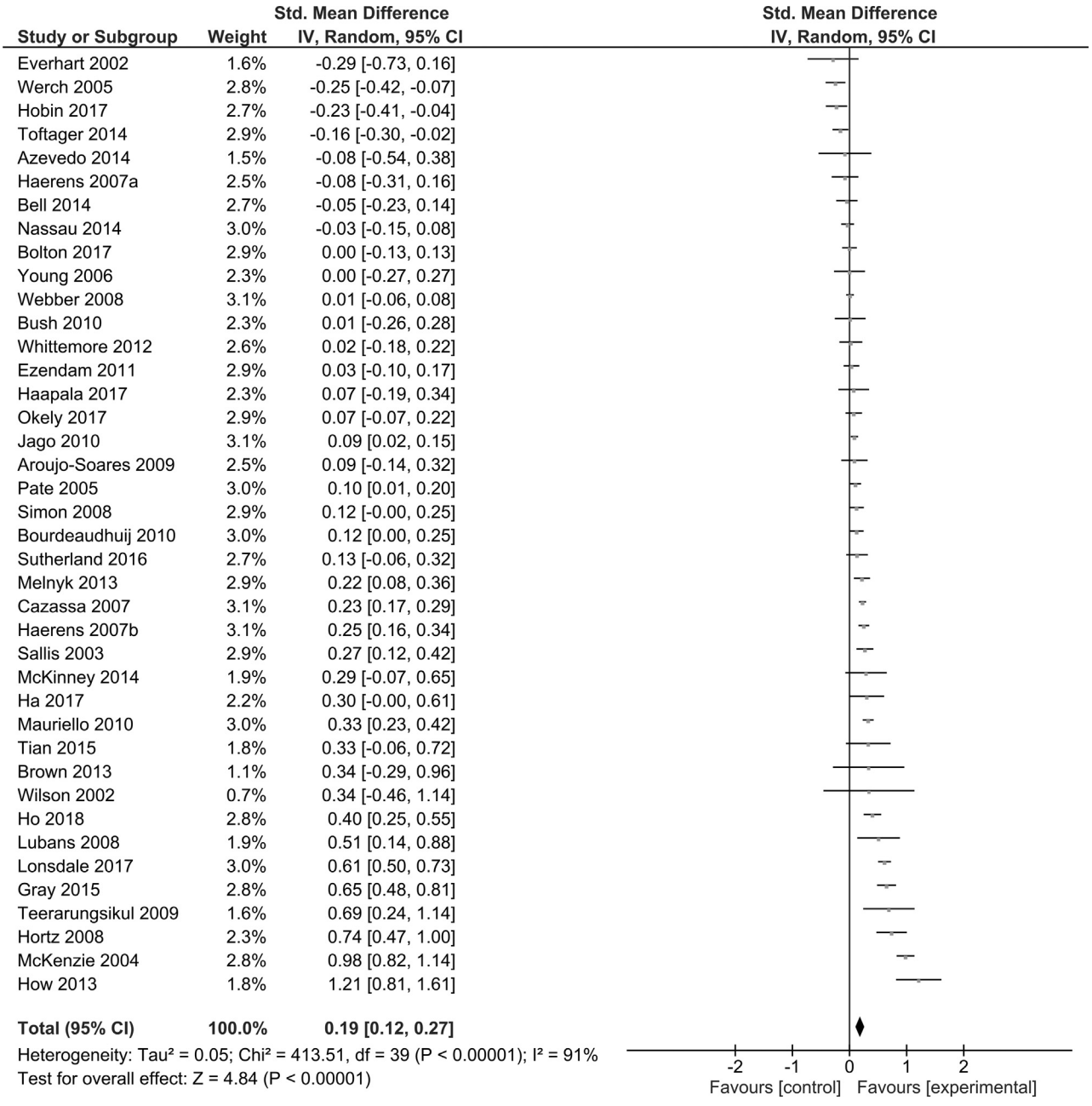

Figure 2. Forest plot of the contribution of each included study to the overall effect in the total group.

studies for girls is .10 (.01, .19; $I^2 = 69\%$; Table 2). Five studies targeting girls only report SMD of .08 (−.02, .19; $I^2 = 62\%$) [34–38]. Because effect estimates of boys do not differ substantially from those of girls, further analyses on intervention characteristics were made on the total target group (combining the results of the 40 studies).

Intervention characteristics

Identification of effective intervention characteristics was performed by subgroup analyses and meta-regression analysis (Table 2). Here, the SMD sizes of subgroup analyses based on intervention characteristics are presented. Intervention characteristics with an SMD size overpassing the overall effect of .19 were considered effective.

An important characteristic was "organizational" in nature and distinguished intracurricular interventions and extracurricular interventions from interventions that had both properties. Interventions that were carried out as exclusively "intracurricular" (n = 21) showed an effect estimate of .29 (.17, .42; $I^2 = 93\%$) with CI not including zero. Only three studies had an exclusively extracurricular intervention. A minimum of five studies was required for inclusion in the ranking of the effects. The SMD size of studies that combined intra and extra-curricular interventions did not reach the levels of .19 (overall effect). The "duration" of an intervention can also be considered as an

Table 2
Results of meta-analyses: (1) overall effect on physical activity level (SMD) with inclusion of all studies and after sensitivity analysis. (2) Ranking of intervention characteristics based on the effect size (SMD) after subgroup analysis. (3) Meta-regression analysis with backward selection procedure of covariates (intervention characteristics)

1. Overall effect							
Meta-analysis	Group	Studies (n)	n (I)	n (C)	SMD	95% CI	I^2
All studies included	♀ + ♂	40	17,593	15,103	**.19**	.12, .27	91
	♂	11	2,498	1,898	.14	−.06, .34	86
	♀	16	5,619	5,077	**.10**	.01, .19	69
Sensitivity	♀ + ♂	32	14,337	12,279	**.11**	.06, .16	70
Analysis	♂	9	2,460	1,810	**.14**	.02, .27	63
2. Subgroup analyses based on intervention characteristics							
Meta-analysis	Characteristics	Studies (n)	Total group (n)		SMD	95% CI	I^2
Subgroup analyses	Intra + PA	11	7,916		**.43**	.19, .68	95
	Intra + staff	13	8,952		**.37**	.16, .58	95
	Intra + tail	10	6,791		**.35**	.13, .58	94
	Intra	21	17,413		**.29**	.17, .42	93
	Short	7	2,922		**.29**	.09, .49	83
	Tail + PA	15	11,234		**.27**	.10, .44	94
	Partic + staff	6	3,179		**.26**	.02, .51	87
	Tail + staff	14	9,187		**.25**	.06, .44	94
	Medium	13	9,379		**.23**	.09, .37	87
	Partic + PA	7	3,947		.22	.00, .44	89
	Partic	10	4,531		**.21**	.04, .39	84
	Tail + Partic	10	4,531		**.21**	.04, .39	84
	Staff	25	19,732		**.21**	.10, .33	93
	PA	22	20,001		**.21**	.11, .30	90
	PA + Digit	7	9,983		**.20**	.01, .38	95
	Staff + PA	15	15,069		**.20**	.07, .32	93
	Overall effect	40	32,696		**.19**	.12, .27	91
3. Meta regression analysis: Intervention characteristics by backward selection							
Meta-regression					Regression equation: PA level = .577 + .353 PA − **.543** MC		

Bold values are significant with $p < .05$.
C = control group; CI = confidence interval; DIGIT = digital technology; I = intervention group; I^2 = heterogeneity; Intra = intracurricular; MC = multicomponent; n = number; PA = physical activity; PARTIC = participatory approach; SMD = standardized mean difference; Staff = personnel involvement; Tail = tailored.

organizational feature. Three intervention periods were distinguished. In contrast to long-term interventions, nine short-term interventions (6–8 weeks) were nearly as effective as 12 midterm (8–26 weeks) interventions with mean effect estimates of .21 (.05, .38; $I^2 = 80\%$) and .26 (.11, .41; $I^2 = 88\%$), respectively. In addition to organizational characteristics, more substantive characteristics played a role. Offering "PAs" in an intervention was an effective way to encourage students to be more physically active with a mean SMD of .21 (.11, .30; $I^2 = 90\%$). Studies where students had a participating role in the intervention and had a mean SMD of .21 (.04, .39; $I^2 = 84\%$).

Eleven studies that embed "PA" into the curriculum were effective (.43; .19, .68; $I^2 = 95\%$). Also, intracurricular studies that involved "personnel" (.37; .16, .58; $I^2 = 95\%$) and "tailored the intervention" to the target population (.35; .13, .58; $I^2 = 94\%$) were among the most effective interventions. When PAs were included in the intervention and were customized to the to the target group (n = 15), the effect size was .27 (.10, .44; $I^2 = 94\%$). This also counted for those interventions (n = 6) that involved personnel combined with a participative approach of the intervention (.26; .02, .51; $I^2 = 87\%$). Finally, sensitivity analyses were performed until a heterogeneity of 70% was achieved. The overall effects were robust for the studies whose interventions were characterized by inclusion of PA, involvement of personnel, intracurricular interventions, tailored interventions, and interventions of short and medium duration. Some interventions that combine two characteristics showed robust SMD. These combinations were interventions with PA that involved personnel and tailored interventions that involved personnel. Effect sizes were not robust for studies characterized by participation or use of digital technology.

Synthesis of the results

Risk of bias. In this review subgroup, analyses were performed on 20 studies with a low risk of bias (conclusive item) against 20 studies with a high risk of bias. For the total group, effect measures were almost equal .19 (.07, .31, $I^2 = 92\%$) and .20 (.09, .30, $I^2 = 89\%$) respectively. For boys, effect estimates for six low risk of bias studies versus five high risk of bias studies were .21 (.03, .39, $I^2 = 56\%$) versus .09 (−.33, .50, $I^2 = 92\%$). For girls, the effect estimates in 10 low-risk studies versus six high-risk studies were .11 (−.01, .23, $I^2 = 65\%$) and .07 (−.05, .22, $I^2 = 74\%$). Although the CIs for the total group as well as for boys and girls overlapped, the quality assessment of the studies seemed irrelevant; therefore, low risk as well as high risk of bias studies were included in further analyses.

Additional analyses. An alternative method for identifying effective characteristics was performed with a meta-regression analysis for the total group. In the regression model, the weighted outcome variable SMD was related to the intervention characteristics (Table 2). First, all variables were entered into the

equation and then sequentially removed. This procedure resulted in the following regression model.

$$\text{Weighed SMD} = .577 + .353\ \text{PA} - .543\ \text{multicomponent}$$

"PA" was positively related and "multicomponent" was negatively related to SMD. Approximately 15% of the variation in the PA level of adolescents was explained by differences in the presence of PAs and the absence of a multidisciplinary approach (R^2 =.145). Effect modification on gender did not identify any significant intervention characteristics.

Discussion

Summary of evidence

The overall effect of school-based PA interventions in adolescents of 40 studies showed that school-based PA promotion interventions increased the PA level of prevocational adolescents. The best estimate of the mean standardized effect measure on PA level was .19 (.12, .27), which corresponds to a small improvement [16–55]. Most effective interventions were characterized by curricula that contain PA customized to adolescents with involvement of school staff. In these studies, the mean effect estimates (SMD) increased to a moderate level (.35, .43). The additional meta-regression analyses seemed to support the outcome of the meta-analyses since PA as part of an intervention were positive not significantly related to students' PA level, whereas a multicomponent approach was negatively related (not significant).

Overall effect

The overall intervention effect found in this review is consistent with the findings of others [10,11]. A positive impact on the duration of PA and a reduction of TV watching time in 6- to 18-year-old students is reported in other reviews [10,56]. In line with this, Sluijs [11] found strong evidence for school-based interventions increasing PA in adolescents although the impact on low socioeconomic groups was inconclusive. The results of this review support the hypothesis that school-based PA interventions are effective for prevocational adolescents.

Single intervention characteristics

The key question in this review is which intervention characteristic or mix of characteristics are responsible for an effective intervention? Therefore, the intervention characteristics associated with the studies that exceed the overall effect of .19 in subgroup analyses were regarded as successful features. The most effective single characteristics were organizational in nature and related to the content of the intervention. These interventions had a duration of 6–26 weeks and included PA in the curriculum. In addition, the interaction process of the students and the intervention provider seemed relevant. Here, school staff and students were both involved and shared responsibility to assemble the intervention.

Intracurriculum

Embedding the intervention as part of the regular curriculum seemed effective (SMD = .29). It ensured that students were engaged in a familiar social and physical environment fostering an effective interaction process between teachers and students. Three studies in this review evaluated an extracurricular intervention program with contradicting results. In neither of these studies, school staff was involved in the intervention. Beets [9], however, do appoint the potential of after-school programs.

Duration

Short (6–12 weeks, n = 7, SMD = .29) and medium-term (12–26 weeks, n = 13, SMD = .23) intervention duration showed a slightly more effective result over long-term studies (>26 weeks, n = 19, SMD = .15) with mean effects estimates with CI not including 0. PA level was apparently a changeable variable with a short time constant. The question is how to reconcile these findings with a desired long-term life-style effect of the intervention. After all, the goal of a school intervention program is to achieve lasting behavioral change. Future interventions might try an on-off approach alternating intervention activity with episodes of no activity. The interval period between two interventions could be used for evaluation of the completed intervention block and for further adjustment and alignment of the upcoming intervention block to the student population "under treatment." Future research could evaluate the effects of such an "interval intervention approach." It should be noted that this review shows post-test results immediately after the completion of the intervention, and no retention test results. Inclusion of retention test results would clarify sustainable effects of school-based PA interventions, but these are rarely investigated. Hence, the long-term effects on lifestyle remain opaque.

Physical activities

The provision of PAs as part of the intervention was an effective intervention characteristic (SMD = .21). The advantage of including PA in an intervention was that participation contributed directly to the PA level as opposed to an educational program without PA. Mandatory (intracurricular) sport and PAs often took the form of adapted PE classes that were organized more intensively and effectively with the aim of increasing the PA level [22,27–29,34,36,39,40]. PA and PE are not the same. PAs are bodily movements that involve physical exertion. A PE program is structured, follows national standards, and often uses a grade system. Both contribute meaningfully to the development of healthy active children [57]. Physical activities on a voluntary basis were mainly organized during breaks and after school.

Combinations of characteristics

The combination of an intracurricular organization with the involvement of school staff appeared an important intervention characteristic (SMD .37). School staff know their students well. Therefore, they are able to make changes to the curriculum and customize the program as much as possible to the preference of students to engage them (SMD .35). In most studies, school staff was trained to administer the intervention as intended. The training addresses more efficient class management, instructions for giving positive feedback, and adaptions of the contents of the lessons [16,17,19,22,23,25,28,31,36,38,41–43]. Students that participated in the intervention were partly responsible for the content of the intervention, for example, by playing a role as an assistant teacher or by codesigning individual exercise programs

[17,26,27,29,44–49]. Especially, the combination of student participation with staff involvement emphasizes the educational process. Participative intervention studies in this review were mostly recent published. The participative approach seemed promising in promotion of PA (SMD = .26), but intervention studies are needed to estimate the importance of a "participative approach."

Multicomponent

This study shows mixed results regarding the effectiveness of the "multicomponent" approach. On the one hand, subgroup analysis showed a small but significant advantage (SMD = .11); on the other hand, the meta-regression analysis suggested the multicomponent approach to be counterproductive (the negative result is however nonsignificant). A multicomponent intervention has been described as an approach to multiple behavioral determinants. So, given the complexity of organizing multicomponent interventions, the question is which mix of intervention characteristics is more effective than others? Some combinations that emphasize the educational interaction between teachers and student have been identified as successful. In contrast, some multicomponent interventions were not. This may suggest that the organizational effectiveness of the team applying the intervention is determining the outcome as well. However, this characteristic of the intervention is not available in the 40 studies.

The use of digital technology in promoting PA is mostly done by completing a survey on the computer where students receive feedback on their health behavior, sometimes followed by a personal consultation [17,18,24,27,29,30,33,35,41,44,50–52]. From this review, the use of digital technology in PA promotion interventions does not seem to be very effective (SMD = .15). But technological developments go fast. The future will show whether applications are developed that can contribute effectively to the promotion of PA.

Thirteen studies involved parents in their intervention. This feature contributed to the effectiveness of the intervention in all analyses. Parent involvement in education was stimulated by the use of, for example, a school newspaper [27,30,40,42]. Sending information to parents combined with a questionnaire or parent–child homework assignments was stimulating too [29,33,45]. Opportunities for parents to ask intervention-related questions had a positive effect.

To summarize, the results of this review suggested to include an intervention into the curriculum and involve the school staff and students to customize PAs. The intracurricular feature seemed a catalyst for the educational learning process to get students and school staff involved and enhanced the PA level of students.

Risk of bias

Ten of the 40 studies [20,23,26,29,39,40,44,46,51,53] lacked a clear description of the randomization process, but the effect sizes were comparable for both categories in the total group. A clear description of when the process of randomization occurred before or after the baseline assessment was lacking in 29 studies [16–18,20,21,23,24,26,28–31,33–37,39,41,42,44,46–48,51–55]. This form of allocation concealment can lead to overestimation of subjective outcomes as mostly used in this review [58]. Detection bias is an important factor but is hard to prevent in this type of interventions. One of the included studies reported blinding of participants and caregivers. Although blinding of outcome assessors in many cases was feasible, in most studies, the assessors knew which participants received an intervention. Most studies did not report the presence of possible detection bias. Publication bias seemed to be a limited factor. Funnel plots show predominantly symmetrical distribution over the effects. However, only 16 of 40 studies reported gender-specific results.

Limitations

Although inclusion criteria used in this review on school setting and age (12–17 years) avoid heterogeneity, the reported outcome measures and the population characteristics such as ethnicity or socioeconomic situation may vary between studies. To respond to the variation of outcome measures, this review performed subgroup analyses using a random effects model. In doing so, somewhat wider CIs were obtained that appeared to be more robust [14]. The random effects model on the other hand consequently limits translation to practical relevance. Agreement between subjectively and objectively assessed PA levels has been discussed previously [56,59,60]. There is a need for developments in the field of objective measurement tools that contribute to the improvement of the measurement of PA in large-scale epidemiologic studies.

Intervention characteristics were determined mainly as dichotomous variables, which means that the feature is, or is not, implemented in an intervention. The presence of an intervention characteristic does not say anything about the quality of application of the characteristic. For example, parental participation can imply that parents are only informed about the content of an intervention or they can actually be involved in the intervention. Although some studies provided sufficient description of the intervention, other studies did not. Intervention descriptions are important to learn from good practices and perform analyses like in this review. In addition to this remark, it is noteworthy that analysis of the treatment effect on an individual level may give an overestimation of effect size in comparison to multilevel analysis. In this review, we included studies using either individual analyses or multilevel analysis. Therefore, an overestimation of effect size could possible.

The key question of this review is "what solutions can be proposed in a school setting to encourage adolescents to be physically more active?" Meta-analyses in this review show that school-based PA interventions are successful to increase the PA level of prevocational adolescents. However, the effects are small. Although multicomponent interventions are advised, they sometimes are not effective. This review shows that a sensible mix in the composition of the multicomponent approach is important. Organizational (intracurricular and short- and medium-term), personal (tailoring), and social determinants (school staff) that serve the educational process are important. Also, the content of the intervention is more effective when PAs are embedded in the curriculum and customized to (and with) the participants. Schools are a target setting for the promotion of PA among children and youth. Therefore, PE teachers, school administrators, and policy makers should consider the recommendations from this review. Finally, it should be noted that PA promotion interventions are aiming for a sustainable active lifestyle. Therefore, in this type of research, retention tests are important and should be included in future intervention studies.

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Supplementary Data

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References

[1] World Health Organization. Global status report on noncommunicable diseases 2014: Attaining the nine global noncommunicable diseases targets; a shared responsibility. Geneva, Switzerland: World Health Organization; 2014.
[2] Wen CP, Wu X. Stressing harms of physical inactivity to promote exercise. Lancet 2012;380:192–3.
[3] Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: Surveillance progress, pitfalls, and prospects. Lancet 2012;380:247–57.
[4] Snowden C. The fat lie. Available at: http://www.iea.org.uk/sites/default/files/in-the-media/files/Briefing_The%20Fat%20Lie.pdf. Accessed February 28, 2016.
[5] World Health Organisation. Global recommendations on physical activity for health. Geneva, Switzerland: World Health Organization; 2010. Available at: http://www.who.int/mediacentre/factsheets/fs385/en/. Accessed February 28, 2016.
[6] Tiessen-Raaphorst A, Ross J. Sport: een leven lang. Den Haag/'s Hertogenbosch, The Netherlands: Sociaal en Cultureel Planbureau; W.J.H. Mulier Instituut; 2010. Available at: https://www.scp.nl/dsresource?objectid=1aa8ed74-263f-412d-a22d-dd8386e33383&type=org. Accessed June 28, 2018.
[7] Hildebrandt VH, Bernards CM, Stubbe JH. Trendrapport Bewegen en Gezondheid 2010/2011. Leiden, The Netherlands: De Brink; 2013. Available at: https://www.volksgezondheidenzorg.info/sites/default/files/hildebrandt_trendrapport_bewegen_gezondheid_2010_2011.pdf. Accessed June 28, 2018.
[8] World Health Organization. School policy framework implementation of the WHO global strategy on diet, physical activity and health. Geneva, Switzerland: World Health Organization; 2008. Available at: http://www.who.int/dietphysicalactivity/SPF-en-2008.pdf. Accessed February 28, 2016.
[9] Beets MW, Beighle A, Erwin HE, Huberty JL. After-school program impact on physical activity and fitness: A meta-analysis. Am J Prev Med 2009;36:527–37.
[10] Dobbins M, Husson H, DeCorby K, LaRocca RL. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. In: Cochrane Database of Systematic Reviews. Hoboken, NJ: John Wiley & Sons, Ltd; 2013. Available at: http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD007651.pub2/abstract. Accessed February 28, 2016.
[11] van Sluijs EMF, McMinn AM, Griffin SJ. Effectiveness of interventions to promote physical activity in children and adolescents: Systematic review of controlled trials. BMJ 2007;335:703.
[12] Herens M, Wagemakers A, Vaandrager L, et al. Evaluation design for community-based physical activity programs for socially disadvantaged groups: Communities on the move. JMIR Res Protoc 2013;2:e20.
[13] Higgins JPT. Cochrane handbook for systematic reviews of interventions. Version 5.1.0 [updated March 2011]. The Cochrane Collaboration; 2011. Available at:, http://handbook.cochrane.org.
[14] Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. Introduction to meta-analysis. 1st ed. Chichester, UK: John Wiley & Sons, Ltd; 2009.
[15] Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale, NJ: Lawwrence Erlbaum Associates; 1988.
[16] Gray HL, Contento IR, Koch PA. Linking implementation process to intervention outcomes in a middle school obesity prevention curriculum, "Choice, Control and Change". Health Educ Res 2015;30:248–61.
[17] How YM, Whipp P, Dimmock J, Jackson B. The effects of choice on autonomous motivation, perceived autonomy support, and physical activity levels in high school physical education. J Teach Phys Educ 2013;32:131–48.
[18] Mauriello LM, Ciavatta MMH, Paiva AL, et al. Results of a multi-media multiple behavior obesity prevention program for adolescents. Prev Med 2010;51:451–6.
[19] Mckenzie TL, Sallis JF, Prochaska JJ, et al. Evaluation of a two-year middle-school physical education intervention: M-SPAN. Med Sci Sports Exerc 2004;36:1382–8.
[20] Petosa RL, Hortz B. Social cognitive theory variables mediation of moderate exercise. Am J Health Behav 2008;32:305–14.
[21] Toftager M, Christiansen LB, Ersbøll AK, et al. Intervention effects on adolescent physical activity in the multicomponent SPACE study: A cluster randomized controlled trial. PLoS One 2014;9:e99369.
[22] Lonsdale C, Lester A, Owen KB, et al. An internet-supported school physical activity intervention in low socioeconomic status communities: Results from the activity and motivation in physical education (AMPED) cluster randomised controlled trial. Br J Sports Med 2019;53:341–7.
[23] Hobin E, Erickson T, Comte M, et al. Examining the impact of a province-wide physical education policy on secondary students' physical activity as a natural experiment. Int J Behav Nutr Phys Act 2017;14:98.
[24] Everhart B, Harshaw C, Everhart B, et al. Multimedia software's effects on high school physical education students' fitness patterns. Phys Educ 2002;59:151–7.
[25] Sutherland RL, Campbell EM, Lubans DR, et al. The physical activity 4 everyone cluster randomized trial. Am J Prev Med 2016;51:195–205.
[26] Tian H, du Toit D, Toriola AL. The effects of an enhanced quality physical education programme on the physical activity levels of grade 7 learners in Potchefstroom, South Africa. Phys Educ Sport Pedagogy 2017;22:35–50.
[27] van Nassau F, Singh AS, Cerin E, et al. The Dutch obesity intervention in teenagers (DOiT) cluster controlled implementation trial: Intervention effects and mediators and moderators of adiposity and energy balance-related behaviours. Int J Behav Nutr Phys Act 2014;11:158.
[28] Bush LP, Laberge S, Laforest S. Physical activity promotion among underserved adolescents: "make it fun, easy, and popular". Health Promot Pract 2010;11:79S–87S.
[29] Ha AS, Lonsdale C, Ng JYY, Lubans DR. A school-based rope skipping program for adolescents: Results of a randomized trial. Prev Med 2017;101:188–94.
[30] Haerens L, Deforche B, Vandelanotte C, et al. Acceptability, feasibility and effectiveness of a computer-tailored physical activity intervention in adolescents. Patient Educ Couns 2007;66:303–10.
[31] Jago R, Mcmurray RG, Drews KL, et al. HEALTHY intervention: Fitness, physical activity, and metabolic syndrome results. Med Sci Sports Exerc 2011;43:1513–22.
[32] Sallis JF, McKenzie TL, Conway TL, et al. Environmental interventions for eating and physical activity: A randomized controlled trial in middle schools. Am J Prev Med 2003;24:209–17.
[33] Haerens L, De Bourdeaudhuij I, Maes L, et al. School-based randomized controlled trial of a physical activity intervention among adolescents. J Adolesc Health 2007;40:258–65.
[34] Pate RR, Ward DS, Saunders R, et al. Promotion of physical activity among high-school girls: A randomized controlled trial. Am J Public Health 2005;95:1582–7.
[35] Webber LS, Catellier DJ, Lytle LA, et al. Promoting physical activity in middle school girls. Am J Prev Med 2008;34:173–84.
[36] Teerarungsikul N, Phuphaibul R, Loveland-Cherry C, et al. Effectiveness of a physical activity promotion program on perceived self-efficacy, physical activity and physical fitness among Thai adolescents. Thai J Nurs Res 2009;13:81–94.
[37] Okely AD, Lubans DR, Morgan PJ, et al. Promoting physical activity among adolescent girls: The Girls in sport group randomized trial. Int J Behav Nutr Phys Act 2017;14:81.
[38] Young DR, Phillips JA, Yu T, Haythornthwaite JA. Effects of a life skills intervention for increasing physical activity in adolescent girls. Arch Pediatr Adolesc Med 2006;160:1255–61.
[39] Azevedo LB, Watson DB, Haighton C, Adams J. The effect of dance mat exergaming systems on physical activity and health–related outcomes in secondary schools: Results from a natural experiment. BMC Public Health 2014;14:951.
[40] Lubans D, Morgan P. Evaluation of an extra-curricular school sport programme promoting lifestyle and lifetime activity for adolescents. J Sports Sci 2008;26:519–29.
[41] Whittemore R, Jeon S, Grey M. An internet obesity prevention program for adolescents. J Adolesc Health 2013;52:439–47.
[42] Melnyk BM, Jacobson D, Kelly S, et al. Promoting healthy lifestyles in high school adolescents. Am J Prev Med 2013;45:407–15.
[43] Araújo-Soares V, McIntyre T, MacLennan G, Sniehotta FF. Development and exploratory cluster-randomised opportunistic trial of a theory-based

intervention to enhance physical activity among adolescents. Psychol Health 2009;24:805–22.
[44] Bolton KA, Kremer P, Gibbs L, et al. The outcomes of health-promoting communities: Being active eating well initiative - a community - based obesity prevention intervention in Victoria, Australia. Int J Obes 2017;41:1080–90.
[45] Brown B, Noonan C, Harris KJ, et al. Developing and piloting the journey to native youth health program in Northern Plains Indian communities. Diabetes Educ 2013;39:109–18.
[46] McKinney C, Bishop V, Cabrera K, et al. NuFit: Nutrition and fitness CBPR program evaluation. J Prev Interv Community 2014;42:112–24.
[47] Bell SL, Audrey S, Cooper AR, et al. Lessons from a peer-led obesity prevention programme in English schools. Health Promot Int 2017;32:250–9.
[48] Wilson DK, Friend R, Teasley N, et al. Motivational versus social cognitive interventions for promoting fruit and vegetable intake and physical activity in African American adolescents. Ann Behav Med 2002;24:310–9.
[49] Ho FKW, Louie LHT, Wong WH, et al. A sports-based youth development program, teen mental health, and physical fitness: An RCT. Pediatrics 2017;140:e20171543.
[50] Ezendam N, Brug J, Oenema A. Evaluation of the web-based computer-tailored FATaintPHAT intervention to promote energy balance among adolescents: Results from a school cluster randomized trial. Arch Pediatr Adolesc Med 2012;166:248.
[51] Casazza K, Ciccazzo M. The method of delivery of nutrition and physical activity information may play a role in eliciting behavior changes in adolescents. Eat Behav 2007;8:73–82.
[52] de Bourdeaudhuij I, Maes L, de Henauw S, et al. Evaluation of a computer-tailored physical activity intervention in adolescents in six European countries: The Activ-O-Meter in the HELENA intervention study. J Adolesc Health 2010;46:458–66.
[53] Haapala HL, Hirvensalo MH, Kulmala J, et al. Changes in physical activity and sedentary time in the Finnish schools on the move program: A quasi-experimental study. Scand J Med Sci Sports 2017;27:1442–53.
[54] Werch CC, Moore MJ, DiClemente CC, et al. A multihealth behavior intervention integrating physical activity and substance use prevention for adolescents. Prev Sci 2005;6:213–26.
[55] Simon C, Schweitzer B, Oujaa M, et al. Successful overweight prevention in adolescents by increasing physical activity: A 4-year randomized controlled intervention. Int J Obes 2008;32:1489–98.
[56] Kriemler S, Meyer U, Martin E, et al. Effect of school-based interventions on physical activity and fitness in children and adolescents: A review of reviews and systematic update. Br J Sports Med 2011;45:923–30.
[57] Society of Health and Physical Educators. Shape of the nation: Status of physical education in the USA. Available at: https://www.shapeamerica.org/uploads/pdfs/son/Shape-of-the-Nation-2016_web.pdf. 2016. Accessed January 19, 2019.
[58] Wood L, Egger M, Gluud LL, et al. Empirical evidence of bias in treatment effect estimates in controlled trials with different interventions and outcomes: Meta-epidemiological study. BMJ 2008;336:601–5.
[59] Prince SA, Adamo KB, Hamel M, et al. A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. Int J Behav Nutr Phys Act 2008;5:56.
[60] Schokker DF, Hekkert KD, Kocken PL, et al. Meten van lichamelijke activiteit van kinderen: Vragenlijsten vergeleken met versnellingsmeter. TvSG 2012;90:434–41.