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## A scoping review on characteristics of school-based interventions to promote physical activity and cardiorespiratory fitness among 6- to 10-year-old children

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1 Which features of the WHO Health Promoting School framework have been addressed by school-  
2 based interventions for the promotion of physical activity and cardiorespiratory fitness among 6- to  
3 10-year-old children from 2010-2019? Findings of a scoping review

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26

## 27 Abstract

28 Physical inactivity, a leading cause of mortality, tracks from childhood to adulthood. Effective  
29 interventions to promote physical activity (PA) at a young age are therefore needed. The aim of this  
30 scoping review was to provide an overview of school-based interventions for the promotion of PA,  
31 cardiorespiratory fitness (CRF), and the reduction of sedentary behaviours (SB) among six- to ten-  
32 year-old school children, and map these interventions to the WHO Health Promoting Schools  
33 framework. Arksey and O'Malley's scoping review methodology framework guided the conduct of  
34 this review. A systematic electronic search of six databases was combined with a hand search of  
35 reference lists to retrieve studies published between 2010 and 2019. Data extraction included  
36 information on study and intervention characteristics, effectiveness on PA, SB and CRF outcomes,  
37 and features of the WHO HPS framework. 192 papers investigating 178 interventions were included.  
38 The majority of the identified interventions were single feature interventions (n=84, 47%) while none  
39 of them encompassed all six features of the HPS framework. 'Health skills and education' (n=104,  
40 58%) was the most frequent feature followed by 'Links with parents or community' (n=95, 53%). A  
41 higher percentage of effective interventions were found for theory-based interventions. Some single-  
42 feature interventions were found to be effective while no specific feature combination seemed to be  
43 associated with better intervention effectiveness. Theory-based single- as well as multi-feature  
44 interventions seem to have the potential to improve effectiveness with regard to PA, CRF, and SB  
45 outcomes.

46

### 47 **Keywords**

48 Physical activity, cardiorespiratory fitness, sedentary behaviours, school-based, scoping review,  
49 Health Promoting School

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56 Abbreviations  
57 ACTIPROS ACTivity PROMotion via Schools  
58 PA physical activity  
59 CRCT cluster randomized controlled trial  
60 CRF cardiorespiratory fitness  
61 SB sedentary behaviour

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## 75 Background

76 Physical inactivity is considered one of the four leading global health risks (1) and is associated with a  
77 large number of diseases, such as cardiovascular diseases, musculoskeletal diseases and diabetes.  
78 Regular physical activity (PA) has been shown to have protective effects and benefits for many health  
79 outcomes, including increasing cardiorespiratory fitness (CRF) (2, 3).

80 Research suggests that childhood is crucial to develop an active lifestyle, which potentially tracks into  
81 adulthood (4, 5). Therefore, desirable patterns of habitual PA established in early childhood increase  
82 the likelihood of reduced mortality and superior longevity (6). Data show that few children aged 2 to  
83 11 fulfil current national and international PA recommendations (7). Research also shows a gradual  
84 decline in PA levels between childhood and adolescence (8). It is therefore of public health relevance  
85 to find effective ways of promoting PA and reducing sedentary behaviours (SB) in young people.  
86 Young peoples' PA behaviours are influenced by many different aspects, including social, family,  
87 environmental, and biological factors (9). Therefore, setting-based holistic approaches have been  
88 suggested. Setting-based approaches, e.g. in the community or in schools, provide the opportunity to  
89 reach many children and to address individual change as well as other dimensions of change  
90 (environmental, family). It is thus not surprising that schools have been considered as a key setting  
91 for health promotion activities (10). Over the past decade, many school-based interventions have  
92 been developed and evaluated with the aim of increasing PA or CRF or decreasing SB during  
93 childhood. Past systematic reviews on the effectiveness of those interventions highlighted mixed  
94 findings overall, e.g. for long-term changes in PA and fitness, and the effectiveness when involving  
95 families (11-13). A recent systematic review by Hartwig and colleagues underlined that on a mean  
96 level, PA promotion is leading to an increase in CRF, but that the increase is less pronounced in girls,  
97 in older children and in children with lower PA at baseline (14).

98 More promising results stem from a Cochrane review and meta-analysis that analysed the  
99 effectiveness of interventions that were based on the World Health Organization Health Promoting  
100 School (WHO HPS) approach on different health outcomes (15). According to the HPS framework  
101 health is promoted through the whole school environment with links to families, the community, and  
102 health services (15). Six features belong to this framework: (1.) School health policies, (2.) Physical  
103 school environment, (3.) Social school environment, (4.) Health skills and education, (5.) Links with  
104 parents and community, and (6.) Access to (school) health services (10). The authors analysed 67  
105 trials and found small but potentially important effects on a population level on certain aspects of  
106 health, e.g. for PA and physical fitness (15). When focussing on PA, fitness or sedentary behaviour, it  
107 is unclear if all features of the HPS framework are addressed equally across different PA  
108 interventions, or if interventions have focussed on specific features. Since most PA interventions are

109 designed for specific age groups and target either primary or secondary school children, in this study,  
110 we decided to focus on interventions suitable for primary school children because primary school is  
111 the first opportunity to reach all school children due to compulsory school attendance and because  
112 current PA interventions seem to work better in this age group (14). Therefore, we limited our  
113 scoping review to interventions that included, but were not limited to, an age range of six-to ten-  
114 year-old. However, this may also include interventions for older children, e.g. eight-to ten-year-old  
115 children. Moreover, we limited our search to papers published between 2010 and 2019, in order to  
116 provide state-of-the-art interventions, e.g. incorporating recent research findings in terms of design,  
117 implementation and evaluation. Furthermore, we hope that this will also result in a high rate of  
118 interventions that are currently still being used.

119 Objectives of this scoping review on existing school-based interventions aiming at PA, CRF  
120 promotion, and/or SB reductions. are the following:

121 (1) To identify school-based interventions for the promotion of PA and CRF or with the aim of  
122 reducing SB in six- to ten-year-old children;

123 (2) To map identified interventions along the features of the HPS framework;

124 (3) To carefully approach the effectiveness of HPS features and feature combinations in a descriptive  
125 manner

## 126 Methods

127 This scoping review is based on the Arksey and O'Malley (16) scoping review methodology, and Levac  
128 et al.'s (17) methodological enhancement. We used the Preferred Reporting Items for Systematic  
129 reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist (Appendix A) (18)  
130 including the "PRISMA" flowchart. The identification of research questions for this specific study is  
131 described in detail in the study protocol (19).

### 132 Literature search

133 MEDLINE, PsycInfo, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Sports  
134 Medicine & Education Index (SMEI), Education Resources Information Center (ERIC), and the  
135 Cochrane Central Register of Controlled Trials (CENTRAL) were used to search studies published  
136 between Jan 2010 and Sep 2019 reporting school-based interventions to promote PA and CRF or to  
137 reduce SB in six- to ten-year-old children. We further hand searched the reference lists of included  
138 studies. We did not apply any language limit. Search results were downloaded and de-duplicated  
139 using EndNote software and imported into Covidence (20) for further review and screening.

140 Search strategy

141 The search strategy consisted of a combination of keywords and controlled vocabulary. We  
142 combined the four search themes ‘physical activity’, ‘setting’, ‘population’, and ‘intervention’ with  
143 Boolean operators. Details on the search terms, e.g. physical activity, physical education, fitness,  
144 primary education, elementary school, child, boy, girl, program, intervention, campaign, health  
145 promotion, and on the search strategy can be found in the published protocol (19). An example of  
146 the MEDLINE search strategy is available in Appendix B.

147 Screening procedure and inclusion/exclusion criteria

148 Following the literature search, identified papers were screened for eligibility based on predefined  
149 inclusion and exclusion criteria (Table 1). The inclusion criteria were defined by population,  
150 intervention, comparator and outcomes (PICO) and are further described in the protocol (19). Briefly,  
151 we included peer-reviewed journal articles that investigated interventions implementing PA or CRF  
152 promoting or SB reducing intervention components within or outside the school setting and that  
153 recruited children via school. Study designs included in this scoping review were cluster randomised  
154 controlled trials (c)RCTs) and non-randomised controlled trials. Studies that targeted children at  
155 increased health risk, e.g. overweight and obese children, studies implemented at schools targeting  
156 children with special educational needs, study samples with a mean age above 10.5 and studies  
157 targeted at preschool-aged children were excluded. In a first step, titles and abstracts were  
158 independently screened by two reviewers (BB and LS). In a second step, full-texts were  
159 independently screened by the same two reviewers. Any disagreements were discussed within the  
160 research team (HB, MB) to obtain a final decision.

161

162 **Table 1 Inclusion and exclusion criteria**

<b>Inclusion criteria</b>	
1	The paper was published in a peer-reviewed journal or as grey literature.
2	Full text available.
3	The target group included apparently healthy children of both sexes aged 6 to 10 years attending primary schools.
4	The paper investigated an intervention (of any duration) that (1) aimed at increasing PA and/or CRF and/or reducing SB, (2) recruitment was done via school.
5	The study measured PA, SB or CRF at the individual child level at baseline and at least at one time point after the intervention.

6 Statistical analyses investigated change in PA, SB or CRF between baseline and follow-up measurement between intervention and control groups.

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**Exclusion criteria**

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- 1 Reviews, books, book chapters, conference abstracts, conference proceedings.
  - 2 Studies that only targeted individuals at increased health risk (e.g. disease prevention/weight-management programs, studies targeted at obese children only).
  - 3 Studies conducted entirely outside of the school setting (e.g. in the community or home setting) e.g. where basic intervention elements, such as recruitment and/or distribution of intervention content, was not done via schools.
  - 4 Studies that evaluated interventions implemented at special schools for children with special educational needs.
  - 5 Studies that did not contain a control group in the same age range as the intervention group.
  - 6 Study samples with a mean age > 10.5.
  - 7 Only baseline data reported.
  - 8 Publication date before 2010.
- 

163

164 **Notes: PA physical activity; SB sedentary behaviour; CRF cardiorespiratory fitness**

165

166 Data extraction

167 Briefly, our data extraction included information on study and intervention characteristics, PA and/or  
168 SB and/or CRF outcomes, features of the HPS framework, and author's conclusions on effectiveness.  
169 An overview of the data extracted can be found in Appendix C. For those interventions that  
170 addressed multiple health behaviours, information and outcomes of intervention components that  
171 did not promote PA, e.g. nutrition-related intervention components such as the provision of lunch  
172 boxes, were not extracted. Further information on the data extraction and on charting the data is  
173 given elsewhere (19). Initially, two reviewers independently extracted the data of 10% of studies to  
174 compare and discuss results (BB, LS). Data extraction of the remaining studies was done by one  
175 reviewer only. Where there were disagreements, the data extraction was discussed with further  
176 members of the research team (MB, HB).



177 As a high amount of studies was expected, an Access database was set up to manage studies and to  
178 execute data extraction. The data analysis for this paper was generated using SAS software, Version  
179 9.4 for Windows copyright © 2002-2012 by SAS Institute Inc. SAS and all other SAS Institute Inc.  
180 product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC,  
181 USA. Microsoft Excel software (21) was used to create graphs of findings. If more than one study  
182 investigated the same intervention (e.g. different outcomes, different time points), data was merged  
183 into one dataset. In this case sample size and intervention content had to be the same. In case of  
184 investigations of revised intervention programs, the investigations were not merged but handled as  
185 separate studies.

## 186 Classification of the intervention effectiveness

187 The classification on the intervention effectiveness was based on the author's conclusion and was  
188 done separately for each outcome. For example regarding PA outcomes, studies that yielded no  
189 significant intervention effect on any available PA outcome in the total sample as well as in  
190 subgroups (if available) were classified as having 'no effect' on the PA outcome(s), studies that  
191 showed at least one significant intervention effect on measured PA outcomes were classified as  
192 'partly positive', and studies that reported significant intervention effects on all measured PA  
193 outcomes were classified as 'positive only'.

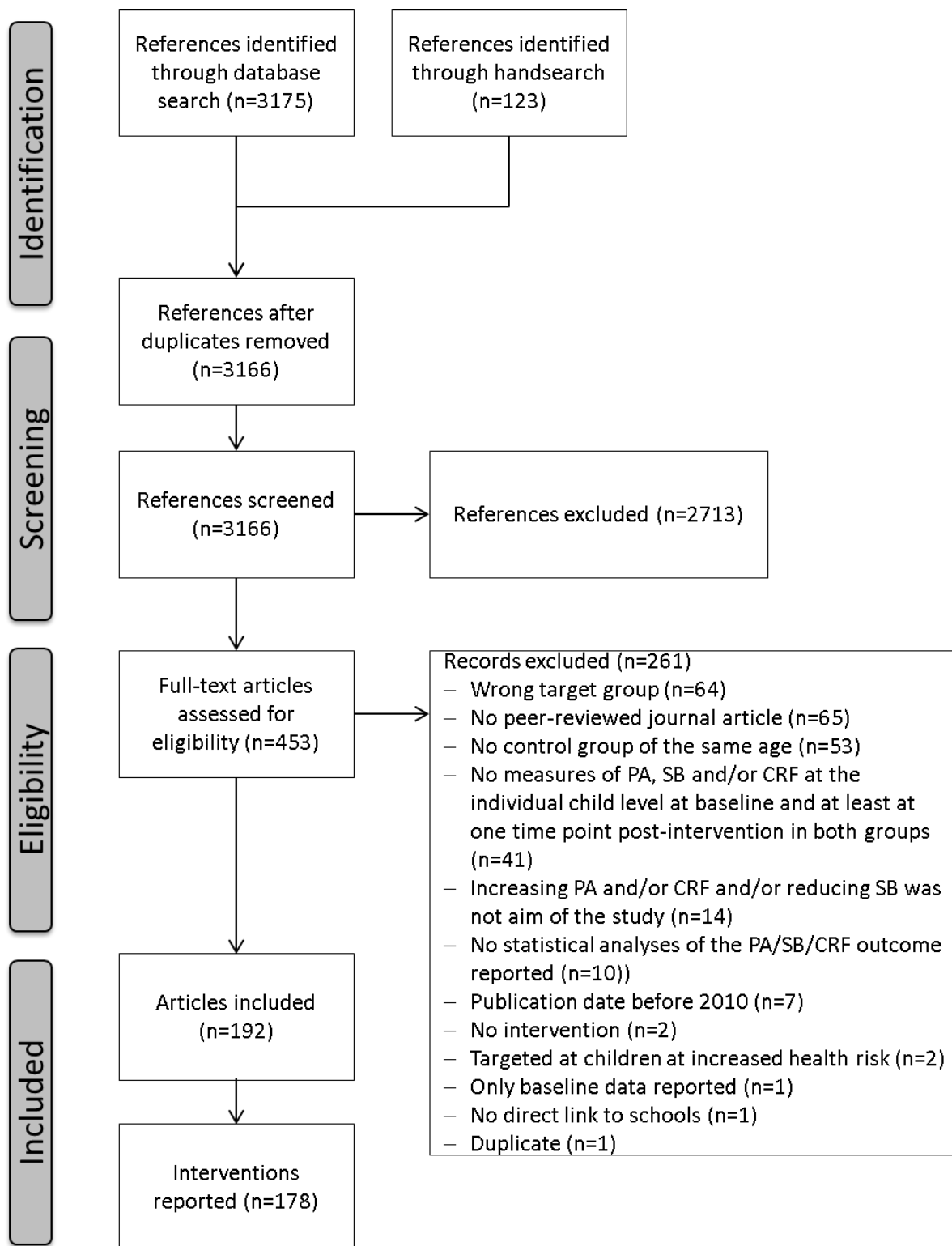
## 194 HPS framework classification

195 According to our study protocol, we classified the interventions with respect to the HPS framework  
196 into the categories 'health skills and education', 'social school environment', 'healthy school policies',  
197 'physical school environment', 'links with parents or communities', and 'access to (school) health  
198 services'. A detailed description of the categories is available in Appendix D.

## 199 Results

### 200 Search results

201 In the database search and hand search of the reference section of all included articles, 3,175 and  
202 123 articles were retrieved, respectively. After controlling for duplicates, 3,166 articles were included  
203 in the title and abstract screening. During the title and abstract screening, 2,713 records did not meet  
204 inclusion criteria. In total, 453 full-text articles were assessed for eligibility. Consequently, we  
205 included 192 articles in the final data analysis reporting on a total of 178 intervention programmes  
206 (Figure 1). Inter-rater agreement for the title and abstract screening and for the full-text assessment  
207 according to Cohen's kappa was 0.48 and 0.56, respectively. According to Cohen (1960) this indicates  
208 moderate agreement (22).



210

211 **Figure 1 PRISMA flow chart.**

212 **Note: PA physical activity, SB sedentary behaviour, CRF cardiorespiratory fitness**

213

214 Characteristics of the selected articles

215 Target group and country of origin

216 An overview of the characteristics of the identified intervention programs (N=178) is given in Table 2.  
217 All studies investigated universal intervention approaches; none of the identified studies was  
218 targeted specifically at less active children. Furthermore, most of the studies were targeted at both  
219 sexes, only two studies targeted girls only (23, 24) and one study was targeted at boys only (25).  
220 Mean age of the children in the intervention programs was 8.7 (standard deviation [SD] = 1.2). The  
221 US (n=60, 34%), the UK (n=24, 14%) and Australia (n=16, 9%) were most often identified as country  
222 of origin. Regarding continents, nearly half of the interventions (n=80, 46%) came from Europe and  
223 36% (n=63) from North America (Figure 2).

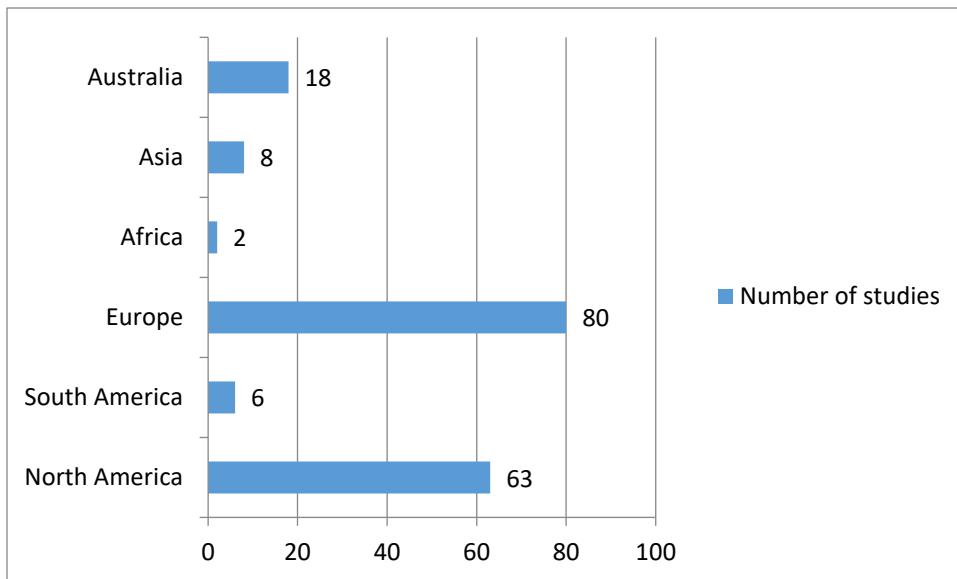
224 **Table 2 Characteristics of the included studies**

<i>Characteristic</i>	<i>Frequency (n)</i>	<i>Percentage (%)</i>
<b>Study design</b>		
<i>(C)RCT</i>	106	60%
<i>CT</i>	68	38%
<i>Other</i>	4	2%
<b>Pilot/feasibility trial</b>	28	16%
<b>Longer-term follow up (over 6 months)</b>	24	13%
<b>Theory-based intervention</b>	62	35%
<b>Outcome</b>		
PA outcome included	146	82%
SB outcome included	69	39%
CRF outcome included	68	38%

225

226 **Note: (C) RCT (cluster) randomized controlled trial; CT controlled trial; PA physical activity, SB sedentary behaviour, CRF**  
227 **cardiorespiratory fitness**

228



229

230 **Figure 2** Number of studies according to continent.

231

232 Study design and year of publication

233 Most of the studies that investigated the effectiveness of the intervention programs were (cluster)  
 234 randomized controlled trials (60%). Controlled trials with and without matching were represented as  
 235 well (38%) and 2% were classified as 'other'. Moreover, most of the studies were efficacy trials  
 236 (n=146, 82%), while 28 studies were pilot/feasibility trials (16%). For six studies, process evaluations  
 237 were retrieved in the search (3%) and for one study, data on cost-effectiveness were reported (0.5%).  
 238 Twenty-four studies (13%) assessed the intervention effectiveness in the long-term meaning that a  
 239 follow-up assessment at least six months after the end of the intervention period has been  
 240 undertaken. Mean sample size of the included studies was 837 (SD = 1.795; Range: 30-16,228  
 241 children). One hundred and nineteen studies (67%) stated that children from the control group  
 242 received standard care or care as usual while 46 studies (26%) provided no information regarding the  
 243 control group and 13 studies (7%) reported that the control group either received incentives (n=4),  
 244 was asked not to provide PE lessons during the study period (n=1), was asked not to provide PA  
 245 promoting lessons during the study period (n=1), received group sessions on health behaviours (n=6),  
 246 or offered 30 minutes of free play each school day (n=1). Between 2010 and 2019, the number of  
 247 publications ranged between 11 and 23, without a clear pattern of an increase or decrease during  
 248 this nine-year period.

249 Intervention characteristics

250 One-third of the studies stated that the intervention investigated was theory-based (n=62, 35%).  
251 Intervention duration on average was 44 weeks (Range: 1-410 weeks). Most of the studies were  
252 delivered in the school setting (n=152, 85%), after-school setting (n=31, 17%) or community setting  
253 (n=13, 7%). Only few interventions were simultaneously implemented in more than one setting  
254 (n=21, 12%). More than half of the articles reported that the intervention was delivered by  
255 (classroom) teachers (n=98, 55%). One-fifth reported that PE teachers were involved in intervention  
256 delivery (n=36, 20%). Research workers were involved in the delivery of the intervention in 23  
257 intervention programs (13%), parents in nine intervention programs (5%) and in 20 studies it was  
258 unclear who was responsible for intervention delivery (11%).

259 Outcome measures

260 Out of 146 studies that assessed PA outcomes, half of the studies (n=74, 51%) used accelerometers,  
261 25 studies (17%) used pedometers, 58 studies (40%) questionnaires and 8 (5%) direct observation.  
262 Studies with SB outcome used accelerometers (n=32, 47%) and questionnaire-based measures (n=38,  
263 55%). The shuttle run was used most often (n=32, 47%) in the identified studies that assessed CRF,  
264 followed by distance runs (n=15, 22%), e.g. 6-minute run. In nearly 90% of the studies assessing PA,  
265 PA outcomes were defined as primary outcomes (n=126), whereas CRF was defined as a primary  
266 outcome in 76% of the studies assessing CRF (n=52), and only half of the studies that assessed SB  
267 used this as a primary outcome (n=36, 52%).

268 Author's conclusion on effectiveness post-intervention and at long-term follow-up

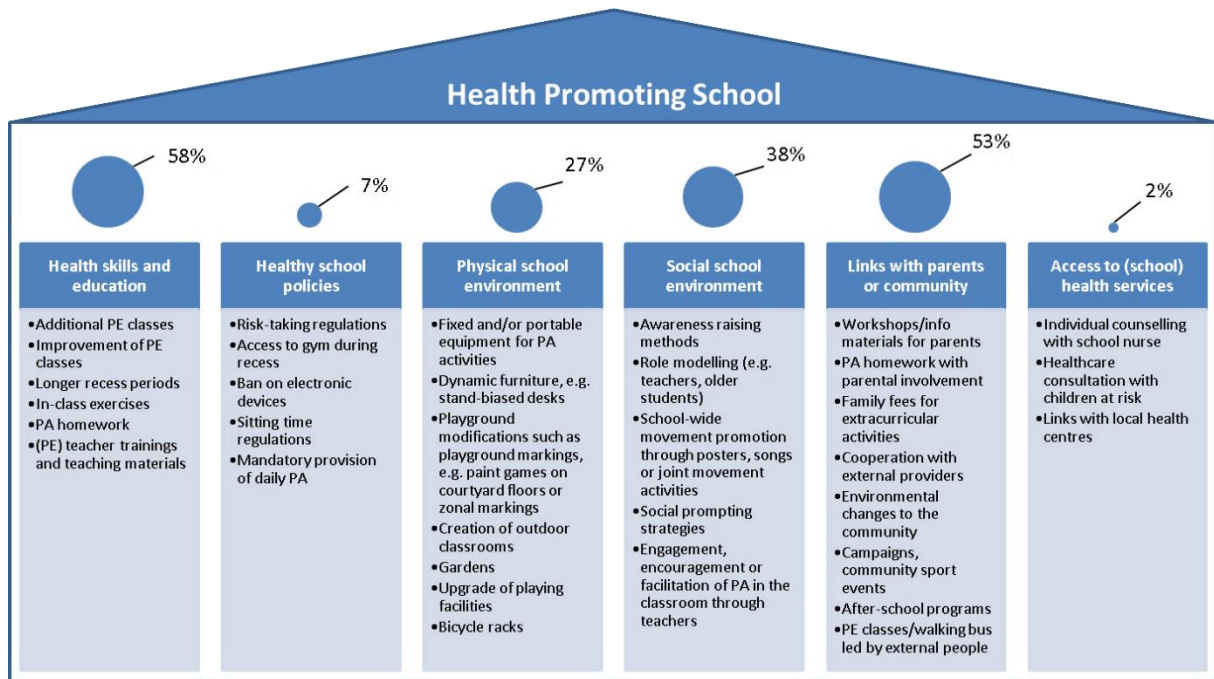
269 Eighty-five (47%) studies included one outcome of interest, 81 (46%) studies included two outcomes  
270 of interest, and 12 studies (7%) included all three outcomes of interest. Generally, 92 studies (52%)  
271 investigated intervention effects in subgroups, e.g. in boys and girls separately. One hundred and  
272 forty-one (79%) studies evaluated the effectiveness of the intervention on PA outcomes post-  
273 intervention and nineteen (11%) studies at long-term follow-up. Of those 141 studies, 93 studies  
274 (66%) were classified as being at least 'partly positive' while 48 studies (34%) did not show any  
275 intervention effect on the PA outcome(s). Regarding long-term effectiveness, 9 of nineteen studies  
276 (47%) were classified as being at least 'partly positive' while ten studies (53%) did not show any  
277 intervention effect on the PA outcome(s). Sixty-seven (37%) and eight (5%) studies evaluated the  
278 effectiveness of the intervention on SB outcomes post-intervention and at long-term follow-up,  
279 respectively. Of those 67 studies, 37 studies (56%) were classified as being at least 'partly positive'  
280 while 30 studies (44%) did not show any intervention effect on the SB outcome(s). Regarding long-

281 term effectiveness, three of eight studies (38%) were classified as being at least 'partly positive' while  
282 five studies (62%) did not show any intervention effect on the SB outcome(s). Sixty-five (37%) and  
283 eight (5%) studies evaluated the effectiveness of the intervention on CRF outcomes post-intervention  
284 and at long-term follow-up, respectively. Of those 65 studies, 34 studies (52%) were classified as  
285 being at least 'partly positive' while 31 studies (48%) did not show any intervention effect on the CRF  
286 outcome(s). Regarding long-term effectiveness, four of eight studies (50%) were classified as 'positive  
287 only' while four studies (50%) did not show any intervention effect on the CRF outcome(s).

288 Use of the key features of the HPS framework for physical activity promotion

289 Frequencies of HPS features that have been addressed and examples of intervention contents

290 School-based interventions from the last decade most often addressed the HPS feature 'Health skills  
291 and education' (n=104, 58%), followed by the feature 'Links with parents or community' (n=95, 53%).  
292 The features 'Healthy school policies' and 'Access to (school) health services' were rarely addressed  
293 in the identified studies (n=13, 7%; n=4, 2%; Figure 3). The majority of the studies addressed only one  
294 feature of the HPS framework (n=84, 47%), one-third of the studies addressed two features (n=51,  
295 29%), some studies addressed three features (n=28, 16%), four features (n=14, 8%), and only one of  
296 the identified studies addressed five of the six key features (1%). Figure 3 gives an overview of the  
297 content of PA-related interventions that have been described in the identified studies and how they  
298 have been mapped according to the features of the HPS framework. Appendix E gives an overview of  
299 key features that have been addressed in each of the included studies. Table 3 shows frequencies of  
300 identified feature combinations according to the included studies in our review.



301

302 **Figure 3 Overview of HPS features and intervention content. Examples of specific intervention contents are given in the**  
 303 **boxes below the HPS features. Bubble size represents percentage of studies addressing each specific feature.**

304

305 **Table 3 Feature combinations and their frequencies in the identified studies (n=178).** Frequencies are given in absolute  
 306 numbers and percentage for single HPS features and feature combinations, as indicated by 'x'.

Health skills and education	Healthy school policies	Physical school environment	Social school environment	Links with parents or communities	Access to (school) health services	Frequency (n)	Percentage (%)
				X		25	14.0
				X	X	1	0.6
			X			19	10.7
			X	X		6	3.4
		X				6	3.4
		X		X		3	1.7
		X	X			2	1.1
		X	X	X		5	2.8
	X					1	0.6
	X			X		1	0.6

	x		x	x	x	1	0.6
	x	x				2	1.1
	x	x	x			1	0.6
	x	x	x	x		1	0.6
x						33	18.5
x				x		25	14.0
x				x	x	2	1.1
x			x			6	3.4
x			x	x		7	3.9
x		x				5	2.8
x		x		x		4	2.3
x		x	x			7	3.9
x		x	x	x		9	5.1
x	x			x		2	1.1
x	x		x	x		1	0.6
x	x	x		x		1	0.6
x	x	x	x			1	0.6
x	x	x	x	x		1	0.6
						178	100

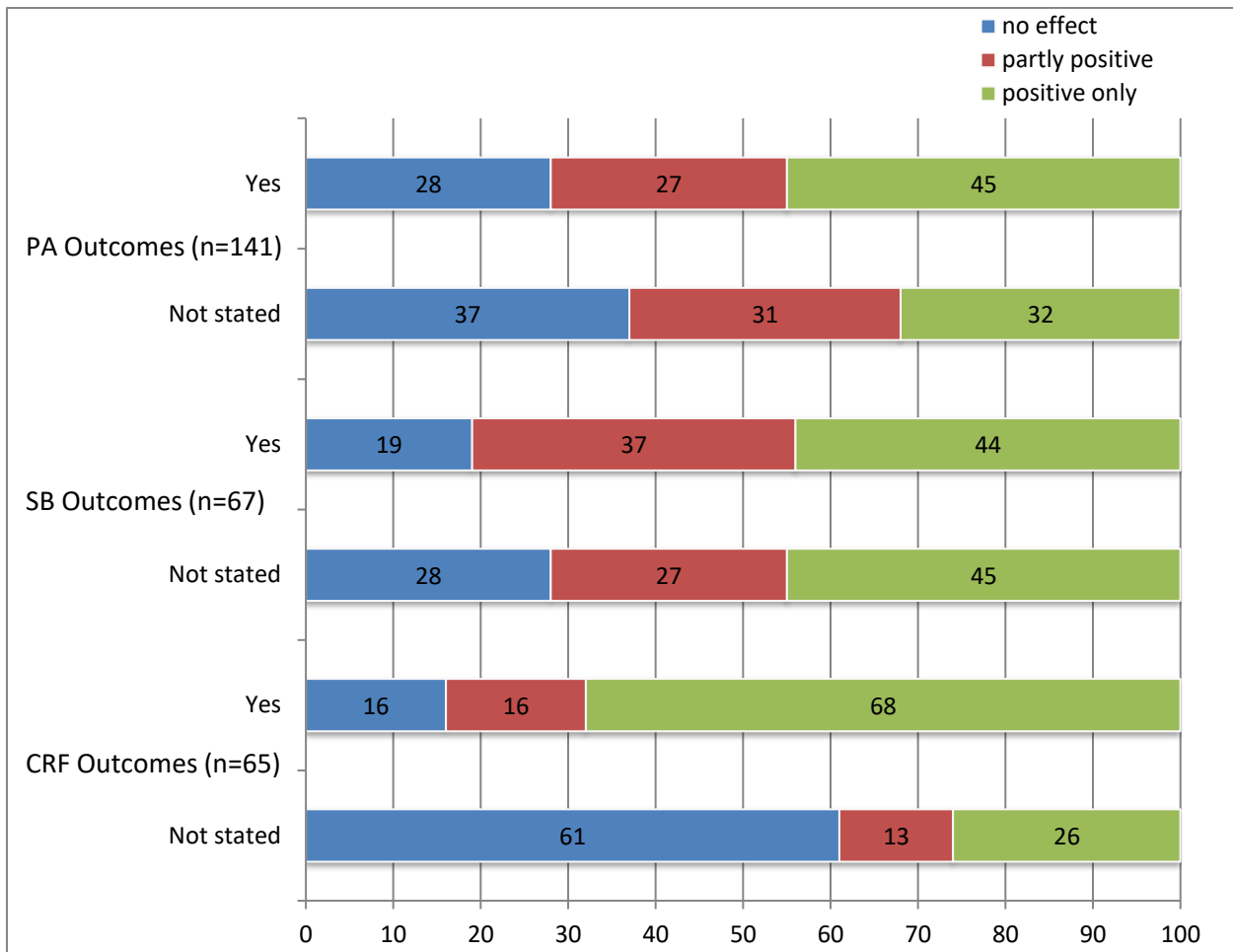
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308

309 Promising intervention components

310 Of the interventions that were delivered by a (PE) teacher and those focusing on PA as the outcome,  
311 64% were deemed as partly positive or positive only (SB outcome: 49%, CRF outcome: 51%). Of those  
312 that were not delivered by teachers, a similar amount of interventions was deemed as partly positive  
313 or positive only (PA outcome: 68%, SB outcome: 65%, CRF outcome: 55%) (Appendix F). Interventions  
314 seem to be successful more often if they have stated a theoretical foundation. For example,  
315 regarding the effectiveness of CRF outcomes, the percentage of non-effective studies was lower  
316 among those that stated having a theoretical foundation compared to those that did not state any  
317 theoretical foundation (15.8% vs. 60.8%; Figure 4).





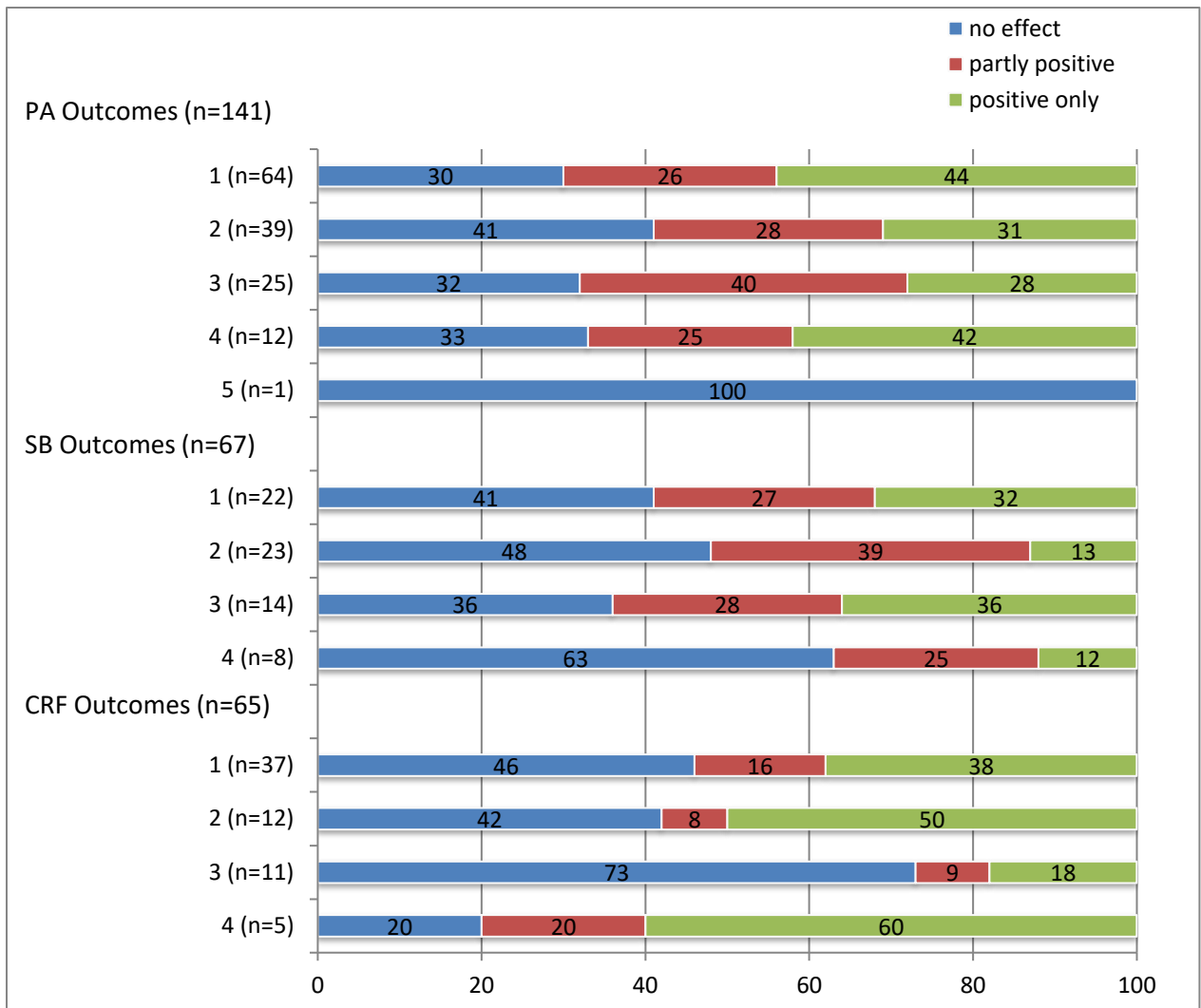
318  
319

320 **Figure 4 Theoretical foundation and intervention effectiveness.**

321 **Note: x-axis in %; y-axis Theoretical foundation stated (yes/not stated); PA physical activity, SB sedentary behaviour, CRF**  
322 **cardiorespiratory fitness**

323

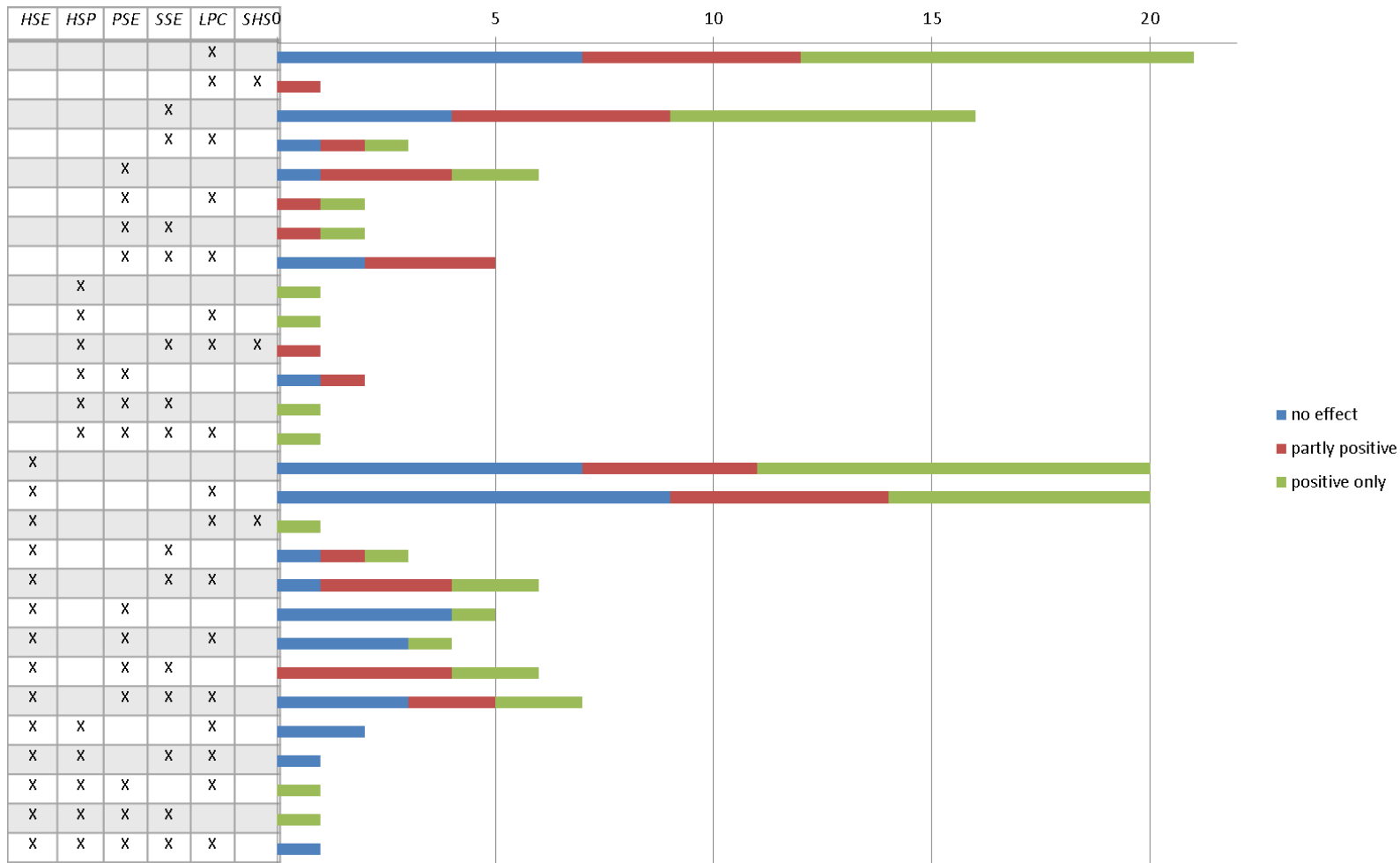
324 Current approaches that used multiple settings did not seem to be more successful regarding the  
325 effectiveness of the interventions whereby they have hardly been examined so far (n=21, 12%)  
326 (Appendix G). Holistic approaches that addressed more than one feature of the HPS framework did  
327 not seem to be more successful either (Figure 5). Furthermore, we tried to identify certain feature  
328 combinations that seem to be associated with better intervention effectiveness per outcome. The  
329 number of studies of each specific HPS feature combination and the effectiveness on the PA  
330 outcome(s) can be found in Figure 6. For the SB and CRF outcome, results are shown in Appendix H.



331  
332

333 **Figure 5** Number of HPS features and intervention effectiveness.

334 **Note:** x-axis in %; y-axis indicates number of HPS features that have simultaneously been addressed; PA physical activity,  
335 SB sedentary behaviour, CRF cardiorespiratory fitness



336

337 **Figure 6 Feature combinations and intervention effectiveness on PA outcomes.**

338 **Note: x-axis indicates numbers of studies; y-axis indicates HPS feature combination; HSE health skills and education; HSP healthy school policy; PSE physical school environment; SSE social**  
 339 **school environment; LPC Links with parents and community; SHS Access to (school) health services**

## 340 Discussion

341 Results of this scoping review show that during the last decade, many school-based interventions for  
342 the promotion of PA and fitness or for the reduction of SB in young children have been implemented  
343 and evaluated worldwide. Studies from Western or high-income countries were over-represented.  
344 Likewise, interventions have mainly been conducted in Europe, North America and Australia. A  
345 negligible number of interventions were gender-specific. Whilst theoretical foundation is generally  
346 deemed important (26), a number of studies lacked information on this aspect.

347 Our systematic search included school-based interventions that also targeted PA beyond the school  
348 setting, in order to fully cover the HPS feature 'links with parents and community'. For example, we  
349 considered an intervention as relevant if the recruitment was done via school and basic content was  
350 delivered via schools, but the setting where the PA was to be increased was in the community or  
351 family. For example, in walking bus and cycling train interventions, primary school children as well as  
352 the accompanying persons (parents) were recruited at school, but the intervention itself took place  
353 outside the school area (27, 28).

354 Nonetheless, most of the interventions from the last decade were delivered via school only.  
355 Regarding features of the HPS framework, interventions most often addressed only one feature of  
356 the HPS framework and only a small number was based on multiple features. This is surprising since  
357 the idea of an HPS is not new and taking a holistic approach to health promotion in schools via  
358 healthy settings etc. has been long promoted. So far, evidence suggests that current school-based  
359 efforts still do not positively impact young people's PA across the whole day (14). Therefore, efforts  
360 within the school setting seem to fail in making substantial changes to decrease levels of physical  
361 inactivity in children as well as eliminating physical activity inequities in children. In contrast, a recent  
362 systematic review on the effectiveness of the HPS framework in improving the health and well-being  
363 of students and their academic achievement by Langford et al. (15), identifying four (C)RCTs that  
364 tackled PA and 18 interventions that tackled PA and nutrition combined, reported that those  
365 interventions were promising regarding positive effects on PA and physical fitness. Current evidence  
366 therefore indicates that school-based efforts should better utilise holistic approaches. Those may  
367 also potentially be suitable for sustainable change and scale-up. At the same time, our results  
368 indicate that besides those multi-level multi-feature approaches, certain single-feature interventions  
369 (e.g. changes in the physical environment) can be recommended. Those simpler interventions may  
370 be used as a "door opener" in schools and hard-to-reach populations when approaching schools for  
371 the first time. They may also be easier to implement than complex interventions. Based on their  
372 systematic review of 500 studies analysing the effects of interventions for primary prevention and  
373 health promotion targeting children and adolescents, Durlak et al. came to the conclusion that higher

374 levels of implementation were often associated with better outcomes (29). An implementation dose  
375 of at least 60% irrespective of intervention complexity should therefore be aimed for (29).

376 Furthermore, independent of the complexity of an intervention, our results show that a sound  
377 theoretical foundation is warranted. There is evidence that interventions underpinned by theory may  
378 be the most effective approaches to positively change children's PA (30) which is also supported by  
379 our findings. We also found that interventions focusing on individual behaviour change were  
380 dominant while there is a growing body of research examining interventions with environmental  
381 changes. However, healthy school policies have rarely been implemented so far. We therefore  
382 suggest better combining components that address individual health behaviour change, social and  
383 physical environmental change, as well as school-wide policies as recommended by theoretical  
384 foundations such as the socio-ecological model by Sallis et al. (31). Since we were not able to identify  
385 key combinations of HPS features that led to a high percentage of effective interventions, potentially,  
386 feature combinations that are carefully linked to a sound theoretical foundation are working best.  
387 We also want to highlight that some features might not be as relevant as other features. For  
388 example, the feature "access to health services" requires the availability of health services close to  
389 the school, and this might not be the case generally. But other important factors such as the quality  
390 of parental engagement or implementation issues that we did not assess in this study, may have a  
391 strong link to intervention effectiveness as well. Beside the question whether an HPS initiative leads  
392 to immediate behaviour change at the individual level, further questions regarding potential markers  
393 of success that are predominantly associated with the process should also be taken into account  
394 while evaluating an HPS (32).

395 Another important finding of our review is that the majority of the studies did not investigate  
396 intervention effects in the long term. Only 13% included long-term findings after at least six months,  
397 whereby a period of only six months must also be viewed critically as a benchmark for long-term  
398 effects. Those who did, most often showed no intervention effect in the long term, with the  
399 exception of CRF outcomes (n=4, 50% positive only). Furthermore, 26% of the studies did not provide  
400 any information on the control group. Summarizing, it is hardly possible to conclude on long-term  
401 effects and sustainability issues from the data available in the screened papers. Generally, most of  
402 the studies utilised heterogeneous measurements for the assessment of PA and SB outcomes (e.g.  
403 accelerometry vs. questionnaire-based instruments). In terms of CRF outcomes, measurement  
404 methods were found to be more homogeneous.

405 Multiple school-based approaches for the promotion of PA, CRF, and the reduction of SB have been  
406 evaluated during the last decade with mixed findings overall. We recommend further research on  
407 single- as well as multi-feature intervention studies with a sound theoretical foundation, because

408 from our perspective, interventions covering multiple HPS features were not shown to be more  
409 successful in contrast to single feature interventions. Furthermore, we emphasise studies on  
410 implementation processes as well as scale-up of existing programs that already have been proven to  
411 be effective in a controlled trial.

## 412 Strengths and limitations

413 To our knowledge, this is the first study that classified interventions from the last decade according  
414 to the HPS framework and analysed data on intervention effectiveness on three different outcomes.  
415 Following the strict methodology of Arskey and O'Malley, and incorporating Levac's enhancement is  
416 a strength of this study. We provide a broad overview of interventions that have been conducted  
417 within the school setting and beyond. However, our classification was based on the intervention  
418 description in the respective study and we did not consider additional information from e.g. study  
419 protocols, manuals and grey literature. Potentially, our classification could lack some minor details  
420 regarding the content of the intervention that has been investigated in the respective study.  
421 However, given the fact that more and more scientific publication cover the main features of an  
422 intervention, e.g. by requiring adherence to the CONSORT list, we believe that our classifications  
423 would not change substantially, if we had considered additional sources of information. Our search  
424 was limited to publications published in the last ten years. Given the time delay between conducting  
425 a study and its publication, a further strength of this scoping review is that it should cover the  
426 majority of interventions which have been implemented and scientifically evaluated within the last  
427 12 years. However, we did not cover interventions that were published in grey literature, which may  
428 have led to a publication bias. As common within scoping reviews, we also did not assess study  
429 quality. Author agreement during the screening process was moderate. A further limitation is that  
430 regarding the effectiveness of interventions we relied on authors' reporting of effectiveness. Again,  
431 we bring to the reader's attention that we only intend to approach effectiveness on a descriptive  
432 basis, and that systematic reviews and meta-analysis are needed to statistically examine  
433 effectiveness. Generally, the number of studies applying certain feature combinations was very  
434 limited and interpretations of the results could only be made with caution.

## 435 Conclusion

436 Our results suggest that, to date, there is inconclusive evidence regarding multi-feature  
437 interventions. To give an example, interventions that implement policy changes at the school level  
438 might be more effective in changing individual behaviours but there is still a need to further evaluate  
439 them. To enrich evidence on particular features, our approach could be evaluated further by  
440 conducting a meta-analysis. We also suggest using the findings of our review to identify existing gaps  
441 and to base future development of interventions on this knowledge while using a sound theoretical

442 foundation, which still seems to be an important factor. We further appreciate other factors at play  
443 that determine effectiveness that should be taken into account in future studies, such as long-time  
444 follow up covering at least 12 months and reporting control group characteristics. Additionally,  
445 effectiveness process evaluations and deeper insights into the “implementation gap” will play an  
446 important role in the near future.

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449 data extraction. The scoping review was written as part of the ACTIvity PROMotion via Schools  
450 (ACTIPROS) project and the results will be used to design a toolbox that will be tested in pilot schools  
451 in a second step. The idea of the toolbox is to enable schools to select and implement promising  
452 evidence-based interventions for the promotion of PA and/or CRF or that aim at reductions in SB and  
453 to adapt their selections to local conditions.

#### 454 Authors' contributions

455 BB made substantial contributions to the conception, design of the study and search strategy,  
456 acquisition of data, analysis and interpretation of the data and drafted the manuscript. BB and LS  
457 were equally responsible for the screening and data extraction. LS made contributions to the  
458 manuscript and provided support in the interpretation of the data. HB and MB made substantial  
459 contributions to the conception and design of the study and provided support in the interpretation of  
460 the data and helped review and edit the manuscript. LC made substantial contributions to the  
461 development of the search strategy and executed the search strategy and also helped to review and  
462 edit the manuscript. All authors read and approved the final version of the manuscript.

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465 funders had no role in defining the scope of the review and have not been involved in conducting the  
466 research.

#### 467 Availability of data and materials

468 The dataset generated and analysed during the current study is available in the OSF repository,  
469 <https://mfr.osf.io/render?url=https%3A%2F%2Fosf.io%2Fm8q6s%2Fdownload>

#### 470 Ethics approval and consent to participate

471 Not applicable.

472 Consent for publication

473 Not applicable.

474 Competing interests

475 The authors declare that they have no competing interests.

476

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561

## Appendix A

### PRISMA-ScR Checklist

Section/topic	Item	PRISMA-ScR Checklist item	Information reported		Line number(s)
			Yes	No	
<b>Title</b>					
Title	1	Identify the report as a scoping review.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	1
<b>Abstract</b>					
Structured Summary	2	Provide a structured summary that includes (as applicable) background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	3,4
<b>Introduction</b>					
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions or objectives lend themselves to a scoping review approach.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	5,6
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (for example, population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions or objectives.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	6
<b>Methods</b>					
Protocol and Registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (for example, a Web address); and if available, provide registration information, including the registration number.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	7
Eligibility Criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (for example, years considered, language, and publication status), and provide a rationale.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	7-9
Information Sources	7	Describe all information sources in the search (for example, databases with dates of coverage and contact with authors to	<input checked="" type="checkbox"/>	<input type="checkbox"/>	7

Section/topic	Item	PRISMA-ScR Checklist item	Information reported		Line number(s)
			Yes	No	
		identify additional sources), as well as the date the most recent search was executed.			
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Additional file 2
Selection of Sources of Evidence	9	State the process for selecting sources of evidence (that is, screening and eligibility) included in the scoping review.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	7,8
Data Charting Process	10	Describe the methods of charting data from the included sources of evidence (for example, calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	7,8
Data Items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	9,10
Critical Appraisal of Individual Sources of Evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	<input type="checkbox"/>	<input checked="" type="checkbox"/>	-
Summary Measures	13	Not applicable for scoping reviews.	<input type="checkbox"/>	<input type="checkbox"/>	N/A
Synthesis of Results	14	Describe the methods of handling and summarizing the data that were charted.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	10
Risk of Bias Across Studies	15	Not applicable for scoping reviews.	<input type="checkbox"/>	<input type="checkbox"/>	N/A
Additional Analyses	16	Not applicable for scoping reviews.	<input type="checkbox"/>	<input type="checkbox"/>	N/A
<b>Results</b>					
Selection of Sources of Evidence	17	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	13
Characteristics of Sources of Evidence	18	For each source of evidence, present characteristics for which data were charted and provide the citations.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	13,14
Critical Appraisal Within Sources of	19	If done, present data on critical appraisal of included sources of	<input type="checkbox"/>	<input checked="" type="checkbox"/>	-

Section/topic	Item	PRISMA-ScR Checklist item	Information reported		Line number(s)
			Yes	No	
Evidence		evidence (see item 12).			
Results of Individual Sources of Evidence	20	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Additional file 4
Synthesis of Results	21	Summarize or present the charting results as they relate to the review questions and objectives.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	13-19
Risk of Bias Across Studies	22	Not applicable for scoping reviews.	<input type="checkbox"/>	<input type="checkbox"/>	N/A
Additional Analyses	23	Not applicable for scoping reviews.	<input type="checkbox"/>	<input type="checkbox"/>	N/A
<b>Discussion</b>					
Summary of Evidence	24	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	20-22
Limitations	25	Discuss the limitations of the scoping review process.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	22
Conclusions	26	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications or next steps.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	23
<b>Funding</b>					
Funding	27	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	24

## Appendix B

### MEDLINE search strategy

Medline via Ovid 1946 to September Week 1 2019

Searched/exported 19.09.2019

#### Line number Search

- 1 (boy\* or child\* or girl\* or kid\* or minor\* or preteen\* or youth\* or p?ediatric).ti,ab.
- 2 exp child/
- 3 or/1-2
- 4 (sport\* or exercis\* or fitness\* or athletic\*).ti,ab.
- 5 (physical adj3 (activit\* or education or exertion? or training)).ti,ab.
- 6 exp sports/
- 7 exp exercise/
- 8 exp "physical education and training"/
- 9 exp "physical fitness"/
- 10 or/4-9
- 11 "school based".ti,ab.  
((elementary or entry or grade or grammar or prep or preparatory or primary) adj3
- 12 school\*).ti,ab.
- 13 ((elementary or primary or "grade school" or "low\* level") adj3 education).ti,ab.
- 14 exp schools/
- 15 or/11-14  
((school\* or "school based") adj5 (promot\* or advoca\* or program\* or intervention\* or
- 16 initiative\* or strateg\* or campaign\*).ti,ab.
- 17 exp "school health services"/
- 18 exp "health promotion"/
- 19 or/16-18
- 20 and/3,10,15,19
- 21 limit 20 to yr="2010 -Current"

## Appendix C

### Overview of the content of the data extraction

Category	Characteristics
1. Study ID	First author and year of publication of main report
2. Report ID	First author and year of publication of the study
3. Aim of the study	Aim of the study
4. Study design	Study design used
5. Long-term evaluation of effects	Study investigated intervention effects at least six month after the end of the intervention Yes/No
6. Origin	The country in which the intervention was carried out
7. Sample size	Total sample size at start of the study
8. Target group	Mean age, age range, sex of the target group
9. Approach	Universal intervention vs. targeted at low active children
10. Theory	Availability of a theoretical framework Yes/Not stated
11. Setting	Setting in which intervention was delivered
12. Providers	Providers of intervention content
13. HPS features	Based on the WHO definition of a Health Promoting School (15) we assessed whether the following six features have been addressed or not  (1) Health skills and education Yes/No (2) Healthy school policies Yes/No (3) Physical school environment Yes/No (4) Social school environment Yes/No (5) Links with parents or communities Yes/No (6) Access to (school) health services Yes/No
14. HPS feature description	Description of intervention content that was classified as belonging to one of the six HPS features
15. PA outcomes	Primary aim Yes/No, PA outcome(s), PA measure(s)
16. SB outcomes	Primary aim Y/N, SB outcome(s), SB measure(s)
17. CRF outcomes	Primary aim Y/N, CRF outcome(s), CRF measure(s)
18. Subgroups	Subgroups have been analysed Y/N/unclear
19. Author's conclusion	Author's conclusion on effectiveness of the intervention on  (1) PA outcome(s) (2) SB outcome(s) (3) CRF outcome(s)

**Note:** PA physical activity, SB sedentary behaviour, CRF cardiorespiratory fitness

## **Appendix D**

### **HPS framework classification**

#### **Health skills and education**

As outlined in the study protocol, skills-based health education refers to both the formal and informal curriculum and aims at teaching PA-related knowledge, experiences and fundamental movement skills, e.g. through increased numbers of PE lessons within the school curriculum, improvement of the quality of PE lessons, longer break times, curriculum-focused active breaks (short bouts of PA that include curriculum content) within the classroom or PA homework (19). We therefore classified any teacher training or the provision of teaching materials that were to some degree related to the improvement of PA-related knowledge or to movement skills within the category 'health skills and education'. All PA-related changes to the formal curriculum such as an increase in PE lessons or longer break times were also classified within this category.

#### **Social school environment**

PA-related interventions that reported changes to the social school environment were classified under the eponymous feature (19). Those mostly school-wide approaches aim at changing the ethos and norms surrounding PA within the whole school and thus also influence people beyond the target group, such as teachers or older students. Examples of activities are teacher training on the promotion of active breaks or school-wide posters or campaigns promoting PA. Other examples include awareness-raising methods, role modelling, social prompting strategies and any encouragement, emphasis or facilitation of PA during classroom time without the focus on skills training or on health education. Regarding social norms and the school ethos, social interactions between teachers and children or teachers and parents are of high relevance. PA-related interventions that aimed at modifying those interactions were therefore classified within the category 'social school environment'. This means at the same time that teachers had to be involved in some way in the delivery of intervention components to satisfy this feature.

#### **Healthy school policies**

PA-related regulations that are written down and implemented at the school level or accepted practices such as risk-taking regulations, agreements that allow access to a gym during break, bans on electronic devices or sitting time regulations were classified as 'healthy school policies'.

#### **Physical school environment**

Changes to the school infrastructure such as extra cycle racks, shaded areas on the playground, activity areas and space for movement within the classroom, purchasing of new PA equipment or dynamic furniture, the creation of outdoor classrooms or gardens were defined as changes to the 'physical school environment'.

## Links with parents or communities

Interventions that included any links to parents or the wider community were categorised as 'links with parents or communities'. For example, this included interventions incorporating newsletters or workshops for parents, family PA homework lessons or the cooperation with external services, e.g. people from sport clubs. Since our search strategy yielded many results that investigated so-called after-school programs, all after-school programs were grouped into the category 'links with parents or communities'. In the US, for example, multiple forms of care exist before and after school among primary school children (22) and 37.7% of five- to fourteen-year old children of the US population participate in some form of organized after-school activity at least once per week (23). Reasons for after-school programs are that they may offer more curricular flexibility and time for prevention activities compared to the school setting itself (23). To date, several after-school programs have been established, mainly focusing on daily PA and/or the provision of skill building sessions (23). Because after-school programs do not necessarily take place within the school building and have no direct link to the typical school day, we decided to consistently classify them within the category 'links with parents and community'.

Moreover, environmental changes outside the school ground, e.g. signs within a radius of one mile for walking school bus activities were classified as 'links with parents and community'. Active transportation activities that were implemented by parents or external providers were also classified as 'links with parents and community' whereas active transportation activities within the school that included the promotion of active transportation by teachers were classified as changes to the 'social school environment'.

## Access to (school) health services

The category 'access to (school) health services' includes education for school nurses in PA-related problems, e.g. obesity, individual counselling with school nurses, or healthcare consultations for children at increased health risk or links with local health centres.



## Appendix E

## Overview of features addressed

<i>Study</i>	<i>Name of trial</i>	<i>Health skills and education</i>	<i>Healthy school policies</i>	<i>Physical school environment</i>	<i>Social school environment</i>	<i>Links with parents or communities</i>	<i>Access to (school) health services</i>
Aadland 2019 (1)	Active Smarter Kids (ASK)	X		X		X	
Aburto 2011(2)		X		X	X		
Adab 2018a (3); Adab 2018b (4)	West Midlands ActiVe lifestyle and healthy Eating in School children (WAVES)				X	X	
Annesi 2016a (5)				X		X	
Annesi 2016b (6); Annesi 2017 (7)	Youth Fit 4 Life					X	
Ariza 2019 (8)	POIBA intervention				X	X	
Bai 2017 (9)	NFL PLAY 60	X		X	X	X	
Barnes 2015 (10)	MADE4 Life					X	
Bartelink 2019 (11)	Healthy Primary School of the Future (HPSF)	X				X	
Beets 2015 (12)						X	
Beets 2016 (13)	Strategies-To-Enhance-Practice (STEPS)					X	
Benden 2014 (14)	Stand-biased desk			X		X	
Bhave 2016 (15)	SYM-KEM study	X			X		
Blaes 2013 (16)				X			
Bolton 2017 (17)	Health-Promoting Communities: Being Active Eating Well (HPC:BAEW, 2007–2010) initiative					X	X
Boyle-Holmes 2010 (18)	Michigan's Exemplary Physical Education Curriculum (EPEC)	X					
Brandstetter 2012 (19)	URMEL-ICE	X			X	X	
Breslin 2012 (20)	Sport for LIFE	X				X	
Breslin 2019 (21)	Sport for LIFE	X					
Brink 2010 (22)	The Learning Landscapes Program			X			
Brittin 2017 (23)				X			
Brusseau 2018 (24)	Fit "n" Cool Kids				X		
Bugge 2012 (25)	Copenhagen School Child Intervention Study	X		X			
Bundy 2017 (26)	Sydney Playground Project			X	X	X	
Bungum 2014 (27)	Nevada Moves Day (NMD)				X		
Centis 2012 (28)		X				X	
Chawla 2017 (29)		X		X	X	X	

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Chesham 2018 (30)	The Daily Mile				X		
Cohen 2015 (31)	Supporting Children's Outcomes using Rewards, Exercise, and Skills (SCORES)		X	X	X	X	
Colin-Ramirez 2010 (32)	RESCATE	X			X	X	
Coombes 2016 (33)	Beat the Street				X	X	
Cradock 2014 (34)	Boston Active School Day Policy	X	X	X	X		
Cradock 2016 (35)	Out of School Nutrition and Physical Activity (OSNAP) Initiative						X
Croker 2012 (36)	Change4Life (C4L)						X
Cronholm 2016 (37)		X					
Cronholm 2017 (38); Cronholm 2018 (39); Detter 2014 (40)	Pediatric Osteoporosis Prevention (POP) study	X					
Crouter 2015 (41)							X
Cvejic 2017 (42)	FITT	X					
Dallolio 2016 (43)		X					
Dave 2017 (44)	Active Living project			X	X	X	
DeBourdeaudhuij 2015 (45)	IDEFICS	X		X	X	X	
Do elly 2017 (46)	Academic Achievement and Physical Activity Across the Curriculum intervention (A+PAAC)				X		
Drummy 2016 (47)					X		
Ducheyne 2014 (48)		X					X
Duncan 2010 (49)					X		
Duncan 2011 (50)	'Healthy Homework' programme	X					X
Dunton 2015 (51)							X
Dzewaltowski 2010 (52)	Healthy Opportunities for Physical Activity and Nutrition (HOP'N) after-school project						X
Efrat 2013 (53)					X		
Elinder 2012 (54)	Stockholm County Implementation Programme (SCIP)	X		X	X	X	
Engelen 2013 (55)				X			X
Erwin 2011 (56)					X		

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Fairclough 2013 (57)	Children's Health, Activity and Nutrition: Get Educated! (CHANGE!)	X					X
Fairclough 2016 (58)	Born to move	X					
Farmer 2017 (59)	PLAY		X	X			
Fassnacht 2015 (60)		X					X
Fetter 2018 (61)	Shaping Healthy Choices Program (SHCP)						X
Folta 2013 (62)	Shape Up Somerville	X		X	X		X
Gallotta 2017 (63)		X					
Gatica-Domínguez 2019 (64)		X		X			X
Gorely 2011 (65)	GreatFun2Run	X					X
Gortmaker 2012 (66)	YMCA	X					X
Graf 2011 (67)	Children's Health Interventional Trial (CHILT-I)	X		X	X		X
Greening 2011 (68)	TEAM Mississippi Project						X
Griffiths 2019 (69)		X	X				X
Grillich 2016 (70)	Classes in Motion				X		
Haapala 2017 (71)	Fi ish Schools on the Move program	X		X	X		
Habib-Mourad 2014 (72)	Health-E-PALS	X					X
Hamer 2017 (73)	Camden Active Spaces			X			
Hardman 2011 (74)	Fit 'n' Fun Dude	X			X		X
Hatzis 2010 (75)		X					X
Have 2018 (76)		X					
Hayes 2015 (77)					X		
Heelan 2010 (78)							X
Hendy 2011 (79)	Kid's Choice Program (KCP)				X		X
Herbert 2013 (80)	Energize	X					
Herrick 2012 (81)	Sports, Play, and Recreation for Youth (SPARK) program						X
Howe 2012 (82)		X					
Huberty 2011 (83)	Ready for Recess			X	X		
Hyndman 2014 (84)	Lunchtime Enjoyment Activity and Play (LEAP) school playground intervention			X			
Jago 2014 (85)	Action 3:30						X
Jago 2019 (86)	Action 3:30R						X

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James-Burdumy 2016 (87)	Playworks program				X		
Jansen 2011 (88)	Lekker Fit! (Enjoy being fit!)	X				X	X
Janssen 2013 (89)	PLAYgrounds			X	X		
Jurak 2013 (90)		X					
Kain 2014 (91)		X					
Katz 2010 (92)	Activity Burts in the Classroom (ABC)				X	X	
Kelly 2012 (93)		X		X			
Kipping 2014 (94); Anderson 2015 (95)	Active for Life Year 5 (AFLY5)	X				X	
Klakk 2014 (96)	CHAMPS study-DK	X			X		
Lammle 2016 (97); Kobel 2014 (98); Kobel 2017 (99)	Join the Healthy Boat	X				X	
Kocken 2016 (100)	"Extra Fit!" (EF!)	X				X	
Kriemler 2010 (101); Meyer 2014 (102)	Kinder- und Jugendsportstudie (KISS)	X					
Kuli a 2012 (103)		X		X	X		
Kvalo 2017 (104)	Active school study	X		X	X		
LaChausse 2017 (105)	Harvest of the Month (HOTM)					X	
Larsen 2018 (106)	Fit First					X	
Larson 2018 (107)	Fit "N" Cool Kids				X		
Lau 2016 (108)						X	
Li 2014 (109)		X				X	
Liu 2019 (110)		X	X	X		X	
Llargues 2011 (111); Llargues 2017 (112)	AVall study	X		X	X	X	
Llaurado 2014 (113)	EdAI-2 study	X					
Lloyd 2012 (114)	Healthy Lifestyles Programme (HeLP)	X				X	
Lloyd 2018 (115)	Healthy Lifestyles Programme (HeLP)	X				X	
Lopes 2017 (116)		X					
Lucertini 2013 (117)		X					
Lynch 2016 (118)	Let's Go! 5-2-1-0	X					
Madsen 2013 (119)	America SCORES					X	
Madsen 2015 (120)	Energy Balance 4 Kids with Play	X	X			X	

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Magnusson 2011 (121); Magnusson 2012 (122)		X		X	X		
Matsui 2019 (123)		X					X
Matvienko 2010 (124)	NutriActive program						X
Mayfield 2017 (125)	Peaceful Playgrounds™	X		X			
McKay 2015 (126)	Action Schools! BC (AS! BC)	X		X	X	X	
McMi 2012 (127)	Travelling Green	X					
Mendoza 2011 (128)	walking school bus program						X
Mendoza 2017 (129)							X
Merrottsy 2019 (130)	Project Spraoi	X			X		
Morris 2013 (131)	Great Activity Programme	X					X
Murtagh 2013 (132)	Bizzy Break!	X					
Nathan 2017 (133)	Great Leaders Active StudentS (GLASS)	X			X		
Nigg 2019 (134)	The Intervention for Physical Activity and Youth (IPLAY)	X		X			X
Norris 2018 (135)	Virtual Traveller (VT)				X		
Nyberg 2016 (136)		X					X
Parrish 2015 (137)	PACE		X	X	X		
Parrish 2016 (138)	Physical Activity Children and the Environment (PACE)		X	X			
Perez-Solis 2015 (139)	Tú decides tu salud. ¡Ponte a vivir!	X	X		X		X
Pettee Gabriel 2011 (140)	Girls on the Run	X			X		
Plachta-Danielzik 2011 (141)	Kiel Obesity Prevention Study (KOPS)	X			X		X
Ploeg 2014 (142)	Comprehensive school health (CSH)		X				X
Quizán-Plata 2014 (143)		X		X	X		
Resaland 2011 (144); Resaland 2011b (145); Resaland 2018 (146)	The Sogndal school-intervention study	X					
Reznik 2015 (147)	Children's Hospital at Montefiore Joining Academics and Movement (CHAM JAM)				X		
Ridgers 2010 (148)				X			
Robertson 2018 (149)	FitQuest project	X					
Sacchetti 2013 (150)			X				

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Safdie 2013 (151)		X		X	X		
Saint-Maurice 2014 (152)	R4R	X		X			
Saint-Maurice 2017 (153)	Fuel Up to Play 60 (FUTP60)				X		
Salmon 2011 (154)	Switch-2-Activity	X					
Santos 2014 (155)	Healthy Buddies				X		
Sharma 2015 (156)	Quest to Lava Mountain (QTLM)	X					
Siegrist 2013 (157)	The JuvenTUM project	X			X	X	
Sigmund 2012 (158)		X		X	X	X	
Slawta 2010 (159)	Be a Fit Kid	X				X	
Springer 2012 (160)	Marathon Kids® (MK)					X	
Sutherland 2017 (161)		X	X	X	X	X	
Szabo-Reed 2017 (162)	“Academic Achievement and Physical Activity Across the Curriculum” (A+PAAC)				X		
Tarp 2018 (163)	CHAMPS-study DK	X					
Taylor 2018 (164)				X	X	X	
Telford 2016 (165)	Lifestyle of our Kids (LOOK)	X				X	
Thivel 2011 (166)						X	
Tholstrup 2014 (167)	Make School A Moving Experience (MSAME)	X					
Toruner 2015 (168)		X				X	
Treu 2017 (169)	Advancing School and Community Engagement Now for Disease Prevention (ASCEND)				X	X	
Tucker 2011 (170)		X				X	
Uys 2016 (171)	HealthKick	X		X		X	
Van Ka 2016 (172)	Active Living			X	X	X	
Vetter 2018 (173)	Math on the Move	X					
Villa-Gonzalez 2016 (174); Villa-Gonzalez 2017 (175)		X					
Wang 2018 (176)	YOG-Obesity study	X			X	X	
Watson 2019 (177)	ACTI-BREAK				X		
Weber 2017 (178)	SMS. Sei schlau. Mach mit. Sei fit.	X				X	
Wells 2014 (179)		X		X			
White 2018 (180)		X					

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Whitt-Glover 2011 (181)	Instant Recess				X		
Wright 2013 (182); Wright 2014 (183)	Kids N Fitness	X				X	X
Xu 2015 (184)	CLICK-Obesity Study	X			X	X	
Yildirim 2014 (185)	Transform-Us!			X	X	X	
Yin 2012 (186)	FitKid					X	
De Greeff 2016a (187)		X					
De Greeff 2016b (188)	Fit en Vaardig op school	X					
De Heer 2011 (189)		X					
De Meij 2011 (190)	JUMP-in		X		X	X	X
Van den Berg 2019 (191)	Just Dance	X					
Van der Niet 2016 (192)		X			X		

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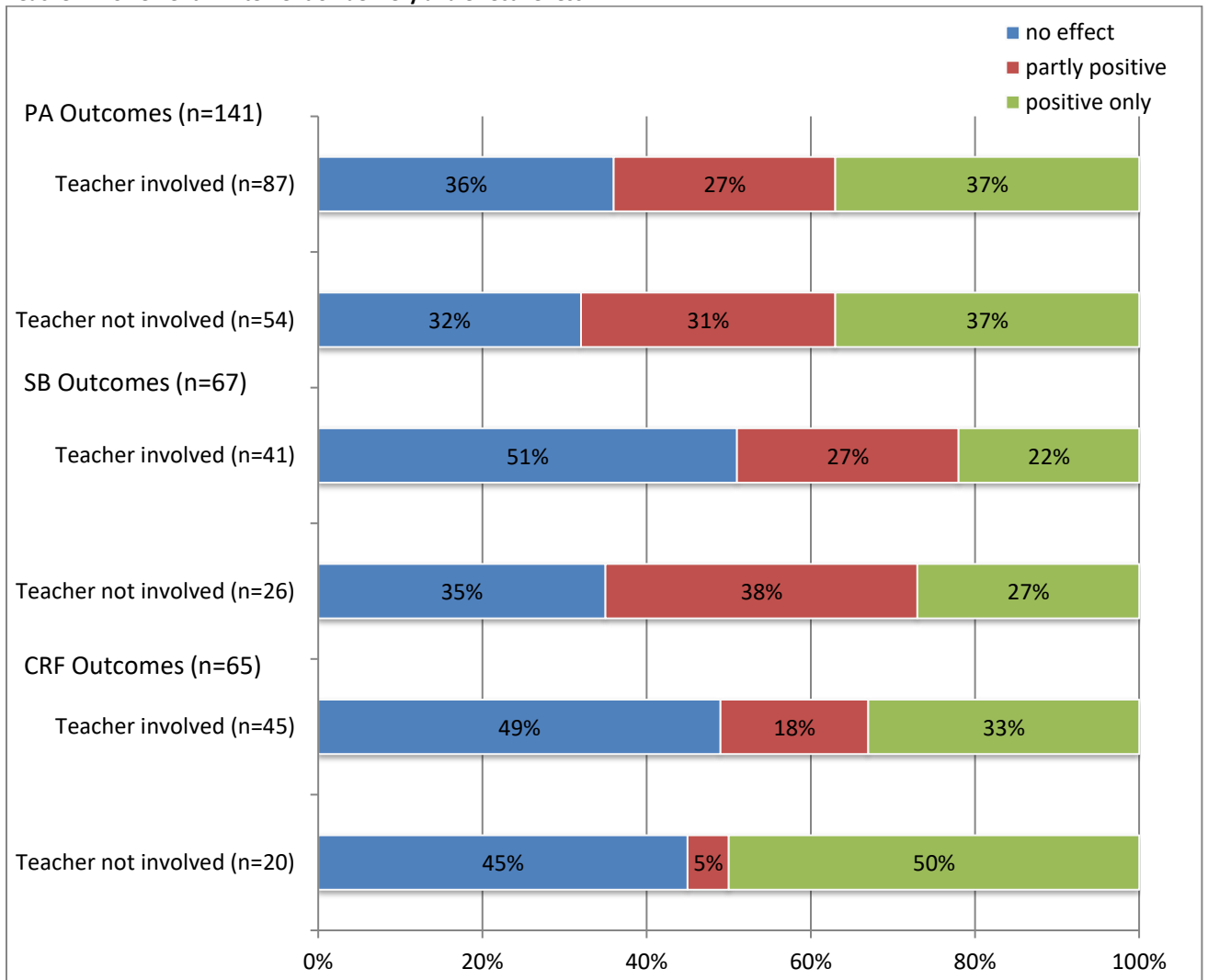
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**Appendix F**

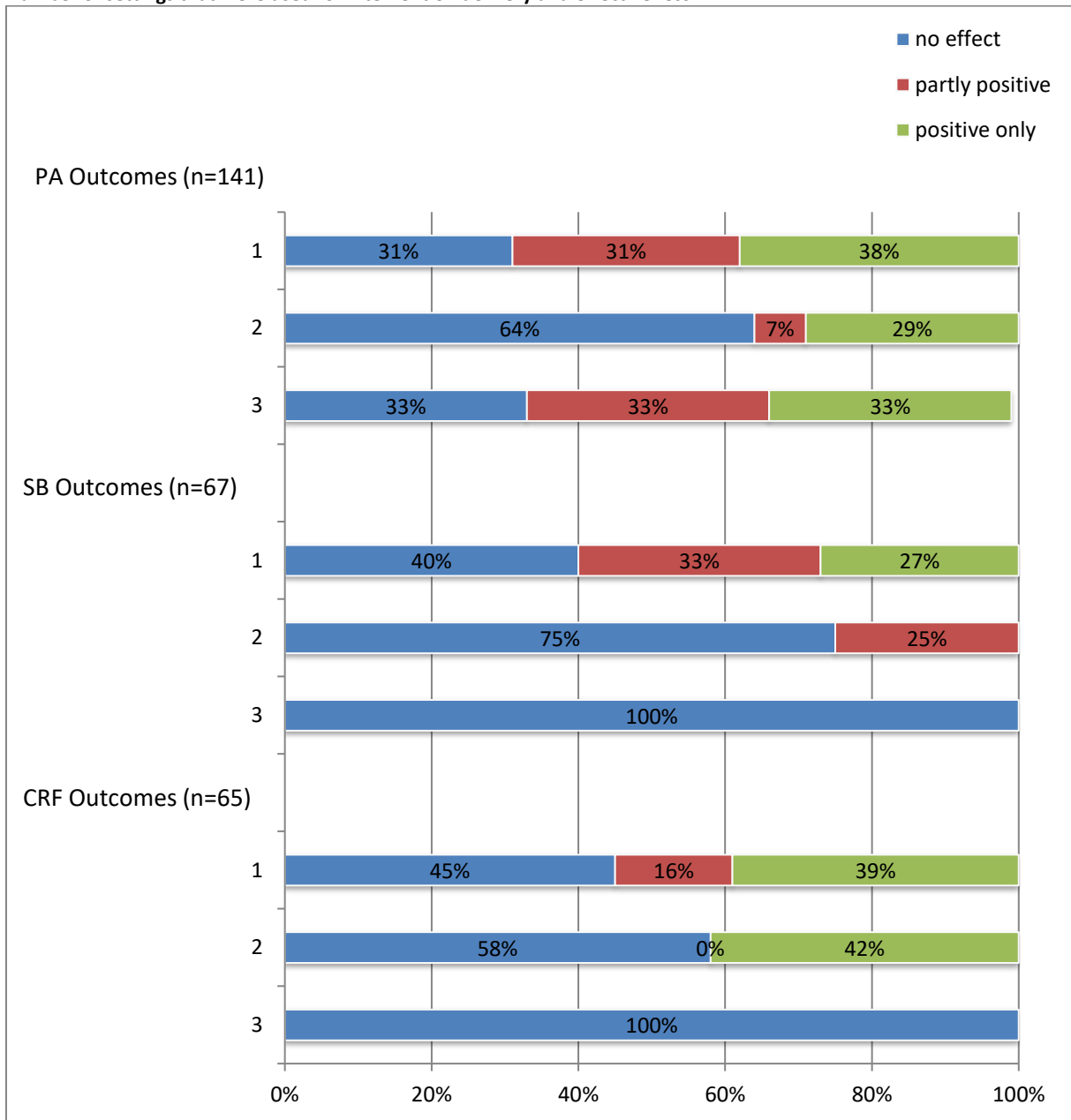
**Teacher involvement in intervention delivery and effectiveness**



**Note:** x-axis in %; (physical education) teachers' involvement in intervention delivery; PA physical activity, SB sedentary behaviour, CRF cardiorespiratory fitness; n number of studies

Appendix G

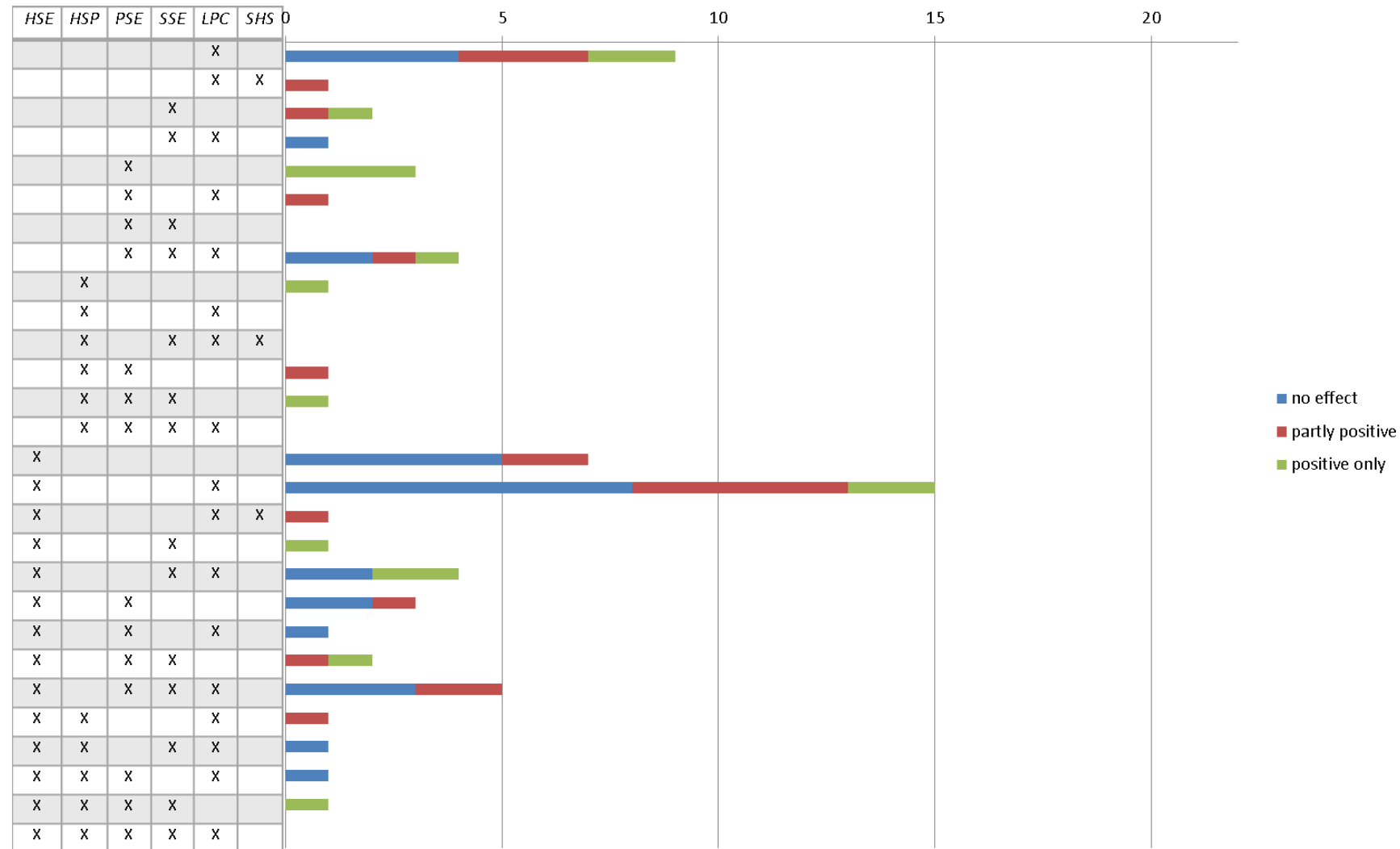
Number of settings that were used for intervention delivery and effectiveness



Note: x-axis in %; y-axis number of settings that were used simultaneously; PA physical activity, SB sedentary behaviour, CRF cardiorespiratory fitness

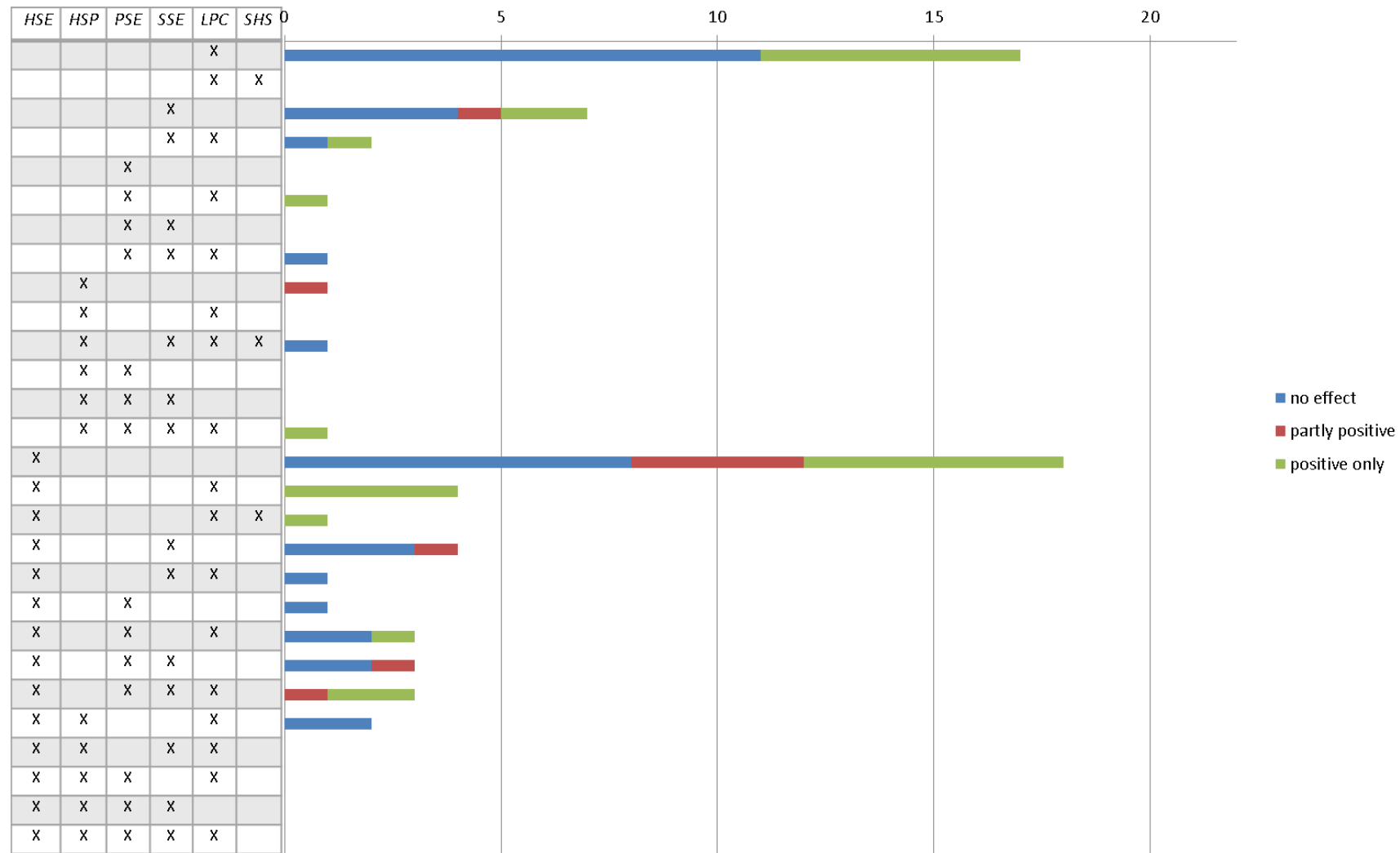


**Appendix H.1 Feature combinations and intervention effectiveness on sedentary behaviour outcomes.**



**Note: x-axis indicates numbers of studies; y-axis indicates HPS feature combination; HSE Health skills and education; HSP healthy school policy; PSE physical school environment; SSE social school environment; LPC Links with parents and community; SHS Access to (school) health services**

**Appendix H.2 Feature combinations and intervention effectiveness on cardiorespiratory fitness outcomes.**



Note: x-axis indicates numbers of studies; y-axis indicates HPS feature combination; HSE Health skills and education; HSP healthy school policy; PSE physical school environment; SSE social school environment; LPC Links with parents and community; SHS Access to (school) health services