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Health Promotion in Primary Schools- Evaluation of Side-Effects on Cognitive and Academic Performance in a Randomized Trial

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Abstract

Background: School-based lifestyle interventions are a cost-effective way to prevent pediatric overweight. The program "Join the Healthy Boat" focuses on physical activity, healthy diet and screen media use in German primary school children, implemented by regular classroom teachers including teaching units, physical activity exercises, and work with parents. Objective of the study was to measure potential side-effects on children's cognitive and academic performance.

Methods: The program was evaluated in a RCT design, measurements took place before and after one year of intervention. Stratification of randomization was carried out for number of classes and grade level. Participants were 1st and 2nd graders of primary schools. Intervention and assessment took place on site at school; questionnaires were issued. N=442 children performed a computer based test battery measuring inhibitory control, cognitive flexibility and sustained attention. Academic achievement was assessed via parental questionnaire.

Results: Multiple regression analyses controlling for age, gender and parental education and Mann-Whitney-U-tests revealed no significant differences between intervention and control group in cognitive changes or academic development from baseline to follow up. In Cognitive Flexibility, however, the number of children who improved was higher in the intervention group.

Conclusion: Taking time from the regular school curriculum for health promotion had no negative impacts on children's cognitive or academic development. To obtain more positive effects a longer period of time and a more intense intervention are presumably necessary. The findings are in line with a recent review indicating no negative effects of school health programs. Eventually there is a positive impact of physical activity interventions on specific cognitive functions but findings regarding academic outcomes are still inconclusive. Weak evidence is reported for nutrition services.

Keywords: Lifestyle intervention; Prevention; Child; Executive functions; Attention; Physical activity; Obesity

Introduction

Pediatric obesity is one of the major health challenges of the 21st century. A number of chronic diseases such as cardiovascular diseases, type 2 diabetes, pulmonary, musculoskeletal, and neurological complications as well as psychosocial consequences are associated with obesity [1-4]. Further, it represents a massive financial burden for society due to medical costs, decreased productivity, increased sick leave or premature pension [2,5]. According to the World Health Organization [6] worldwide obesity has been doubled in the recent 35 years. Prevalence rates (overweight and obesity) among children in Europe lie between 14.8% and 23.3% [7]. Halting of the global obesity rates and reducing premature mortality are targets of the WHO Global Action Plan 2013 - 2020, including strategies at global, regional and local levels to promote healthy diet, physical activity and health in the entire population [6].

Lifestyle interventions that aim to change obesogenic behavior patterns (diet, physical activity and sedentary behaviour) can be effective in reducing weight compared to self-help or standard care [8-10]. One promising strategy is the integration of healthy lifestyle elements in the school curriculum [11]. Reviews and meta-analyses report effects on weight-related measures, prevalence and remission rates, knowledge and health behaviour as studied by Katz et al. and Kropski et al. [12-16]; School-based programs should combine educational and environmental practices to promote healthy eating and physical activity [11,12]. Contents should be integrated in the curriculum and increased physical activity sessions, improvements of food supply, teacher support, parental involvement and home activities are recommended [11].

In the past two decades, the popularity of school-based programs has increased significantly mainly due to its universal preventive character -all children can be reached on a daily basis with a reasonable effort. Although positive effects have been reported, overall findings are mixed and the number of high quality studies is limited [11,16,17]. Further, besides physical and behavioral measures, effects on cognitive or academic outcomes are scarcely investigated although highly relevant: Interventions integrated in the school curriculum might be criticized for taking class time from other school subjects and for threatening children's academic achievement. Thus, negative side-effects should be monitored. On the other hand, promoting physical activity and a healthy nutrition may also impact the cognitive and academic development in a positive way.

In a recent literature review Murray et al. [18] reported findings

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of 17 coordinated school health programs on academic achievement and concluded that there is little but promising evidence (e.g. a positive effect in low income asthmatic children and a lack of negative effects). Similarly, no negative outcomes of physical activity interventions on academic performance have been reported by now even when time for other school subjects was reduced [19-21]; research rather indicates positive effects of physical activity on cognitive functions [21,22]. Effects of dietary interventions focusing on breakfast consumption, sugar or nutrients intake are inconclusive; some studies report a decrease in school absenteeism and tardy rates and an increase in academic achievement [18,23,24]. Finally, dehydration is quite common in school children and there is some evidence that it is adversely associated with cognitive performance [25]. Nevertheless, quality research especially with longer intervention duration is limited and methodological problems concerning recruitment, sample size, implementation adherence and measurements are quite common [18,23].

As there is only few data available compared to the number of programs running and due to its importance for health promotion and school policies, we analyzed the effects of a school-based lifestyle intervention on cognitive and academic outcomes. We hypothesized that school based health promotion had no negative impact. We assumed that the promotion of physical activity via psychosocial and neurophysiological pathways [21,26-28], the promotion of healthy breakfast and water drinking via a better supply with energy and nutrients and a better hydration [24,29], the reduction of TV viewing via more real-life experiences and neurophysiological pathways [30,31] and the improved health status via a reduction of school absenteeism affected children's cognitive and academic performance rather in a positive way.

Methods

Overview

The school-based health promotion program "Komm mit in das gesunde Boot" in southwest Germany (trans.: "Join the Healthy Boat") focuses on the promotion of physical activity and healthy diet and the reduction of sedentary behaviour in primary school children. To evaluate the superiority of the intervention we conducted a prospective, stratified, cluster-randomized study (Baden-Württemberg Study; German Clinical Trial Registration Number: DRKS00000494). Stratification of randomization was carried out for number of classes and grade level. Baseline assessment of the evaluation study took place in autumn 2010 at the beginning of the academic year, followed by the implementation of the program "Join the Healthy Boat" in the intervention group. Meanwhile the control group followed the regular school curriculum. Follow up assessment took place in autumn 2011, after one year of intervention. Each time, the measurements were performed on site at school. Those assessing the outcomes were blinded to group assignment. After the measuring period of two months, a parental questionnaire was issued and returned within six weeks. The study protocol with a more detailed description of the general procedure, recruitment and randomization has been published elsewhere [32]. The Baden-Württemberg Study was approved by the Ministry of Culture and Education and the institutional ethics committee.

Intervention

Our interdisciplinary scientific team of the University of Ulm had developed a teacher-centered intervention referring to the social cognitive theory of Bandura [33]. We provided teachers with materials that could be integrated in the regular curriculum and supported them with regular teacher trainings. The materials comprised teaching units presenting alternatives for action and promoting self-efficacy, furthermore daily physical exercise breaks of 15 minutes, family homework, letters to parents in different languages and material for parent's evenings. The trainings covered the theoretical background, handling of the material, further practical advices (e.g. cooperation with sports clubs, healthy school breakfast) and suggestions for environmental changes (e.g. installation of water fountains, design of the courtyard, school break policies). The contents of the intervention were mainly focused on physical activity in everyday life, reduction of sugar-sweetened beverages and promotion of water drinking, healthy breakfast and reduction of screen media consumption. More details about the intervention have been published in Dreyhaupt et al. [32] and Wartha et al. [34]. Intervention effects on behavioral measures have been published in Kobel et al. [35].

Participants

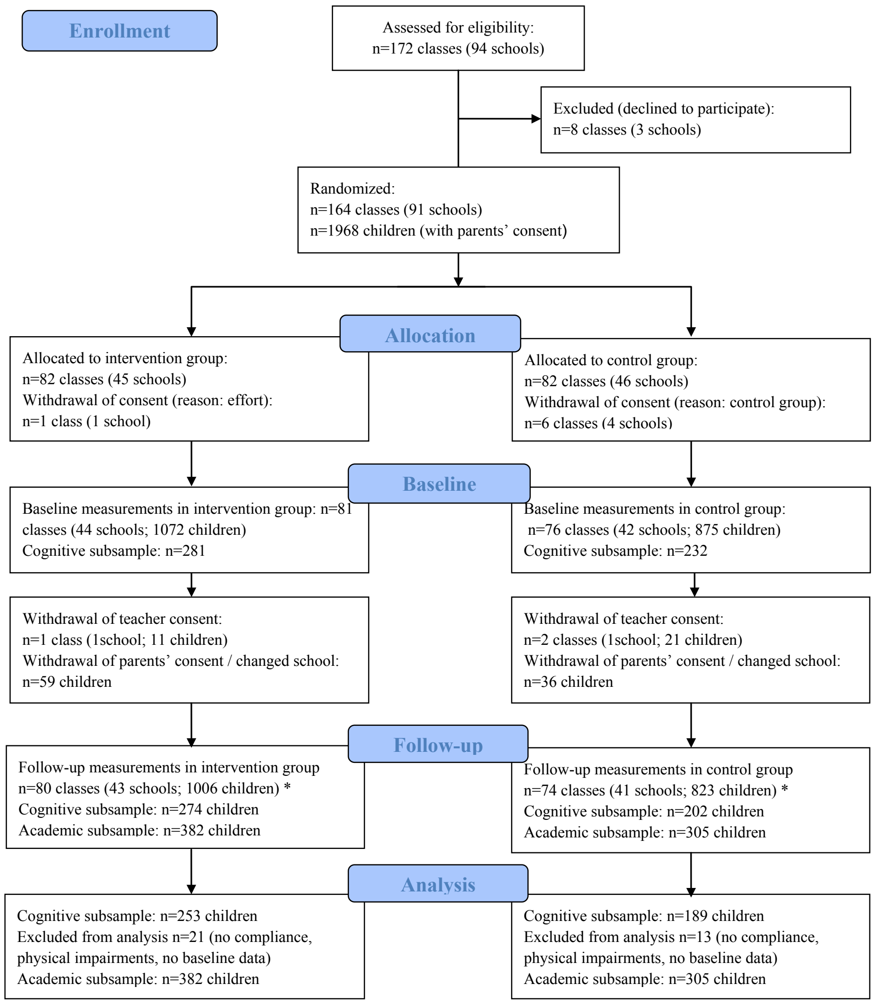
Prior to the study we had informed all primary school classes in the federal state of Baden-Württemberg about the program and its evaluation. Interested teachers had opted in voluntarily and had agreed with the randomization process. Parents had provided written informed consent. In total, n=157 school classes in Baden-Württemberg, 1st and 2nd grade, participated (n=1964 children). Sample size had been determined based on a priori power calculations, feasibility considerations and response rate during recruiting process. Mean age of the children was 7.1 ± 0.6 years, 49.9% were boys, 9.5% were overweight or obese. For logistical reasons (distances between schools, technical equipment) cognitive testing was carried out in a subsample in the southern part of Baden-Württemberg (n=45 classes, 513 children). Children with motor impairment, color blindness or without compliance were excluded from the analysis. Valid baseline and follow up data were available as follows: anthropometric data: n=1736, cognitive data: n=442, socio-demographic data: n=1494, academic performance: n=687 (Figure 1).

Anthropometric assessment

We measured body height and weight of the children according to the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK; [36]). A calibrated electronic scale (Seca model 862, Seca®, Germany) was used to measure weight, with an accuracy of 0.05 kg; and a portable stadiometer (Seca model 217, Seca®, Germany) was used to measure height, with an accuracy of 0.1 cm. Children were measured in underwear or without shoes, respectively. Body mass index (BMI) was calculated (kg/m^2) and converted to BMI percentiles using national age- and sex-specific reference data [37] and children were classified into non-overweight and overweight/obese.

Cognitive testing

We used the computer-based test battery of attention for children (KiTAP; [38]) to assess cognitive performance. The KiTAP consists of a broad range of non-verbal subtests measuring different attentional components and executive functions validated for children aged 6 to 10 years. The KiTAP had been widely used in neuropsychological and cross-cultural research [39-43] and significant associations with intellectual abilities, school outcomes and behavioral questionnaires had been reported [41,43,44], validity and reliability were satisfying [38,39]. In our study, we administered three tests: a Go-No-go task (inhibitory control), a cognitive flexibility task and a sustained attention task. Number of errors (incorrect response to a noncritical stimulus), number of omissions (missed response to a critical stimulus) and reaction time (milliseconds in medians) were recorded. According to



*Including children absent at baseline.

Figure 1: Flow chart presenting study sample composition.

the test manual errors and reaction time were the key parameters for inhibitory control and cognitive flexibility, and errors and omissions the key parameters for sustained attention. Cognitive testing took place during the first three school hours in small groups and lasted in total 30 minutes. As recommended we conducted short preceding practice trials to ensure comprehension and willingness of the children. Lack of comprehension, irregular and disruptive behavior were documented.

Academic performance

Parents were asked by questionnaire to report marks in the subjects 'Writing and Spelling' and 'Arithmetic'. Due to the regional school policy the first marks are given by the end of grade 2. Thus, academic performance was only available for half of the sample at follow up (children who had entered grade 2 at baseline and who had just finished grade 2 at follow up). For data protection reasons there was no possibility to obtain information or academic test results from teachers directly.

Socio-demographic data

As co-variables age and gender of the children were recorded. Further, we assessed parent education via parental questionnaire according to the CASMIN classification (Comparative Analysis of Social Mobility in Industrial Nations; [45]). The CASMIN is the most widely used international instrument to classify education and distinguishes primary, secondary and tertiary education level. Mothers and fathers education was assigned to the respective level and parent education determined as the highest level from both or the level of a single parent, respectively. Due to the small number of parents with primary education (1.0%) we dichotomized data into primary and secondary versus tertiary education level.

Data analysis

We conducted descriptive analyses to present characteristics and cognitive test scores of the study sample. For group analyses t-test or Mann-Whitney-U-test, respectively, were used depending on the distribution of the variables. To determine intervention effects on cognitive performance a multiple linear regression analysis was computed, with differences in test scores between baseline and follow up measurement as criterion (changes of cognitive performance) and group assignment as predictor (intervention vs. control group). Further control variables were baseline test scores, age, gender and parent education. Additionally, we dichotomized the cognitive change variables into "improved" performance and "decreased" performance and looked-for differences in frequency between the two groups.

Variables	Total Sample	Boys	Girls	Overweight	Non-overweight	Intervention Group	Control Group
	n=442	*n*=215	*n*=227	*n*=32	*n*=408	*n*=215	*n*=227
Inhibitory control							
Number of errors (m[a]. sd[b])	5.22 ± 3.26	5.90 ± 3.22	4.59 ± 3.17	6.47 ± 3.88	5.21 ± 3.19	5.33 ± 3.37	5.23 ± 3.09
Reaction time in ms[c] (m. sd)	511.05 ± 73.66	498.25 ± 74.23	523.03 ± 71.24	489.30 ± 65.65	513.23 ± 74.70	516.70 ± 74.95	504.54 ± 72.60
Flexibility							
Number of errors (m. sd)	6.28 ± 3.74	7.02 ± 3.71	5.62 ± 3.66	6.64 ± 3.58	6.39 ± 3.77	6.36 ± 3.81	6.41 ± 3.70
Reaction time in ms (m. sd)	1274.74 ± 313.61	1292.57 ± 318.45	1258.66 ± 309.10	1239.86 ± 288.66	1273.80 ± 313.50	1283.62 ± 310.82	1258.43 ± 313.43
Sustained attention							
Number of errors (m. sd)	15.37 ± 16.03	18.26 ± 17.80	12.63 ± 13.65	19.33 ± 19.56	15.20 ± 15.94	15.86 ± 17.12	15.30 ± 15.53
Number of omissions (m. sd)	13.91 ± 8.06	14.24 ± 7.94	13.59 ± 8.17	12.57 ± 6.44	14.07 ± 8.16	14.51 ± 8.34	13.12 ± 7.59
	n=687	*n*=340	*n*=347	*n*=64	*n*=608	*n*=382	*n*=305
School marks[d]							
Arithmetic's (mdn[e]. sd)	2.00 ± 0.76	2.00 ± 0.71	2.00 ± 0.807	2.00 ± 0.75	2.00 ± 0.75	2.00 ± 0.78	2.00 ± 0.73
Writing and Spelling (mdn. sd)	2.00 ± 0.77	2.00 ± 0.76	2.00 ± 0.76	2.00 ± 0.87	2.00 ± 0.75	2.00 ± 0.75	2.00 ± 0.79
	n=1736	*n*=887	*n*=849	*n* =165	*n*=1570	*n* =953	*n*=782
BMI percentile (m. sd)	48.53 ± 27.67	48.16 ± 27.57	48.91 ± 27.79	95.57 ± 3.30	43.58 ± 24.25	48.12 ± 27.49	48.86 ± 27.84
Overweight (n (%))	165 (9.50)	60 (8.40)	59 (8.30)	-	-	95 (10.00)	70 (9.00)
	n=1494	*n*=745	*n*=749	*n*=124	*n*=1334	*n*=814	*n*=680
Age (m. sd)	7.06 ± 0.62	7.07 ± 0.62	7.06 ± 0.62	7.21 ± 124	7.05 ± 1334	7.06 ± 0.62	7.06 ± 0.62
Male gender (n (%))	745 (49.90)	-	-	62 (50.00)	667 (50.00)	400 (49.1)	345 (50.7)
Parental education (n (%))	477 (33.50)	240 (33.70)	237 (33.30)	27 (22.90)	438 (34.40)	269 (34.6)	208 (32.1)

Note: [a] m=mean; [b] sd=standard deviation; [c] ms=milliseconds; [d] school marks were collected at follow up; [e] mdn=median.

Table 1: Baseline values in the total sample and separated by gender. weight group and study group.

Intervention effects on academic performance were analyzed using Mann-Whitney-U-Test but without baseline control. Finally, t-test or Fisher's exact test were used for missing analysis. All statistical analyses were carried out using SPSS 19 and statistical significance was set at α=0.05.

Results

Descriptive characteristics

Children's cognitive performance and socio-demographic characteristics at baseline and academic performance at follow up are represented in Table 1. Boys and girls differed significantly in inhibitory control (number of errors: U=16.886; p=.000; reaction time: t (422)=-3.62; p=0.000), flexibility (number of errors: U=15.292; p=.000), sustained attention (number of errors: U=16.235; p=0.000), arithmetic's (U=64.476; p=0.024) and Writing and Spelling (U=50.395; p=0.000). Overweight and non-overweight children did not differ significantly in cognitive or academic performance but in age (t (142.60)=-2.67; p=0.008), BMI percentiles (t (1673.07)=78.31; p=0.000) and parent education (p=.011). There were no differences in baseline characteristics between the intervention and control group.

Effects on cognitive performance

After one year of intervention inhibitory control performance improved in the intervention group (mean decreased number of errors: 1.7; mean decreased reaction time: 32.2 ms) as well as in the control group (mean decreased number of errors: 2.1; mean decreased reaction time: 28.2 ms). Similarly, cognitive flexibility improved in the intervention group (mean decreased number of errors: 2.4; mean decreased reaction time: 180.9 ms) and in the control group (mean decreased number of errors: 3.0; mean decreased reaction time: 200.4 ms). Furthermore, sustained attention improved in the intervention group (mean decreased number of errors: 7.2; mean decreased number of omissions: 5.0) and in the control group (mean decreased number of errors: 6.6; mean decreased number of omissions: 5.1). Regression analysis on changes in cognitive test scores revealed no significant difference between intervention and control group on any variable (Table 2), thus both groups showed equivalent changes. Significant predictors for cognitive changes were baseline scores and age in all test scores, and gender and parental education in cognitive flexibility.

Looking at the number of children improving and worsening during the academic year, however, we found a significant difference between control and intervention group in Cognitive Flexibility (number of errors): n=66 (31.3%) of children in the intervention group performed better after one academic year, n=145 (68.7%) performed worse. In the control group n=37 (21.6%) improved after one year, n=134 (78.4%) worsened. This difference was significant and remained significant when controlling for covariates (age, gender, parental education, baseline values) (OR=1.99 [CI=1.08; 3.68]; p<0.05).

Effects on academic performance

Mann-Whitney-U-Test resulted in no differences in academic performance between the intervention and control group (Writing and spelling: U=57.192, p=.650; Arithmetic: U=60.232, p=0.456). Average mark at follow up was in both groups Mdn=2.0 in Writing and Spelling (intervention group sd=0.79, control group sd=0.75) and Mdn=2.0 in Arithmetic (intervention group sd=0.73, control group sd=0.78). Subgroup analyses based on weight status revealed the same results.

Missing analysis

Children of the cognitive subsample (n=442) did not differ from children of the total study population in terms of age, sex, parental education, and BMI percentiles. There was a significant difference in weight group: Less children in the cognitive subsample were overweight or obese compared to the total sample (7.3%; p=0.029). Similarly, the academic subsample (n=687) did not differ from the total study sample in terms of sex, parental education, weight group and BMI percentiles.

Predictors	Inhibitory control (n=366)		Cognitive flexibility (n=341)		Sustained attention (n=356)	
	Diff E[a]	Diff RT[b]	Diff E	Diff RT	Diff E	Diff O[c]
	B[d]	*B*	*B*	*B*	*B*	*B*
	95% CI[e]	95% CI	95% CI	95% CI	95% CI	95% CI
Study group	0.51	-0.87	0.41	46.03	0.97	0.5
	(-0.01; 1.03)	(-11.10; 10.26)	(-0.18; 1.01)	(-1.67; 93.72)	(-0.86; 2.80)	(-0.80; 1.79)
Baseline values	**-0.72*** **	**-0.53*** **	**-0.67*** **	**-0.67*** **	**-0.82*** **	**-0.58*** **
	(-0.80; -0.64)	(-0.61; -0.46)	(-0.75; -0.59)	(-0.75; -0.60)	(-0.88; -0.76)	(-0.66; -0.50)
Age	**-0.56** **	**-10.35* **	**-0.75*** **	**-37.88* **	**-2.93*** **	-1.56
	(-0.96; -0.16)	(-19.34; -1.36)	(-1.22; -0.28)	(-75.45; -0.31)	(-4.38; -1.48)	(-2.60; -0.52)
Gender	-0.45	3.35	**-0.59* **	-16.84	-1.24	0.37
	(-0.94; 0.05)	(-7.32; 14.02)	(-1.17; -0.02)	(-62.33; 28.64)	(-3.00; 0.52)	(-0.85; 1.59)
Parent education	-0.29	2.36	**-0.62* **	5.17	-0.38	-0.29
	(-0.80; 0.23)	(-8.87; 13.56)	(-1.21; -0.03)	(-42.56; 52.89)	(-2.21; 1.46)	(-1.60; 1.02)
R^2	0.48	0.36	0.47	0.5	0.7	0.38
F	66.55***	40.04***	58.56***	65.77***	162.56***	43.55***

Note: [a] Diff E= Difference in errors between T1 and T2; [b] Diff RT=Difference in reaction time between T1 and T2; [c] Diff O=Difference in omissions between T1 and T2; [d] *B*=Non-standardized regression coefficients; [e] CI=Confidence interval; *p<0.05; *p<0.01; ***p<0.001.

Table 2: Multiple linear regression analysis on changes in cognitive performance between baseline and follow up.

There was a significant difference in age (t (1895.77)=32.10; p=.000) due to the fact that school performance was only measured in second grade.

Discussion

Investigating effects of a school based health promotion program on cognitive outcomes in a sample of German primary school children we found no significant differences neither positive nor negative between intervention and control group. In one task (cognitive flexibility) the number of children who improved was significantly higher in the intervention group. Looking at indices of academic performance (school marks at follow up) the intervention and control group did not differ as well. Although research literature on this topic is quite rare, the findings are in line with one recent review from Murray et al. [18] who analyzed the impact of school health programs on academic achievement. They reported only one study with a strong evidence for a positive effect, however in a special group with asthmatic low-income children. Weak evidence exists for nutrition services such as school breakfast programs, health or mental health services. Murray and colleagues stated that studies evaluating physical activity interventions mostly find neither a positive nor a negative effect on academic achievement. Further reviews and meta-analyses concentrating only on physical activity programs concluded that there are indices of a positive impact on specific cognitive functions (executive functions) but findings on academic outcomes remain inconclusive, mainly due to methodological issues [21]. However, in no study a negative effect has been revealed yet [19-21]. Thus, children may benefit from health promotion programs in terms of developing a healthier lifestyle, avoiding excessive weight gain and morbidity and enjoying a higher health-related quality of life without negative side-effects such as cognitive or academic disadvantages.

The lack of significant positive results might be due to the short study duration: The intervention took one academic year, assessments were before and after the intervention. To result in positive cognitive or academic changes, the health contents must first reach the children, change their attitudes and behavior, lead to an improved health status and to physiological changes. Thus, such a chain reaction takes probably more time than one academic year. Moreover, a more intensive intervention or specific components are presumably necessary. Recent literature on the association between physical activity and cognition suggests that especially endurance exercises or cognitive-demanding activities are quite promising [26-28]. The integration of additional physical education or afterschool training in school-based health promotion is one possibility. However, the program “Join the Healthy Boat” was developed to reach regular classroom teachers and to be feasible without any special sports background. Objective was to be integrated in children’s daily life and to be sustainable over a long period of time without additional financial or personnel resources. Integrating certain elements in the regular physical education that were found to be associated with cognitive improvements can be a cost-effective compromise. For this reason, our research group is developing new additional materials and teacher trainings based on current research [26,46,47]. Regarding breakfast or drinking habits, standardized school policies such as regular water drinking or healthy school breakfast may have an additional influence and should play a bigger role in such programs [18,48].

Limitations

Results should be interpreted in light of study limitations. First, the analysis was based on a field study in the school setting what rose external validity on the on hand, but, on the other hand, made it difficult to control the implementation of the intervention in detail (internal validity). Intensive process evaluation, however, was conducted and showed high satisfaction with materials and trainings [34].

Second, due to the voluntary participation there might have been a selection bias as eventually more interested and motivated teachers and parents participated in the study. The sample consisted of more children with higher parental education than found in the population (23.9%) tertiary parent education in German school children are reported officially [49]. However, we controlled for education level in regression analyses. Concerning the subsamples, missing analyses revealed that there was no difference to the total sample in important variables besides overweight status and age.

Third, the effect on school performance was measured indirectly via parental report. Future studies focusing on academic effects should use objective standardized academic tests. As school performance was not a primary outcome of the intervention and time was limited on the assessment days, and as teachers were not allowed to report marks, we had decided to use the parental questionnaire.

Strengths of the study were the randomized control study design, the large sample size and the objective cognitive assessment focusing on three highly relevant abilities. Furthermore, the intervention was theory-based, targeted important and malleable health behaviors and was highly accepted by teachers [34]. We conducted intensive written process-evaluation and were constantly available for teachers.

Conclusion

A one year school based lifestyle intervention focusing on physical activity, nutrition and screen media consumption did not affect cognitive and academic performance of children- neither in a positive nor negative way. School based health promotion provides a great opportunity to reach a high number of children at an important age by their natural caregivers to build up the basis for a healthy life, to prevent certain health risks, and to keep intervention costs to a feasible level. To obtain positive cognitive changes a longer observation duration and a higher intensity, for example additional physical education, the integration of short but more cognitive-demanding exercises, more focus on regular water drinking and regular breakfast during the school day, are necessary. Currently, teachers can be encouraged to invest in health promotion as there are no cognitive or academic disadvantages for participating school classes.

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Declaration of Conflicting Interests

The authors declare that there is no conflict of interest.

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