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KEIGAAF

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KEIGAAF

Implementation and evaluation of a context-based physical activity and nutrition intervention in the primary school environment

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KEIGAAF

Implementation and evaluation of a context-based physical activity and nutrition intervention in the primary school environment

Proefschrift

ter verkrijging van de graad van doctor aan de Universiteit Maastricht,
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Chapter 1

General introduction

Background

Children's unhealthy energy balance-related behaviors

In the last three decades, the percentage of children with overweight and obesity has increased worldwide [1]. Although these levels of overweight and obesity among children have been plateauing in developed countries in recent years, they are still alarmingly high [2]. In 2017, 9.8% of the Dutch children between the ages of four and twelve years were overweight and 3.3% of children in the same age range were obese [3]. Childhood overweight and obesity are associated with adverse health consequences. Being overweight in childhood is related to an increased risk of premature mortality and cardiometabolic morbidity in adulthood [4]. These high overweight and obesity numbers are a result of high levels of unhealthy energy balance-related behaviors. Children spend too much time inactive and consume too much foods and drinks that are high in calories and low in nutrients. About half of the Dutch children (aged 4-12 years) did not meet the physical activity (PA) recommendations of 60 minutes of moderate-to-vigorous physical activity per day and muscle-strengthening activities three times per week, in 2017 [3]. Additionally, almost three in five Dutch children in the age of 4 to 12 years did not consume sufficient amounts of fruit and vegetables daily [3]. Children raised in families with a low socioeconomic status (SES) were less likely to comply with the recommendations of PA and daily consumption [5-9]. Consequently, children of low SES families had a higher body mass index [10]. In this chapter, the current state of children's energy balance-related behavior is outlined. Further, an introduction in environmental influences on these behaviors from a theoretical perspective will be provided and, in particular, the role of the school environment will be described. Finally, the general intervention principles of the KEIGAAF intervention will be touched upon.

The influence of the environment on children's energy balance-related behaviors

According to ecological models, children's energy balance-related behaviors are not only influenced by individual characteristics, such as beliefs regarding being active, but to a very large extent by their environment, for example, the neighborhood in which they live and the presence of appealing playgrounds [11]. Ecological models are models that show the influence of environmental determinants, policy factors, and individual characteristics on an individual's behavior. These factors operate at various levels, i.e., at the personal, interpersonal, organizational, community, and policy level, and multiple levels interact with each other in influencing a behavior [11]. Different ecological frameworks use different typologies for environmental influences. Bronfenbrenner [12] distinguishes systems in which individuals interact with their environment. In this ecological systems approach, systems are defined as micro-, meso-, exo-, or macrosystem [12]. The microsystem is considered the interaction between an individual and its environment in the most proximal setting that an individual is part of, e.g., interactions within the home environment (for example between the child and its parents). When two or more microsystems interact, they are considered a mesosystem, e.g., the

interaction between the family system and the school system [12]. Looking at the child and the systems in which it is involved, the family system is considered one of the most important microsystems influencing a child's energy balance-related behaviors [13]. Next to the family system, the school system plays a role in children's energy balance-related behaviors [14, 15], because children consume their lunch more often at school and spend a substantial part of their physical activity and sedentary behavior at schools [14, 16, 17]. Certain ecological frameworks distinguish distinct types of environments that interact with the individual [18]. In the ANGELO-framework, the micro-level environment is classified into four environmental types: the physical, the sociocultural, the political, and the economic [19]. The physical environment is everything that is available, tangible and less tangible, such as supermarkets, but also (health-related) information. The sociocultural environment entails the community's attitudes, beliefs and values towards nutrition and PA, and are "visible" in the climate, culture, or ethos of a setting, e.g., teachers expressing the importance of healthy energy balance-related behaviors. The political environment consists of the formal and informal rules/policies, laws and regulations towards nutrition and PA, for example home rules concerning screen time use. Finally, the economic environment entails the costs related to nutrition and PA, for example national taxes on unhealthy foods or the cost of a membership of sports club [19]. The ecological view posits that these environmental types interact in influencing an individual's behavior [11]. How these types of environments impact an individual's behavior can differ widely. Kremers and colleagues [20] illustrated this in the Environmental Research framework for weight Gain prevention (EnRG framework). The environment can either influence an individual's energy balance-related behavior directly (i.e., automatically) or indirectly (mediated by individual cognitive factors) [20]. Further, the framework states that both the direct and indirect pathway can be moderated by demographic and contextual factors. This emphasizes the need to thoroughly consider on whom the environment has an influence on energy balance-related behaviors and under what conditions [20].

Improving energy balance-related behaviors by targeting the environment

To improve children's energy balance-related behaviors, it is important to target the environments within the most important microsystems that the child is part of, e.g., home and school. Parents and schools can stimulate children to eat healthily and be physically active. Schools can stimulate children's energy balance-related behaviors by providing opportunities for physical activity, such as physical education, active recess periods, activity breaks during educational hours, access to school playgrounds, and encouraging physical activity by teachers or external professionals. Additionally, schools can enforce nutrition policies that support healthy nutrition, provide healthy foods and drinks (e.g., fruit and water) and teachers can serve as role models for children in nutrition behavior [15]. Focusing on both the school and the home system is important because these systems interact (the mesosystem) and this interaction influences children's behavior [21]. Besides focusing on these two important microsystems, it is important that different types of environments stimulate the behavior, for example,

the social and the physical environments, instead of just one type of environment [18]. Targeting both the social and the physical school environments enhances the potential of efforts to improve children's physical activity behavior compared to an intervention that is focused mainly on one type of environment [22].

School-based interventions to promote healthy energy balance-related behaviors

Given the considerable amount of time children spend in schools and the large reach of schools, schools were and still are acknowledged as ideal settings to promote children's health and they were considered to not only influence children, but also their families and the wider community [23]. Many school-based interventions were developed, but not all of these interventions were successful in improving children's energy balance-related behaviors [24-30]. Traditionally, school-based interventions were classroom focused: they aimed to increase children's knowledge by providing health education [31]. However, according to the ecological frameworks and studies on environmental determinants on children's energy balance-related behaviors, this focus is too limited. Instead, successful school-based intervention were interventions that: (i) combined both education and environmental components [25]; (ii) that targeted both physical activity and nutrition [25]; (iii) were of long duration [32]; (iv) were multicomponent in nature [27, 33, 34]; and (v) involved the family [27, 35]. Long-term and sustainable results were believed to be the result of multidisciplinary collaborations in the implementation of the intervention, e.g., collaborations between school, parents, and other stakeholders [36]. Finally, tailoring interventions to school needs was considered an essential element of school-based interventions [36, 37]. The latter element refers to an approach that is flexible and open to local needs [36]. Such an approach differs from the traditional approach to school-based intervention development and implementation in which health professionals developed the interventions and used the schools merely as sites for disseminating health messages, materials, and intervention programs [38]. Acknowledgement of local needs can be achieved by active involvement of school staff in the planning and implementation of the intervention [35].

The KEIGAAF intervention

A physical activity and nutrition intervention targeting the school and the home environment

The KEIGAAF intervention was implemented in primary schools located in low socioeconomic neighborhoods in Eindhoven. KEIGAAF is a Dutch acronym for 'Chances in Eindhoven for a family-based approach by Fontys' ('Kansen in Eindhoven voor GezinsAAnpak met Fontys') and refers to a local term for 'supercool' or 'awesome'. The aim of the intervention was to promote healthy energy balance-related behaviors among children, using a combined top-down and bottom-up approach. The combined top-down and bottom-up approach was implemented first in the Active Living project

[22, 39, 40]. Based on their project experiences, the intervention approach was refined and applied in a different context. In the KEIGAAF intervention, a top-down steering committee and bottom-up working groups developed and implemented activities to promote healthy nutrition and physical activity among school-aged children (average age between 7 and 12 years). The output consisted of small-scale, low-budget, and easy-to-implement activities aimed at the social, physical and political environments. The combined top-down and bottom-up approach was school-centered, aiming to intervene within and around school grounds (e.g., local neighborhoods) with help of local stakeholders. The intervention was considered long-term, with almost a year of preparation time and two years of implementation. Given the importance of the home environment on children's energy balance-related behaviors, the KEIGAAF intervention also aimed to improve the home environment of the children. This was to be achieved by implementing a family-based intervention in the intervention schools, to improve parents' energy balance-related parenting practices. The family-based intervention was previously proven effective in improving various energy balance-related behaviors of children [41, 42].

The aims and outline of this dissertation

This dissertation has three aims: the first aim was to conduct a systematic review, the second aim was to design the KEIGAAF intervention and the intervention study, and the third aim was to evaluate the intervention. Different studies were conducted to attain these aims, which are described below. Also, a graphic depiction of the outline is provided in Figure 1.1.

Aim 1: Systematic review

Many studies and many (systematic) reviews had evaluated the evidence of school-based interventions on children's weight status and/or energy balance-related behaviors. However, there was limited evidence concerning school-based interventions that also targeted the home environment. A systematic review to study the effectiveness of school-based interventions that directly involved parents in the intervention on children's body mass index and energy balance-related behaviors was conducted (**Chapter 2**).

Aim 2: Intervention design

The design of the KEIGAAF intervention was described in a protocol paper. We explained how the effectiveness of the intervention on children's energy balance-related behaviors was evaluated in a quasi-experimental controlled study and how intervention implementation was studied (**Chapter 3**). Secondly, the baseline data of this quasi-experimental study were used to gain more insight into the influence of the family environment on children's behavior, particularly children's nutrition behavior. We conducted a cross-sectional study on the relation between the Family Nutrition Climate and children's daily nutrition behavior (**Chapter 4)**.

Aim 3: Evaluation of the KEIGAAF intervention

Finally, we evaluated the KEIGAAF intervention. In a qualitative study, the implementation of the KEIGAAF intervention in the intervention schools was studied and the contextual and intervention factors facilitating and hindering implementation were investigated (**Chapter 5**). In an exploratory cross-sectional study, we investigated how many and what type of children and parents participated in the alternative family-based component of the KEIGAAF intervention (**Chapter 6**). Finally, we studied the KEIGAAF intervention effectiveness in improving children's BMI z-score and their energy balance-related behaviors. A quasi-experimental longitudinal study with a two-year follow-up was conducted in which the outcome measures (BMI z-score, physical activity behavior, sedentary behavior, and nutrition behavior) of intervention children were compared to the outcome measures of children, who were not exposed to the intervention (i.e., the control condition) (**Chapter 7**).

This dissertation ends with a discussion of the most important findings of the studies and describes methodological considerations. Additionally, a reflection on the study and intervention approach are provided and recommendations for future implementation studies and for dissemination of the intervention are given. Finally, a general conclusion is drawn (**Chapter 8**).

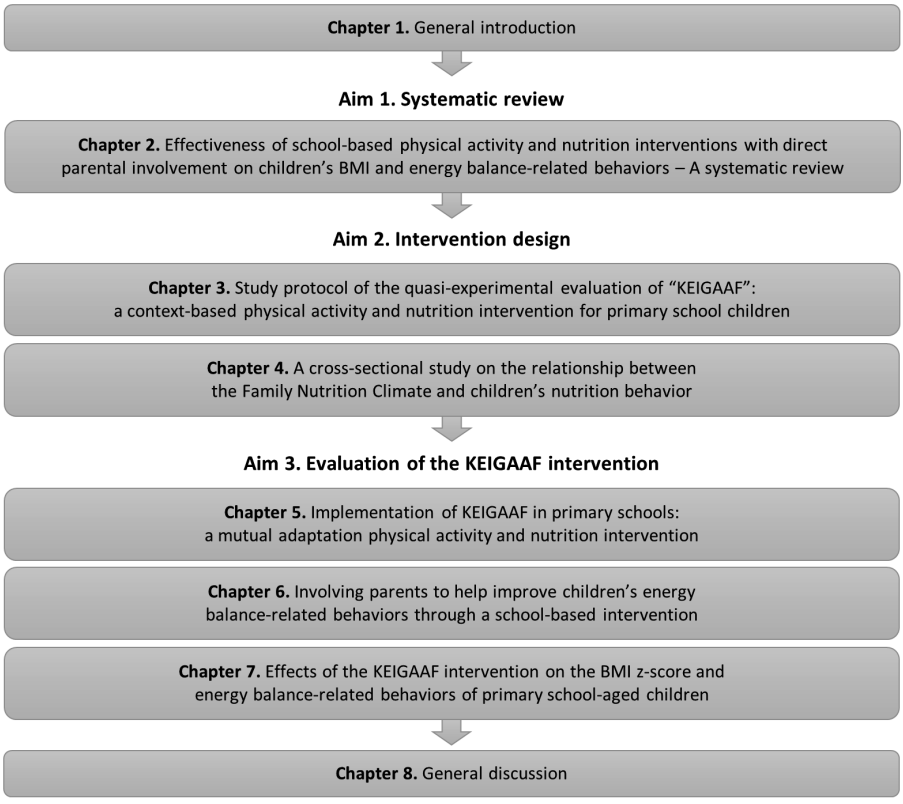


Figure 1.1. Outline aims and chapters dissertation

Chapter 2

Effectiveness of school-based physical activity and nutrition interventions with direct parental involvement on children's BMI and energy balance-related behaviors – A systematic review

This chapter has been published as:
Verjans-Janssen SRB, van de Kolk I, Van Kann DHH, Kremers SPJ, & Gerards SMPL. Effectiveness of school-based physical activity and nutrition interventions with direct parental involvement on children's BMI and energy balance-related behaviors – A systematic review. PLoS ONE. 2018;13(9):e0204560.

Abstract

Background

The aims of this systematic review were to study the effectiveness of primary school-based physical activity, sedentary behavior and nutrition interventions with direct parental involvement on children's BMI or BMI z-score, physical activity, sedentary behavior and nutrition behavior and categorize intervention components into targeted socio-cognitive determinants and environmental types using the Environmental Research framework for weight Gain prevention.

Methods

In March 2018, a systematic search was conducted in four electronic literature databases. Articles written in English about effectiveness studies on school-based interventions with direct parental involvement targeting 4–12 year olds were included. Interventions with indirect parental involvement, interventions not targeting the school environment, and pilot studies were excluded. Study and intervention characteristics were extracted. Study quality and study effectiveness were assessed and effect sizes (Cohen's d) were calculated for the outcome measures. Types of socio-cognitive factors and environmental types targeted were distinguished.

Results

In total, 25 studies were included. Most studies on BMI or BMI z-score, physical activity and sedentary behavior found favorable results: 61.1%, 81.1% and 75%, respectively. Results regarding nutrition behavior were inconclusive. Methodological study quality varied. All interventions targeted multiple environmental types in the school and family environment. Five targeted socio-cognitive determinants (knowledge, awareness, attitude, self-efficacy and intrinsic motivation) of the children were identified. No consistent pattern was found between either type of environment targeted, number of type of environment targeted, or the child's targeted socio-cognitive determinants and intervention effectiveness.

Discussion

School-based interventions with direct parental involvement have the potential to improve children's weight status, physical activity and sedentary behavior. Based on the results, it is recommended that school-based interventions with direct parental involvement target more than one EBRB, last at least one year, and focus particularly on the physical and social environment within both the school and the family environment.

Background

Since 1980, overweight and obesity prevalence rates among children have increased rapidly [1]. Although many local, national and international efforts have been implemented to reduce overweight and obesity [43, 44], their prevalence among children and adolescents is still alarmingly high and increasing. In 2013, 23.8 percent of boys and 22.6 percent of girls in developed countries were overweight or obese [1]. Unhealthy eating behaviors, low levels of physical activity and a sedentary lifestyle are important causes of overweight and obesity [45]. These individual energy balance-related behaviors (EBRBs) are influenced by multiple factors, such as the environment to which a child is exposed [46, 47].

Two important environmental settings affecting children's EBRBs are the family environment and the school environment. Since schools have a large reach [48], many school-based interventions have been developed with the aim to promote healthy EBRBs of primary school children [44]. Considering the important influence of parents on children's EBRBs, the WHO School Health Promotion Framework advocates parental involvement in these school-based interventions [32]. As a result, a larger number of school-based interventions with parental involvement are being implemented [49].

Although the importance of parental involvement in school-based interventions is recognized [32, 36, 50], the evidence regarding the effectiveness of school-based, overweight-prevention interventions in which the parents were involved is inconclusive. A systematic review conducted in 2010 on combined community or school and home-based, obesity-prevention interventions found the results of 7 of the 15 included studies to be effective regarding nutrition behavior, physical activity behavior, sedentary behavior, weight status, or health risk factors [51]. A more recent review on school-based, overweight-prevention interventions in which the family environment was also targeted showed that 8 studies were effective regarding weight-related outcomes, whereas 19 studies had mixed results and 14 studies had ineffective results [52]. Also, the evidence regarding the additional effectiveness of parental involvement in school-based interventions remains uncertain [53, 54]. The explanations for this were an inadequate number of studies on school-based interventions with parental involvement [53, 54] and the mixed results reported by these studies [54].

These previous systematic reviews included both school-based interventions with direct or indirect parental involvement. Their results did show that school-based physical activity and nutrition interventions with direct parental involvement (e.g., parents were educated on health-related topics via group sessions) were more likely to be effective than school-based interventions in which parents were indirectly involved (e.g., parents were sent a newsletter). However, more research is needed to confirm these results [53]. Along with different settings (e.g., school and home), socio-ecological frameworks suggest the importance of targeting different types within these environments [18-20]. According to the Environmental Research framework for weight Gain prevention (EnRG) [20] the physical, social, economic and political environment influences children's EBRBs at the micro- and macro-levels [19], either directly or mediated by sociocognitive factors. The framework can be used to disentangle the determinants targeted in interventions (individual socio-cognitive determinants and the different environmental types within different settings) that may have been important for changing children's EBRBs. To our

knowledge, no systematic review on the effectiveness of school-based physical activity and nutrition interventions with direct parental involvement has identified targeted child's socio-cognitive determinants and environmental types within the school and family environment in order to explore a pattern between these factors and intervention effectiveness. Including this contextual information can contribute substantially to the understanding of intervention effectiveness. The aims of this systematic review were to study the effectiveness of school-based physical activity and nutrition interventions with direct parental involvement regarding children's weight status and EBRBs and to categorize the intervention components into distinct types of socio-cognitive factors and different environmental types targeted using the EnRG framework [20].

Methods

Although the protocol of this systematic review was not registered before conduct of the study, procedures were protocoled and described in detail here to enhance transparency and reproducibility. A literature search was performed in order to conduct two systematic reviews: one systematic review regarding preschool interventions with a direct parental involvement component targeting the EBRBs of children aged 2–4 years (manuscript in preparation), and one systematic review regarding primary school interventions with direct parental involvement targeting the EBRBs of children aged 4–12 years. The latter review is the current study. The literature search was conducted by two reviewers (SV and IvdK) in Pubmed, Web of Science, PsychInfo and ERIC in June 2016 and updated in June 2017 and March 2018. A list of relevant categories and related search terms and keywords was prepared (Table 2.1), consisting of six categories: (1) intervention participants, (2) intervention target behaviors, (3) school environment, (4) family environment, (5) intervention, and (6) effectiveness studies. As an illustration, the search strategy used in Pubmed is presented in Table 2.6 (Additional file 2.1).

Inclusion criteria

Studies were included if they:

1. investigated the effectiveness of a school-based intervention targeting physical activity behavior (PA), sedentary behavior (SB) and/or nutrition behavior (NB);
2. considered the effects on children's Body Mass Index (BMI), the BMI z-score (BMI adjusted for age and gender) and/or PA, SB and NB;
3. targeted children aged 4 to 12 years attending primary school;
4. studied a school-based intervention which consisted of at least one of the following types of interventions: (a) changes to the school's physical environment, e.g., providing fruit or vegetables at school, or creating an activity-friendly playground; (b) changes to the school's social environment, e.g., training school staff about health promotion, or the implementation of activity breaks by teachers; (c) changes to the school's policies, e.g., rules about fruit and vegetable consumption at school or active transportation to school; or (d) economic support for the school, e.g., a

budget for implementing activities promoting physical activity or providing fruit and vegetables;
5. studied a school-based intervention that directly involved parents. The definition of 'direct parental involvement' by Hingle et al. [53] was used: requesting parents to attend energy balance-related education sessions, e.g., workshops or lessons promoting physical activity, improving children's diet or reducing sedentary behavior; or asking parents to attend or participate in family behavior counseling or parent training sessions [53]. These sessions could have been conducted at home (in group sessions or one-on-one) or at a different location (at school, for example);
6. were written in English.

Table 2.1. Categories and terms of the search strategy.

Category 1: Intervention participants
Child(ren), preschool child(ren), minor(s), toddler(s), infant(s)
Category 2: Intervention target behaviors
Motor activity, physical activity, physical activities, sedentary behavior, lifestyle, energy balance, diet(s), dietary, food, nutrition, (un)healthy food, (un)healthy eating, energy intake
Category 3: School
Nursery, nurseries, child day care center(s), day care(s), preschool(s), kindergarten(s), playgroup(s), school(s), primary school(s), school-based, school-centered
Category 4: Family
Parent(s), father(s), mother(s), caregiver(s), family, families, family based, home (based), parental
Category 5: Intervention
Intervention(s)
Category 6: Effectiveness studies
Evaluation(s) (study), effect(s), effective(ness), effectivity, pre-post-test(s)

Exclusion criteria

A study was excluded if:
1. the intervention only indirectly involved parents, as defined by Hingle et al. [53]: (1) sending newsletters or information sheets to parents; (2) inviting parents to attend a health-related information evening; or (3) giving children homework that should be made with the help of their parents;
2. the intervention did not target the school environment (i.e., change the normal school's routine);
3. the intervention was exclusively aimed at a particular subpopulation, e.g., overweight primary school children;
4. it was defined as a pilot study by the study authors. This was done because the aim of pilot studies is to test an intervention's feasibility instead of its effectiveness.

Study selection

After removing the duplicates, the retrieved articles were screened independently on title/abstract by the two researchers (SV and IvdK). The remaining articles were screened as full text to assess the eligibility of the studies, based on the inclusion and exclusion criteria, determined a priori. Again this was done, independently, by two researchers (SV and IvdK). An overall agreement between the researchers of 74.6% existed. Discrepancies were discussed until consensus was reached. If no consensus was reached, a third researcher (SG) independently assessed the eligibility of the studies. The third researcher was consulted for four articles.

Data extraction

The PRISMA statement was used in writing this systematic review [55] (Additional file 2.2: Figure 2.2). One researcher (SV) conducted the data extraction regarding the study characteristics, intervention characteristics, and study effectiveness using predefined forms. The information on the following study characteristics was extracted: study design, setting, number of schools participating in the study, the timeframe in which follow-up measurements were made, number of participants, drop-out rates, characteristics of the participants and outcome measures.

The methodological quality of the studies was assessed using the quality assessment instrument of the Effective Public Health Practice Project (EPHPP) [56]. This instrument can be used to assess the quality of quantitative studies with a variety of study designs [56]. The studies were rated on six key quality components: selection bias, study design, confounders, blinding, data collection methods, withdrawals and drop-outs. Each of these quality components was rated 'weak', 'moderate' or 'strong'. For example, a strong score was given when the study design was described as an RCT or a controlled clinical trial. An overall score was given based on the scores of the six quality components. The overall quality was rated: 'strong' when there were no weak and at least four strong ratings for the six quality components; 'moderate' when only one quality component was rated as weak; and 'weak' in case there were two or more weak ratings [56]. Two researchers (SV and IvdK) independently rated the quality of the articles. The interrater reliability was 72.1%. Differences were the result of different interpretations of the studies. The researchers compared their quality scoring results and reached consensus by discussion.

The effects on BMI, BMI z-score, physical activity behavior, sedentary behavior, and nutrition behavior were described. Study effectiveness was regarded as positive when all results regarding a particular outcome (e.g., BMI and BMI z-score) showed a statistically significant improvement for the intervention group. Study results were considered mixed when at least one finding of a particular outcome was statistically significant in favor of the intervention group but the other findings were not (e.g., a statistically significant improvement in fruit intake and ineffective or negative results regarding vegetable intake). The results were considered negative, when the results were statistically significant in favor of the control group. An intervention was considered ineffective when there were no statistically significant results for either the intervention or the control group.

Where possible, Cohen's d effect sizes were calculated to indicate the standardized difference between the means of the intervention and control groups for the different outcome measures [57]. In case of multiple intervention arms, only the effects of the intervention arm that was school-based and included parental involvement were recorded. For studies without a control group, Cohen's d was calculated by dividing the mean change in the outcome measure by the standard deviation of the baseline value. Lipsey's cut-off points [58] were used to classify the magnitude of the effect: an effect size below 0.32 was considered 'small', between 0.33 and 0.55 'moderate' and 0.56 or more 'large' [58]. When information required for calculating an effect size was missing (as was the case in five studies), a request was sent to the authors to provide the missing information. One author responded to this request.

Regarding the interventions, information was extracted on the intervention duration and the behavior targeted by the intervention. In addition, the different types of socio-cognitive determinants of the children (knowledge, awareness, attitude, subjective norms, self-efficacy, intrinsic motivation) and the different environmental types (political, economic, physical and sociocultural) affecting the child were distinguished, according to the EnRG framework by Kremers et al. [20]. Examples of the environmental types are the parental rules regarding the child's dietary behavior (political), the costs of healthy foods in the school canteen (economic), the availability of play equipment during school breaks (physical) and the stimulation of physical activity behavior at school by the teachers (sociocultural).

Results

The literature search resulted in a total of 5,564 studies and after removal of duplicates, a total of 3,705 studies remained. After screening on title and abstract, 146 records were assessed for eligibility by reading the full text. Finally, 25 studies describing the effectiveness of primary school-based interventions with direct parental involvement were included (Figure 2.1). The main reason for exclusion was that parents were only indirectly involved (n = 66): in most cases parents only received newsletters or information documents (n = 31).

General study characteristics

The 25 included studies described the effectiveness of 24 school-based interventions with direct parental involvement. Of the 25 included studies, ten were randomized controlled trials [59-68], eleven were quasi-experimental studies [69-79], three had a pretest-posttest design [80-82] and one study had a repeated cross-sectional design [67] (Table 2.2). Most interventions (n = 9) were conducted in the USA [62, 69, 71-73, 76, 78, 79, 81]. The interventions were conducted between 1992 and 2015. The number of schools participating in the studies ranged from 1 [73] to 38 [83]. All studies performed the follow-up measurements immediately at the end of the intervention. One study conducted longer-term follow-up measurements (one year follow-up) [60]. The number

of children participating in the study at baseline ranged from 97 [73] to 9867 [67]. Drop-out rates varied from 2% [61] to 48% [81]. Information on drop-out rates was missing in six studies [59, 71-73, 76, 79]. The average age of children participating in the included studies ranged from 5 [82] to 12 years [60]. Eighteen studies measured intervention effects on BMI or BMI z-score [59, 61, 62, 64-70, 72, 74, 75, 77, 79-81, 83]. Eleven studies measured PA [59, 62, 63, 65-68, 70, 75, 80, 82] and nine studies measured SB [62, 63, 66-68, 70, 71, 80, 82]. Twelve studies measured NB [59, 60, 62, 65, 67, 68, 72, 73, 76, 78, 80, 82].

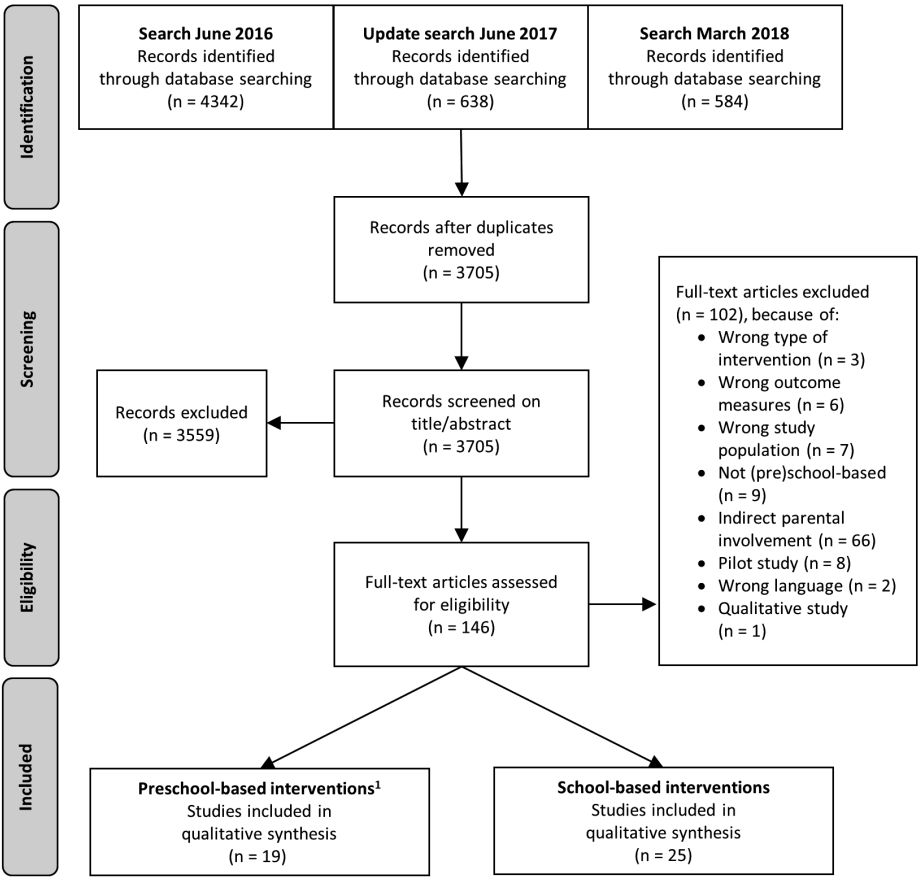


Figure 2.1. Flowchart of study selection.

Note.[1] Results are published as: van de Kolk I, Verjans-Janssen SRB, Gubbels JS, Kremers SPJ, & Gerards SMPL. Systematic review of interventions in the childcare setting with direct parental involvement: effectiveness on child weight status and energy balance-related behaviours. International Journal of Behavioral Nutrition and Physical Activity. 2019;16(1): 110.

Table 2.2. General characteristics of the included studies

	Study characteristics	**Intervention characteristics**	**Population characteristics**	**Outcome measures**			
Authors	***Study design, follow-up, sample size (dropout)***	***Country, year, duration, behavior targeted***	***No. of schools, mean age***	***BMI (z-score)***	***Physical activity behavior***	***Sedentary behavior***	***Nutrition behavior***
Alexander et al. (2014) [69]	Quasi-exp.	USA, 2011	2 Intervention schools	BMI (kg/m^2) per BMI percentile subgroup[a]			
	6 months	6 months	2 Control school				
	N = 749 (25%)	PA, NB	NR (range: 6-8 yrs)				
Angelopoulos et al. (2009)	RCT	Greece, 2005-2006	13 Intervention schools	BMI (kg/m^2)[a]	MVPA (min/day)[b]		Fruit intake (exchanges/day)[b]
[59]	14 months	12 months	13 Control schools	BMI z-score[a]			Vegetable intake (exchanges/day)[b]
	N = 646 (NR)	PA, NB	10.3 ± 0.4 yrs				Dairy intake (exchanges/day)[b]
							Fats and oils intake (exchanges/day)[b]
							Meat intake (exchanges/day)[b]
							Grains intake (exchanges/day)[b]
							Sweets and beverages intake (exchanges/day)[b]
Bacardí-Gascon et al. (2012) [80]	Pretest-posttest	Mexico, 2008-2010	4 Intervention schools	BMI (kg/m^2)[a]	Outdoor play (h/day)[b]	Sitting (h/day)[b]	Fruit intake (portions/day)[b]

	Study characteristics	Intervention characteristics	Population characteristics	Outcome measures			
Authors	***Study design, follow-up, sample size (dropout)***	***Country, year, duration, behavior targeted***	***No. of schools, mean age***	***BMI (z-score)***	***Physical activity behavior***	***Sedentary behavior***	***Nutrition behavior***
Bacardí-Gascon et al. (2012) [80] (continued)	24 months	6 months	*No control schools*	BMI z-score[a]	Physical education (h/week)[b]	TV watching (h/day)[b]	Vegetable intake (portions/day)[b]
	N = 532 (10%)	PA, NB	8.5 ± 0.7 yrs		Supervised sports or dancing (h/week)[b]	Computer and video games (h/day)[b]	Sugar-sweetened beverages intake (portions/day)[b]
							Soda intake (portions/day)[b]
							Chocolate and candy intake (portions/day)[b]
							Snack intake (portions/day)[b]
Bere et al. (2006) [60]	RCT	Norway, 2001-2003	9 Intervention schools				Fruit and vegetable intake at school (portions/day)[b]
	8 months and 1 year and 8 months	6 months	10 Control schools				Fruit and vegetable intake (portions/day)[b]
	450 (18%)	NB	11.3 ± *NR yrs*				
Cao et al. (2015) [61]	cluster RCT	China, 2011-2013	8 Intervention schools	BMI z-score[a]			
	1, 2 and 3 years	34 months	8 Control schools				
	1854 (2%)	PA, NB	6.9 ± 0.3 yrs				

Authors	Study characteristics *Study design, follow-up, sample size (dropout)*	Intervention characteristics *Country, year, duration, behavior targeted*	Population characteristics *No. of schools, mean age*	Outcome measures *BMI (z-score)*	*Physical activity behavior*	*Sedentary behavior*	*Nutrition behavior*
Centis et al. (2012) [70]	Quasi-exp.	Italy, 2008-2009	7 Schools	BMI (kg/m^2)[a]	Time spent in outdoor activities (h/week)[c]	Time spent watching TV (h/week)[c]	
	8 months	5 months	(1 intervention-arm & control-arm)	BMI z-score[a]	Time spent in extra-curricular sports courses (h/week)[c]		
	209 (10%)	PA, NB	9.4 ± 0.3 yrs				
Chomitz et al. (2010) [81]	Pretest-posttest	USA, 2005-2007	12 Intervention schools	BMI z-score[a]			
	3 years	3 years	*No control schools*				
	3561 (48%)	PA, NB	7.7 ± 1.8 yrs				
Cong et al. (2012) [71]*	Quasi-exp.	USA, 2007-2008	2 Intervention schools			Sedentary behavior (hours of screen viewing/day)[c]	
	22 months	22 months	2 Control schools				
	N = 416 (NR)	PA, NB	6.7 ± 1.0 yrs				
Crespo et al. (2012) [62]	RCT	USA, 2003-2006	3 Intervention schools	BMI z-score[a]	PA behavior (PA behavior compared to other children of same age and sex with 1=much less than others; 5 = much more than others)[c]	TV viewing (frequency of TV viewing while getting ready for school with 1=never; 5= always)[c]	Fruit and vegetable intake (servings/day)[c]

Authors	Study characteristics *Study design, follow-up, sample size (dropout)*	Intervention characteristics *Country, year, duration, behavior targeted*	Population characteristics *No. of schools, mean age*	Outcome measures *BMI (z-score)*	*Physical activity behavior*	*Sedentary behavior*	*Nutrition behavior*
Crespo et al. (2012) [62] (continued)	1, 2 and 3 years	3 years	4 Control schools	BMI percentile for age and gender[a]	Team sports (no. of team sports participated in the past year)[c]		Snack intake (servings/day)[c]
	N = 392 (45%)	PA, NB	5.9 ± 0.9 yrs				Sugar-sweetened beverages intake (servings/day)[c] Water consumption (servings/day)[c]
Engelen et al. (2013) [63]	RCT	Australia, 2009-2010	6 Intervention schools		Light PA (min/day)[a]	Time spent sedentary (min/day)[a]	
	13 weeks	13 weeks	6 Control schools		MVPA		
	N = 221 (7%)	PA	6.0 ± 0.6 yrs		(min/day)[a]		
Feng et al. (2016) [72]*	Quasi-exp.	USA, 2007-2008	2 Intervention schools	BMI percentile for age and gender[a]			Sugar-sweetened beverages consumption (oz/day)[c]
	4, 10, 16 and 22 months	22 months	2 Control schools				
	N = 555 (NR)	PA, NB	6.7 ± 1.0 yrs				
Hopper et al. (1996) [73]	Quasi-exp.	USA, *NR*	1 school				Cholesterol intake (mg/weekday)[c]

Authors	Study characteristics *Study design, follow-up, sample size (dropout)*	Intervention characteristics *Country, year, duration, behavior targeted*	Population characteristics *No. of schools, mean age*	Outcome measures *BMI (z-score)*	*Physical activity behavior*	*Sedentary behavior*	*Nutrition behavior*
Hopper et al. (1996) [73]	12 weeks	10 weeks	(1 intervention-arm & 1 control-arm)				Saturated fat intake (mg/weekday)[c]
(continued)	N = 97 *(NR)*	PA, NB	8.9 ± 1.2 yrs				Fruit and vegetable intake (servings/ weekday)[c]
							Grain and cereal intake (servings/ weekday)[c]
Jiang et al. (2007) [64]	RCT	China, NR	2 Intervention schools	BMI (kg/m^2)[a]			
	3 years	3 years	3 Control schools				
	N = 2489 (3%)	PA, NB	8.3 ± 1.5 yrs				
Kain et al. (2004) [74]	Quasi-exp.	Chile, 2002	3 Intervention schools	BMI (kg/m^2)[a]			
	8 months	6 months	2 Control schools	BMI z-score[a]			
	N = 3577 (14%)	PA, NB	10.6 ± 2.5 yrs				
Li et al. (2014) [75]	Quasi-exp.	China, 2012-2013	2 Intervention schools	BMI (kg/m^2)[a]	Duration of MVPA (min/day)[b]		
	12 weeks	12 weeks	2 Control schools				
	N = 921 (7%)	PA, NB	10.4 ± 2.2 yrs				
Manios et al. (1999) [65]	RCT	Greece, 1992-1995	12 Intervention schools	BMI (kg/m^2)[a]	Leisure-time MVPA (h/week)[c]		Energy intake (kcal/days)[c]
	3 years	3 years	9 Control schools				Total fat (g/day)[c]

Authors	Study characteristics *Study design, follow-up, sample size (dropout)*	Intervention characteristics *Country, year, duration, behavior targeted*	Population characteristics *No. of schools, mean age*	*BMI (z-score)*	Outcome measures *Physical activity behavior*	*Sedentary behavior*	*Nutrition behavior*
Manios et al. (1999) [65]	N = 579 (19%)	PA, NB	*NR*				Cholesterol (g/day)[c]
(continued)							Protein (g/day)[c]
							Carbohydrate (g/day)[c]
							Fiber (g/day)[c]
Müller et al. (2001) [82]	Pretest-posttest	Germany, 1996-1999	3 Intervention schools		PA (% Children performing daily PA)[b]	TV watching (h/day)[b]	Fruit and vegetables intake (% children with daily intake)[b]
	1 year	4 years	3 Control schools (waiting list control group)				
	N = 2440 (33%)	PA, NB	*NR* (range: 5-7 yrs)				
Prelip et al. (2012) [76]	Quasi-exp.	USA, 2009-2010	4 Intervention schools				Fruit intake (number of times/day)[b]
	10 months	10 months	2 Control schools				Vegetables intake (number of times/day)[b]
	N = 399 (NR)	NB	*NR* (range: 8-11 yrs)				

Authors	Study characteristics *Study design, follow-up, sample size (dropout)*	Intervention characteristics *Country, year, duration, behavior targeted*	Population characteristics *No. of schools, mean age*	Outcome measures *BMI (z-score)*	*Physical activity behavior*	*Sedentary behavior*	*Nutrition behavior*
Sanigorski et al. (2008) [77]	Quasi-exp.	Australia, 2003-2006	10 Intervention schools (4 preschools and 6 primary schools)	BMI (kg/m^2)[a]			
	3-4 years	3 years	16 Control schools (4 preschools and 12 primary schools)	BMI z-score[a]			
	N = 2184 (17%)	PA, NB	8.3 ± 2.2 yrs				
Sharma et al. (2016) [78]	Quasi-exp.	USA, 2013-2015	6 Intervention schools				Fruit intake (cups/1000 kcal/day)[c]
	16 weeks	16 weeks	6 Control schools				Vegetable intake (cups/1000 kcal/day)[c]
	N = 717 (26.6%)	NB	6.2 ± 0.4 yrs				Added sugar intake (tsp/1000 kcal/day)[c]
							Estimated percent of daily kilocalories from sugar beverages (%)[c]
							Fiber intake (grams/1000 kcal/day)[c]

Authors	Study characteristics *Study design, follow-up, sample size (dropout)*	Intervention characteristics *Country, year, duration, behavior targeted*	Population characteristics *No. of schools, mean age*	Outcome measures *BMI (z-score)*	*Physical activity behavior*	*Sedentary behavior*	*Nutrition behavior*
Sharma et al. (2016) [78]							Fat intake (grams/ 1000 kcal/day)[c]
(continued)							Average daily kilocalories (kcal/day)[c]
							Whole grains intake (ounce/1000 kcal/day)[c]
Siegrist et al. (2013) [66]	cluster RCT	Germany, 2006-2007	4 Intervention schools	BMI (kg/m^2)[a]	Active ≥ 60 min (days/week)[b]		
	1 year	1 year	4 Control schools	SDS-BMI[a]			
	N = 826 (12%)	PA	8.4 ± 0.7 yrs				
Treu et al. (2015) [79]	Quasi-exp.	USA, 2010-2011	9 Intervention schools	BMI (kg/m^2)[a]			
	6 months	6 months	9 Control schools	BMI z-score[a]			
	N = 1071 (NR)	PA, NB	8.7 ± 0.4 yrs				
Waters et al. (2017) [67]	Repeated cross-sectional	Australia, 2006-2009	12 Intervention schools	BMI (kg/m^2)[a]	Active games at lunchtime (% children performing active games at lunchtime)[b]	TV viewing week day (% children watching TV 2 hours or less per week day)[c]	Serves of fruit[c]

Authors	Study characteristics *Study design, follow-up, sample size (dropout)*	Intervention characteristics *Country, year, duration, behavior targeted*	Population characteristics *No. of schools, mean age*	Outcome measures *BMI (z-score)*	*Physical activity behavior*	*Sedentary behavior*	*Nutrition behavior*
Waters et al. (2017) [67] (continued)	4-5 years	3.5 years	10 Control Schools	BMI z-score[a]	Being outside yesterday (% children being outside 2 hours or more after school yesterday)[c]	TV viewing weekend day (% children watching TV 2 hours or less per weekend day)[c]	Serves of vegetables[c]
	N = 3167 (N/A)	PA, NB	*NR*		Being outside weekend day (% children being outside 2 hours or more on a weekend day)[c]		Soft drink consumption (% children consuming any soft drink/day)[c]
							Fruit juice consumption (% children consuming any fruit juice/day)[c]
							Water consumption (% children consuming 2 or more glasses of water/day)[c]
Xu et al. (2015) [68]	RCT	China, 2010-2011	4 Intervention schools	BMI (kg/m^2)[a]	Jogging/running frequency (% children with improved frequency)[b]	TV viewing or computer use (% children with reduced sedentary behavior)[b]	Red meat intake (% children with reduced intake)[b]

Authors	Study characteristics *Study design, follow-up, sample size (dropout)*	Intervention characteristics *Country, year, duration, behavior targeted*	Population characteristics *No. of schools, mean age*	*BMI (z-score)*	Outcome measures *Physical activity behavior*	*Sedentary behavior*	*Nutrition behavior*
Xu et al. (2015) [68] (continued)	10 months	10 months	4 Control schools		Walking frequency (% children with improved frequency)[b]		Fried snack intake (% children with reduced intake)[b]
	N = 1182 (6%)	PA, NB	10.2 ± 0.5 yrs		Ball playing (% children improved frequency)[b]		Soft drink consumption (% children with reduced intake)[b]
					Walking or riding bicycles to school (% children improved frequency)[b]		Vegetable intake (% children with increased intake)[b]
Xu et al. (2017) [83]	RCT	China, 2009-2010	21 Intervention schools	BMI (kg/m^2)[a]			
	1 year	1 year	17 Control schools	BMI z-score[a]			
	N = 9867 (10.3%)	PA, NB	9.0 ± 0.5 yrs				

Note. RCT = Randomized Controlled Trial, Quasi-exp. = Quasi-experimental, N/A = Not Applicable, NR = Not Reported, PA = Physical Activity, NB = Nutrition behavior, yrs = years, BMI = Body Mass Index, MVPA = Moderate-to-Vigorous intensity Physical Activity. *Cong et al. [71] and Feng et al. [72] studied the effectiveness of the same intervention. [a] Measurement objectively assessed; [b] Child-reported; [c] Parent-reported.

Quality of the included studies

The methodological quality of eight studies (32%) was rated as weak [62, 67, 69, 72, 75-77, 82] (Table 2.3). Twelve studies (48%) were rated as being of moderate methodological quality [59, 60, 64, 66, 71, 73, 74, 78-81, 83] and five studies (20%) as being of high methodological quality [61, 63, 65, 68, 70]. Weak ratings were mainly due to information not being reported. For example, only four studies reported whether investigators were blinded to the intervention status of the participants [63, 67, 75, 78]. In addition, information on validity and reliability of data collection instruments or drop-out rates was missing in many studies [59, 62, 64, 66, 69, 71, 76, 77, 79, 82, 84].

Table 2.3. Quality rating of included studies (based on Thomas et al. [56]).

	Selection bias	Study design	Confounders	Blinding	Data collection methods	Withdrawals and drop-out	Overall Score
Alexander et al. (2014) [69]	Weak	Strong	Weak	Moderate	Weak	Moderate	Weak
Angelopoulos et al. (2009) [59]	Strong	Strong	Strong	Moderate	Strong	Weak	Moderate
Bacardí-Gascon et al. (2012) [80]	Weak	Strong	Strong	Moderate	Strong	Strong	Moderate
Bere et al (2006) [60]	Strong	Strong	Weak	Moderate	Strong	Moderate	Moderate
Cao et al. (2015) [61]	Strong	Strong	Strong	Moderate	Strong	Moderate	Strong
Centis et al. (2012) [70]	Strong	Strong	Strong	Moderate	Strong	Strong	Strong
Chomitz et al. (2010) [81]	Moderate	Moderate	Strong	Moderate	Strong	Weak	Moderate
Cong et al. (2012) [71]	Moderate	Strong	Strong	Moderate	Strong	Weak	Moderate
Crespo et al. (2012) [62]	Moderate	Strong	Strong	Moderate	Weak	Weak	Weak
Engelen et al. (2013) [63]	Strong	Strong	Strong	Moderate	Strong	Strong	Strong
Feng et al. (2016) [72]	Weak	Strong	Weak	Moderate	Strong	Strong	Weak
Hopper et al. (1996) [73]	Weak	Strong	Strong	Moderate	Strong	Strong	Moderate

	Selection bias	Study design	Confound-ers	Blinding	Data collection methods	Withdraw-als and drop-out	Overall Score
Jiang et al. (2007) [64]	Strong	Strong	Strong	Moderate	Weak	Strong	Moderate
Kain et al. (2004) [74]	Weak	Strong	Strong	Moderate	Strong	Strong	Moderate
Li et al. (2014) [75]	Weak	Strong	Weak	Strong	Strong	Strong	Weak
Manios et al. (1999) [65]	Strong	Strong	Strong	Moderate	Strong	Strong	Strong
Muller et al. (2001) [82]	Weak	Weak	Weak	Moderate	Weak	Weak	Weak
Prelip et al. (2012) [76]	Weak	Strong	Strong	Moderate	Strong	Weak	Weak
Sanigor-ski et al. (2013) [77]	Weak	Strong	Moderate	Moderate	Weak	Strong	Weak
Sharma et al. (2016) [78]	Weak	Strong	Strong	Moderate	Moderate	Moderate	Moderate
Siegrist et al. (2013) [66]	Strong	Strong	Strong	Moderate	Weak	Strong	Moderate
Treu et al. (2015) [79]	Moderate	Strong	Strong	Moderate	Strong	Weak	Moderate
Waters et al. (2017) [67]	Weak	Moderate	Weak	Moderate	Weak	Moderate	Weak
Xu et al. (2015) [68]	Strong	Strong	Strong	Moderate	Strong	Strong	Strong
Xu et al. (2017) [83]	Weak	Strong	Strong	Moderate	Strong	Strong	Moderate

Intervention results regarding BMI or BMI z-score

Eleven of the eighteen studies measuring intervention effects on BMI or BMI z-score found favorable results [59, 61, 64, 65, 69, 70, 74, 75, 77, 81, 83]. Of these, seven studies were positively effective on BMI and BMI z-score [64, 65, 70, 75, 77, 81, 83, 85] and four studies found mixed results [59, 61, 69, 74]. Of the studies with mixed results, one study found the intervention to be positively effective regarding BMI, but ineffective regarding the BMI z-score [59], the remaining three studies found effective results for particular subgroups: normal and overweight subgroups [69]; children who were overweight and

obese at baseline [61]; and boys [74] (Additional file 2.3: Table 2.7). Of the studies with favorable results, effect sizes for BMI or BMI z-score were mainly small (ES -0.04 to -0.27) [61, 70, 74, 75, 77, 81]. Two studies had a moderate effect size (ES -0.34 and -0.48) [59, 65] and one study found a large effect on BMI (ES -0.79) [64] (Additional file 2.3: Table 2.7). The study quality of these studies was strong for three studies [61, 65, 70], moderate for five studies [59, 64, 74, 81, 83] and weak for three studies [69, 75, 77]. Six studies reported their intervention to be ineffective regarding BMI and BMI z-score [62, 66-68, 72, 79], although three of these showed a positive trend (ES -0.10 and -0.01, respectively) [67, 68, 72]. One study found negative results [80]. This was a pretest-posttest study without a comparison group.

Intervention results regarding physical activity behavior

Except for two studies, all eleven studies on PA found favorable results on at least one PA outcome measure [59, 62, 63, 65, 68, 70, 75, 80, 82]: four studies found significant positive results for all PA outcome measures [59, 65, 75, 82] and five studies found significant positive results for at least one PA outcome but were ineffective regarding other PA outcomes [62, 63, 70, 80, 83]. Small to large significant positive effects were found on total daily moderate-to-vigorous PA (MVPA) (ES 0.41 and 0.48) [59, 75], MVPA during school break time (ES 0.19) [63], leisure-time MVPA (ES 0.98) [65], time spent in outdoor activities (ES 0.49) [70], daily physical activities [82], frequency of jogging/running [68], number of sports participated in during the past year (ES 0.10) [62], and supervised sports or dancing per week (ES 0.34) [80]. PA was mostly self-reported by the children [59, 68, 75, 80, 82] or the parents [62, 65, 70]. One study measured PA by the use of accelerometers [63]. The methodological study quality of the studies with favorable results was strong for four studies [63, 65, 68, 70], moderate for two studies [59, 80] and weak for three studies [62, 75, 82]. Two studies found the intervention to be ineffective on PA [66, 67], however one study found a positive trend (ES 0.20) [66].

Intervention results regarding sedentary behavior

Six of the eight studies measuring SB found favorable results [63, 68, 70, 71, 80, 82]. Of these, four studies reported merely significant positive results [68, 70, 71, 82] and two reported significant positive result for at least one SB outcome but were ineffective regarding other SB outcomes [63, 80]. Small to moderate significant positive effects were found on TV watching per week (ES -0.38) [70] and TV watching per day (ES -0.15) [80, 82], screen-time behavior [71], TV viewing and computer use [68], sitting per day (ES -0.20) [80] and SB during school break time (defined by the use of accelerometer-specific cut-off points) (ES -0.02) [63]. SB was mainly measured via child-questionnaire [68, 80, 82] or parent-questionnaire [70, 71]. One study used accelerometers to measure SB [63]. Three studies were of strong methodological quality [63, 68, 70], two of moderate [71, 80] and one of weak quality [82]. Two interventions were found to be ineffective regarding frequency TV viewing. Although not significant, the results were in favor of the intervention group (ES -0.41) [62, 67].

Intervention results regarding nutrition behavior

Twelve studies measured intervention effects on NB. Five studies found favorable results regarding NB outcomes measured [68, 72, 73, 78, 82], of which two studies reported merely statistically significant positive results for all NB outcomes [72, 82] and three studies reported significant positive results, but were ineffective regarding other NB outcomes [68, 73, 77]. Small to moderate significant positive effects were seen on daily sugar-sweetened beverages consumption (ES -0.42) [72], fruit and vegetable consumption (ES 0.17, 0.21, 0.35) [73, 78, 82], added sugar intake (ES -0.21) [78], and red meat consumption [68]. The methodological study quality was mainly weak [72, 77, 82]; two studies were of moderate [73] and strong [68] methodological quality. Two studies reported mixed results: with statistically significant positive results for some NB outcomes and statistically negative results for other outcomes [59, 80]. Five studies found the intervention to be ineffective on NB [60, 62, 65, 67, 76].

Intervention characteristics

The intervention durations varied from ten weeks [73] to four years [82] (Table 2.2). It seems that interventions of longer duration (at least one year) were more likely to lead to favorable results regarding weight status [59, 61, 64, 65, 77, 81, 83], but not for PA, SB or NB. Two interventions targeted PA only [63, 66] and three interventions targeted NB only [60, 76, 78]. These interventions were mainly ineffective. The remaining interventions targeted children's PA as well as their NB. Eight studies reported to target children's SB (e.g., reduce TV viewing) [62, 66, 71, 72, 75, 77, 80-82].

The child's socio-cognitive determinants targeted

Five socio-cognitive determinants of the children targeted by the interventions could be distinguished: knowledge, awareness, attitude, self-efficacy and intrinsic motivation (Table 2.4). Except for three studies [63, 68, 70], all interventions educated the children on nutrition, physical activity, or health with the aim of increasing knowledge about EBRBs. Active ways of nutrition education (cooking classes) and physical education (in the form of extra and better-quality physical education) were implemented by 14 interventions, aiming to increase energy balance-related skills and self-efficacy [59, 60, 62, 65-73, 79-81]. Seven interventions aimed to increase the children's awareness on their own PA or NB, by asking them to monitor their behavior [59, 60, 66, 68, 70, 75, 80]. Six studies emphasized that their intervention was fun/enjoyable for the children, in order to increase intrinsic motivational regulation [59, 63, 65, 66, 68, 70]. Four interventions aimed to change children's attitudes toward PA and/or nutrition [59, 60, 70, 76]. No pattern was found between the child's socio-cognitive determinants targeted and intervention effectiveness.

Environmental types targeted

With the exception of the intervention by Manios et al. [65], all interventions targeted at least three environmental types in the school and family environment combined (Table 2.4). All interventions targeted at least the social school environment (teachers and/or other school staff) and the social family environment (the parents). Sixteen interventions aimed to change the physical school environment [59-63, 66-68, 70-72, 74, 76, 77, 80, 81, 83]. Physical changes to the school environment included changes to the school menu, gymnasium equipment and school playground improvement. The third most targeted environmental type was the political school environment (n = 10) (e.g., school health policies) and the political family environment (n = 11); parents were counseled on implementing parental rules which stimulate healthy EBRBs at home [60-62, 64, 66, 68, 69, 71, 72, 76-78, 82]. Four studies considered their interventions to be community-based [62, 72, 77, 81]. They targeted two or three environmental types in the community environment, one of which was the social community environment: training professionals of afterschool organizations [81], community health workers [62, 72], and club coaches and canteen staff [77]. There was no consistent pattern to the results in terms of the types and number of environmental types targeted.

Parental involvement components

All interventions involved the parents directly; 17 interventions additionally applied indirect involvement strategies by providing written information to parents, like newsletters, brochures, information sheets, recipe cards and lists of tips (n = 13) [60-62, 64-68, 71, 72, 77-79, 83], and/or by requesting parents to assist their child with the intervention-related homework (n = 8) [59, 61, 62, 65, 66, 73, 78, 79] (Table 2.5). Parents were predominantly directly involved in the intervention by attending educational sessions (n = 17) [59-61, 63-68, 70, 74-76, 78, 80, 82, 83]. These sessions were mainly organized as group sessions for the parents [60, 63, 64, 68, 70, 74-76, 80, 82]. Eight interventions implemented energy balance-related activities for parents and children (family activities), e.g., family cooking nights, fruit and vegetable bazaars, activities in the supermarket [59, 60, 69, 71, 72, 77-79, 81]. In seven interventions one-on-one counseling was provided, mostly by home visits [62, 69, 71, 72, 82], or telephone counseling [70, 73]. One study did not report the counseling method used [81]. Five interventions additionally targeted parents of overweight children [64, 69, 71, 72, 81, 82]; in these interventions parental counseling sessions were held [69, 71, 72, 81, 82] or information meetings were arranged [64]. These interventions were effective on children's BMI [64, 69], BMI z-score [81], PA [82], SB and NB [71, 72, 82]. In the four interventions in which parents were provided a report on their child's health status [59, 65, 80, 81] favorable results were found regarding the intervention effect on children's BMI [59, 65] and BMI z-score [81], their PA [65, 80] and SB [80].

Table 2.4. Children's socio-cognitive determinants, the community, school and family environmental types targeted, and effectiveness of the interventions.

	Socio-cognitive determinants					Environment												Effectiveness‡			
	Child					Community				School				Family				BMI			
Authors	Kn	Aw	At	S-E	I-M	Ph	So	Ec	Po	Ph	So	Ec	Pol	Ph	So	Ec	Po	(z)	PA	SB	NB
Alexander et al. (2014) [69]	•			•							•		•		•		•	+/0			
Angelopoulos et al. (2009) [59]	•	•	•	•	•					•	•		•	•	•			+/0	+		+/-/0
Bacardí-Gascon et al. (2012)† [80]	•	•		•						•	•				•			-	+/0	+/0	+/-/0
Bere et al. (2006) [60]	•	•	•	•						•	•	•		•	•		•				0
Cao et al. (2015) [61]	•									•	•		•		•		•	+/0			
Centis et al. (2012) [70]		•	•	•	•					•	•			•	•			+	+/0	+	
Chomitz et al. (2010)† [81]	•			•			•		•	•	•		•		•			+			
Cong et al. (2012) [71] / Feng et al. (2016) [72]	•			•						•	•			•	•		•	0		+	+
Crespo et al. (2012) [62]	•			•		•	•		•	•	•		•	•	•		•	0	+/0	0	0
Engelen et al. (2013) [63]					•					•	•				•				+/0	+/0	
Hopper et al. (1996) [73]	•			•							•				•	•					+/0
Jiang et al. (2007) [64]	•										•			•	•		•	+			
Kain et al. (2004) [74]	•									•	•	•			•			+/0			
Li et al. (2014) [75]	•	•									•		•	•	•			+	+		
Manios et al. (1999) [65]	•			•	•						•				•			+	+		0
Müller et al. (2001) [82]	•										•			•	•		•		+	+	+
Prelip et al. (2012) [76]	•		•							•	•			•	•		•				0
Sanigorski et al. (2008) [77]	•					•	•			•	•	•	•		•		•	+			

	Socio-cognitive determinants					Environment												Effectiveness‡			
	Child					Community				School				Family				BMI			
Authors	Kn	Aw	At	S-E	I-M	Ph	So	Ec	Po	Ph	So	Ec	Pol	Ph	So	Ec	Po	(z)	PA	SB	NB
Sharma et al. (2016) [78]	•										•			•	•	•	•				+/0
Siegrist et al. (2013) [66]	•	•		•	•					•	•		•		•		•	0	0		
Treu et al. (2015) [79]	•			•							•			•	•	•		0			
Waters et al. (2017) [67]				•						•	•	•	•		•			0	0	0	0
Xu et al. (2015) [68]	•	•		•	•					•	•		•		•		•	0	+/0	+	+/0
Xu et al. (2017)[83]	•									•	•				•			+			

Note. Kn = Knowledge, Aw = Awareness, At = Attitude, S-E = Self-efficacy, I-M = Intrinsic Motivation, Ph = Physical, So = Sociocultural, Ec = Economic, Po = Political, BMI (z) = Body Mass Index or Body Mass Index z-score, PA = Physical Activity Behavior, SB = Sedentary Behavior, NB = Nutrition Behavior. †Effect sizes are changes over time (no control group). Other effect sizes are effect sizes for the standardized mean difference (end line - baseline) between intervention group and control group. ‡The effectiveness of the studies is presented as Positive (+): all results for the particular outcome were statistically significant in favor of the intervention group; Mixed effects (+/-; +/0; +/-/0): at least one result was statistically significant in favor of the intervention group, whereas the other results were not; Negative effects (-): all results for the particular outcome were statistically significant in favor of the control group; Ineffective (0): no statistically significant results for one of the groups.

Table 2.5. Parental involvement components of interventions and effectiveness of the interventions.

	Direct parental involvement			Indirect parental involvement			Effectiveness‡			
Authors	**Education-al sessions**	**Family activities**	**One-one-one parent counseling**	**Support with child's homework**	**Provision of written informa-tion**	**Report with health sta-tus child**	**BMI/ BMI z**	**PA**	**SB**	**NB**
Alexander et al. (2014) [69]		•	•				+/0			
Angelopoulos et al. (2009) [59]	•	•		•		•	+/0	+		+/-/0
Bacardí-Gascon et al. (2012)† [80]	•					•	-	+/0	+/0	+/-/0
Bere et al. (2006) [60]	•	•			•					0
Cao et al. (2015) [61]	•			•	•		+/0			
Centis et al. (2012) [70]	•		•				+	+/0	+	
Chomitz et al. (2010)† [81]		•	•			•	+			
Cong et al. (2012) [71] / Feng et al. (2016) [72]		•	•		•		0		+	+
Crespo et al. (2012) [62]			•	•	•		0	+/0	0	0
Engelen et al. (2013) [63]	•							+/0	+/0	
Hopper et al. (1996) [73]			•	•						+/0
Jiang et al. (2007) [64]	•				•		+			
Kain et al. (2004) [74]	•						+/0			
Li et al. (2014) [75]	•						+	+		
Manios et al. (1999) [65]	•			•	•	•	+	+		0
Müller et al. (2001) [82]	•		•					+	+	+
Prelip et al. (2012) [76]	•									0
Sanigorski et al. (2008) [77]		•			•		+			
Sharma et al. (2016) [78]	•	•		•	•					+/0

Authors	Direct parental involvement			Indirect parental involvement			Effectiveness‡			
	Education-al sessions	Family activities	One-one-one parent counseling	Support with child's homework	Provision of written informa-tion	Report with health sta-tus child	BMI/ BMI z	PA	SB	NB
Siegrist et al. (2013) [66]	•			•	•		0	0		
Treu et al. (2015) [79]		•		•	•		0			
Waters et al. (2017) [67]	•				•		0	0	0	0
Xu et al. (2015) [68]	•				•		0	+/0	+	+/0
Xu et al. (2017) [83]	•				•		+			

Note. BMI (z) = Body Mass Index or Body Mass Index z-score, PA = Physical Activity Behavior, SB = Sedentary Behavior, NB = Nutrition Behavior. †Effect sizes are changes over time (no control group). Other effect sizes are effect sizes for the standardized mean difference (end line - baseline) between intervention group and control group. ‡The effectiveness of the studies is presented as positive (+): all results for the particular outcome were statistically significant in favor of the intervention group; Mixed effects (+/-; +/0; +/-/0): at least one result was statistically significant in favor of the intervention group, whereas the other results were not; Negative effects (-): all results for the particular outcome were statistically significant in favor of the control group; Ineffective (0): no statistically significant results for one of the groups.

Discussion

The aims of this systematic literature review were to explore the effectiveness of school-based physical activity and nutrition interventions with direct parental involvement regarding children's BMI, BMI z-score and their EBRBs and to distinguish the children's socio-cognitive determinants and environmental types targeted in these interventions. A total of 25 studies describing 24 school-based interventions with direct parental involvement were included. The majority of the studies reporting results regarding BMI and BMI z-score (11 of 18 studies) found favorable, though mainly small, effects. In addition, almost all studies that measured effects on physical activity behavior (9 of 11 studies) or sedentary behavior (6 of 8 studies) showed favorable results. The effects on nutrition behavior were inconclusive.

The results of this systematic review show more beneficial results for physical activity behavior and sedentary behavior compared to previous systematic reviews conducted on the effectiveness of these types of interventions [51, 52]. A possible explanation for the discrepancy in the results may be the fact that this study included only school-based interventions in which parents were directly involved, while other studies included mainly interventions with indirect parental involvement. This may indicate the importance of directly engaging parents in school-based interventions that aim to improve children's EBRBs instead of using indirect strategies such as intervention-related newsletters.

While no consistent pattern was found between intervention's effectiveness and the number of environmental types and specific environmental types targeted, a successful interaction between the social and physical environment in the school and the family environment is presumably important for school-based interventions to be effective. Most studies targeted both the social and the physical environment in the school and the family environment. Research has confirmed the influence of both the physical and social environment in the school and the family environmental setting on children's EBRBs [22, 86-88] and the enhancing effect that occurs when the social and physical environments interact [18]. This enhancing effect is seen in former studies in both the school setting [22] and the home setting [89]. The lack of a consistent pattern between targeted determinants and study outcomes may also be explained by the focus on more distal outcomes (BMI, EBRBs) used in this study. The mediating role of these targeted determinants on the outcomes fell out of scope for this review. However, it might be important to study intervention effects on these determinants, as this may be part of the explanation of effectiveness on BMI and EBRBs. In addition, the current review did not take into account the behavioral change techniques (BCTs) used in the intervention studies. There was substantial missing information across studies regarding BCTs, limiting comparability of the study results. However, taking into account BCTs may also be an important factor in understanding intervention effectiveness.

The results of this review should be interpreted with caution: the methodological quality between the studies varied greatly. In particular, the results regarding physical activity and sedentary behavior should be interpreted carefully, as most PA and SB were measured by self-reporting. Only one study objectively assessed PA and SB with accelerometers [63]. Subjective measurements are prone to social desirability and recall bias [90]. However, the overall methodological quality of the studies did not apparently

influence the results on PA and SB, as both studies of weak and strong quality had comparable results. This is something also encountered by other researchers, showing less strong effects on robust outcome measures (i.e., BMI or PA) for studies rated with a strong study design compared to studies with a weak study design [91]. Furthermore, process-related quality measures such as fidelity or compatibility, may be also important factors related to effectiveness in addition to research design aspects. This could be an aspect to consider in future reviews when assessing the quality of the included studies.

An explanation for the inconclusive results regarding intervention effectiveness on nutrition behavior might be intervention duration. Nutrition behavior is complex and it takes time to change dietary habits [92], thus it may be likely that interventions of longer duration will be more effective in changing dietary behaviors. However, this possible association between intervention duration and nutrition behavior outcomes has not yet been explored as the majority of the studies were of relative short duration (one year or less). This emphasizes the need to conduct long-term school-based interventions measuring effects on nutrition behavior. The need for long-term interventions when aiming to change children's weight status and EBRBs is confirmed by the studies measuring intervention effects on BMI or BMI z-score: long-term interventions (at least one year) were more likely to have favorable effects on children's weight status. In addition, interventions should target more than one EBRB. Interventions targeting more than one EBRB were more likely to be effective than interventions targeting a single EBRB. This result is in line with the empirical evidence that these behaviors tend to cluster, e.g., a clustering of high sedentary behavior and high levels of physical activity, indicating that a healthy single behavior not necessarily results in an overall healthy lifestyle [93]. Therefore, limiting interventions to a single behavior may result in missing an essential component of the energy balance, which may lead to less favorable results in relation to child outcomes [93].

Paying additional attention to the parents of an overweight or obese child may also be important for intervention effectiveness on children's weight status and EBRBs. One risk of school-based interventions is that healthy children may benefit more from the interventions than high-risk children [94]. Additional interventions or more intensive interventions for high-risk populations may overcome this problem [95, 96]. All interventions in which the parents of high-risk children were additionally targeted were effective at improving BMI, BMI z or EBRBs.

The implementation of school-based interventions with direct parental involvement is challenging since achieving parental engagement in school-based interventions is considered difficult [37]. Involving parents directly is even more challenging. The large number of studies on school-based interventions with indirect parental involvement [24] compared to the low number of studies on school-based interventions with direct parental involvement, confirms this assumption. There is a clear need to better operationalize parental involvement in school-based interventions in order to increase parental engagement. Perhaps parental involvement should be the primary focus of these types of interventions, taking into account parental perspectives and parental needs at first, and secondarily focusing on schools and children [97]. A focus on interpersonal aspects, such as parent-child bonding or providing set family time, which were rated by parents equally important as health reasons, may help in convincing them to participate in intervention activities [98]. The 'Healthy Dads, Healthy Kids'-

intervention is an example of a successful intervention, both on outcomes and retaining participation, incorporating these aspects in their intervention program [99].

A qualitative study on engaging families in physical activity research found that parents were more willing to engage in interventions when they received information about their children's health [100]. Two intervention studies that organized sessions in which the children's health status reports were distributed to the parents and information was provided about health-promoting strategies, showed high levels of parental attendance at these sessions [59, 65]. Lastly, a study among parents and early childhood professionals showed a preference for internet-delivered interventions in order to increase parental engagement [101]. Evidence regarding effective strategies to involve parents in school-based interventions is lacking [37]. These results need to be confirmed by future research, since information on parental attendance at information sessions was lacking in most papers.

Limitations of the studies

There are some limitations of the studies included in this review. Methodological study quality was difficult to rate in most papers because of a lack of detail. As a result, it might be underestimated. A second limitation was the great variation in outcome measures of EBRBs. We tried to overcome this problem by calculating effect sizes. Since only one author answered our request for additional information to allow the calculation of effect sizes, it was impossible to calculate the effect sizes for all studies. Another limitation was the incomplete description of most interventions. This limitation impeded comparison and extraction of information and may have biased the results as presented in this systematic review.

Strengths and limitations of the systematic review

To our knowledge this is the first systematic review aiming to disentangle the socio-cognitive determinants and different environmental types targeted in the school and home environment to explain the intervention effectiveness of school-based physical activity and nutrition interventions with direct parental involvement. We used the EnRG framework [20], which has been employed in other studies to analyze intervention content (e.g., [102]). Methodological strengths of this systematic review were the use of the EPHPP tool to assess the methodological quality of the studies (this quality assessment tool has proven content and construct validity) [56]; the use of the PRISMA statement [55] and the calculation of effect sizes (Cohen's d).

The limitations of this systematic review should also be acknowledged. There is a risk of publication bias, as we used only four databases and included only articles written in English. Another limitation may be the inclusion of studies with a weak methodology. In most cases, the weak methodological ratings were due to missing information. We decided to include these studies anyway, as we did not know whether the components determining quality were indeed not implemented by the researchers or whether they merely failed to report the information. The inclusion of studies with any other design

than a randomized controlled trial (RCT) can also be a limitation of this study, since RCTs are considered the gold standard [103]. However, the results of quasi-experimental study designs are valuable because of their external validity, and that study design is considered more appropriate for these types of interventions [104].

Recommendations

This systematic review demonstrates the potential of school-based interventions with direct parental involvement to improve BMI, BMI z, and physical activity and decrease sedentary behavior. We recommend that policymakers and practitioners develop and implement school-based interventions with direct parental involvement, focus on multiple EBRBs simultaneously to take into account the total energy balance, and target different environmental types, in particular the social and physical environments, both within the school and the home. We recommend that sustainability of interventions should be carefully considered as sustainable interventions (twelve months or longer) appear to be more effective compared to studies of shorter duration. This may require a shift in focus and budgeting, implementing less but more extensive intervention activities. To enable the implementation of these interventions, research should focus on effective strategies to engage parents and enhance parental involvement. This may need a shift in focus from primarily focusing on schools and children towards parents, making this the key element and taking into account their needs and perspectives. Further, we recommend an extended exploration of the role of behavioral change techniques alongside the types of environments and socio-cognitive determinants. This may add to the ability to explain intervention effectiveness, however fell out of scope for the current review. In addition, we recommend future studies to study the effectiveness on intermediate outcomes (e.g., socio-cognitive and environmental determinants) in order to explore the pathways of effectiveness of these types of interventions.

Appendices Chapter 2

Additional file 2.1

Table 2.6. Search strategy Pubmed.

Category	Search terms
Child	(Child [Mesh] OR Child [Title/Abstract]) OR Children [Title/Abstract] OR (Child, preschool [Mesh] OR Child, preschool [Title/Abstract]) OR Children, preschool [Title/Abstract] OR Minors [Mesh] OR Minor [Title/Abstract] OR Minors [Title/Abstract] OR (Pre-schoolers [Title/Abstract] OR Preschoolers [Title/Abstract]) OR Preschooler [Title/Abstract] OR Toddler [Title/Abstract] OR Toddlers [Title/Abstract] OR (Infant [Mesh] OR Infant [Title/Abstract]) OR Infants [Title/Abstract])
Intervention components	((“Motor activity” [Mesh] OR physical activity [Title/Abstract] OR physical activities [Title/Abstract]) OR (“Life Style” [Mesh] OR “lifestyle” [Title/Abstract] OR lifestyle [Title/Abstract] OR lifestyles [Title/Abstract]) OR “Energy balance” [Title/Abstract] OR (“Diet, Food and Nutrition” [Mesh] OR Food [Mesh] OR “healthy food” [Title/Abstract] OR “unhealthy food” [Title/Abstract] OR (Diet [Mesh] OR Diet [Title/Abstract] OR Dietary [Title/Abstract] OR Diets [Title/Abstract]) OR Nutrition [Title/Abstract] OR “Child Nutrition” [Mesh] OR (“healthy eating” [Title/Abstract] OR “unhealthy eating” [Title/Abstract]) OR (“energy intake” [Mesh] OR “energy intake” [Title/Abstract]) OR (“Sedentary Life Style” [Mesh] OR “Sedentary Life Style”[Title/Abstract] OR “Sedentary behavior” [Title/Abstract] OR “Sedentary behavior” [Title/Abstract])
Pre-School/ School	(“Schools, nursery” [Mesh] OR (“Child Day Care Centers” [Mesh] OR “Day Care” [Title/Abstract] OR “Daycare” [Title/Abstract] “Day Cares” [Title/Abstract] OR “Daycares” [Title/Abstract]) OR (Pre-school [Title/Abstract] OR Pre-schools [Title/Abstract] OR Preschool [Title/Abstract] OR Preschools [Title/Abstract]) OR (Kindergarten [Title/Abstract] OR Kindergartens [Title/Abstract]) OR (Nursery [Title/Abstract] OR Nurseries [Title/Abstract]) OR (Playgroup [Title/Abstract] OR Playgroups [Title/Abstract]) OR (Schools [Mesh] OR School [Title/Abstract] OR Schools [Title/Abstract] OR “Primary school” [Title/Abstract] OR “Primary schools” [Title/Abstract]) OR (“School based” [Title/Abstract] OR “School centered” [Title/Abstract]))
Family	(Parents [Mesh] OR Parent [Title/Abstract] OR Parents [Title/Abstract]) OR (Fathers [Mesh] OR Fathers [Title/Abstract] OR Father [Title/Abstract]) OR (Mothers [Mesh] OR Mothers [Title/Abstract] OR Mother [Title/Abstract]) OR (Caregiver [Title/Abstract] OR Caregivers [Title/Abstract]) OR (Family [Mesh] OR Family [Title/Abstract] OR Families [Title/Abstract]) OR (“Family based” [Title/Abstract] OR Home [Title/Abstract] OR “Home based” [Title/Abstract]) OR Parental [Title/Abstract])
Intervention	(Intervention [Title/Abstract] OR Interventions [Title/Abstract])
Effectiveness	((Evaluation [Title/Abstract] OR evaluations [Title/Abstract]) OR (“evaluation studies” [Publication type] OR “evaluation studies as topic” [Mesh]) OR (effects [Title/Abstract] OR effectiveness [Title/Abstract] OR effectivity [Title/Abstract] OR effective [Title/Abstract] OR effect [Title/Abstract]) OR “pre post test” [Title/Abstract] OR “pre post tests” [Title/Abstract])

Additional file 2.2

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	15
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	16
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	17-18
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	18
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	18
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	18-19
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	18
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	47 Additional file 2.1: Table 2.6
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	20
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	20-21
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	20
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	20

Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	21
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I2) for each meta-analysis.	n/a
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	n/a
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	n/a
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	22, Figure 2.1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	23-32, Table 2.2
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	33-34, Table 2.3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	34-36, 49-63 Additional file 2.3: Table 2.7
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	n/a
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	n/a
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	n/a
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	42-44
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	44-45
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	45-46
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	n/a

Note. n/a = not applicable. From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Figure 2.2. PRISMA Statement.

Table 2.7. Intervention effects on BMI/BMI z-score, physical activity behavior, sedentary behavior and nutrition behavior.

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Alexander et al. (2014) [69]	*BMI percentile <25:* A larger decrease in BMI for the intervention group (0.090 kg/m2) compared to the control group (0.029 kg/m2) (p =.64) *BMI percentile 25 to <50:* A decrease in BMI for the intervention group (0.161 kg/m2) and an increase for the control group (0.133 kg/m2) (p =.027) *BMI percentile 50 to <75:* A decrease in BMI for the intervention group (0.141 kg/m2) and an increase for the control group (0.109 kg/m2) (p =.045) *BMI percentile 75 to <95:* A smaller increase in BMI for the intervention group (0.074 kg/m2) compared to the control group (0.684 kg/m2) (p =.00007) *BMI percentile >95:* A smaller increase in BMI for the intervention group (0.48 kg/ m2) compared to the control group (0.78 kg/ m2) (p =.085)			

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Angelopoulos et al. (2009) [59]	A larger decrease in BMI z-score for the intervention group (-0.46) compared to the control group (-0.16) (p =.074) **ES -0.33** A decrease in BMI for the intervention group (-1.1 kg/m2) compared to an increase in BMI for the control group (0.1 kg/m2) (p =.047) **ES -0.34**	An increase in MVPA for the intervention group (2.2 min/day) and a decrease for the control group (-16.4 min/day) (p =.041) **ES 0.48**	NA	An increase of fruit exchanges/ day for the intervention group (0.4 exchanges/day) and a decrease of for the control group (-0.2 exchanges/day) (p =.044) **ES 0.44** A decrease in vegetables exchanges/ day for the intervention group (-0.02 exchanges/day) and no change for the control group (0.0 exchanges/ day) (p =.680) **ES -0.29** A decrease in dairy intake for the intervention group (-0.2 exchanges/ day) compared to an increase for the control group (0.2 exchanges/ day) (p =.008) **ES -0.30** A decrease in grains intake for the intervention group (-0.9 exchanges/ day) compared to an increase for the control group (0.3 exchanges/ day) (p =.055) **ES -0.38** A decrease in fats and oils intake for the intervention group (-1.6 exchanges/day) and an increase for the control group (0.7 exchanges/ day) (p =.028) **ES -0.47**

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Angelopoulos et al. (2009) [59] (continued)				A decrease in sweets and beverage intake for the intervention group (-0.8 exchanges/day) and an increase for the control group (0.2 exchanges/day) (p =.039) **ES -0.41**
Bacardí-Gascon et al. (2012) [80]	An increase in BMI z-score for the intervention group (0.09) (no control group) (p =.001) **ES 0.07**	A decrease in outdoors play for the intervention group (-0.03 h/day) (no control group) (p =.63) **ES -0.03**	A decrease in hours sitting per day for the intervention group (-0.49 h/day) (no control group) (p =.001) **ES -0.20**	A decrease in fruit portions per weekday for the intervention group (-0.08 portions/weekday) (no control group) (p =.26) **ES -0.07**
	An increase in BMI for the intervention group (1.3 kg/m2) (no control group) (p =.001) **ES 0.33**	An increase in physical education for the intervention group (0.07 h/week) (p =.003) **ES 0.23**	A decrease in TV watching for the intervention group (-0.16 h/day) compared to the control group (p =.02) **ES -0.15**	An increase in vegetable portions per weekday for the intervention group (0.09 portions/weekday) (no control group) (p =.007) **ES 0.15**
		An increase supervised sports or dance for the intervention group (0.76 h/week) (no control group) (p =.0001) **ES 0.34**	An increase in computer and video games usage for the intervention group (0.07 h/day) (p =.31) **ES 0.07**	An increase in sugar sweetened beverages consumption for the intervention group (0.62 portions/day) (no control group) (p =.0001) **ES 0.67**
				An increase in soda consumption (0.01 portions/day) (no control group) (p =.56) **ES 0.02**
				A decrease in chocolate and candy intake (0.06 portions/day) (no control group) (p =.24) **ES -0.06**
				A decrease in snack intake (0.08 portions/day) (no control group) (p =.03) **ES -0.10**

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Bere et al. (2006) [60]	NA	NA	NA	*After 8 months (end of intervention):* A larger decrease in portions fruit and vegetable per day at school for the intervention group (-0.07 portions/day) compared to the control group (-0.02 portions/day) (p =.53) **ES -0.04** A larger decrease in portions fruit and vegetable per day all day for the intervention group (-0.62 portions/ day) compared to the control group (-0.44 portions/day) (p =.23) **ES -0.04** *After 1 year and 8 months (follow-up):* A decrease in portions fruit and vegetable per day at school for the intervention group (-0.22 portions/ day) and a small increase for the control group (from 0.02 portions/ day) (p =.76) **ES -0.19** A larger decrease in portions fruit and vegetable per day all day for the intervention group (-0.88 portions/ day) compared to the control group (-0.42 portions/day) (p =.41) **ES -0.36**
Cao et al. (2015) [61]	*Normal weight at baseline:* No difference in BMI z-score for the intervention group compared to the control group (β = 0.002) (p =.638)	NA	NA	NA

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Cao et al. (2015) [61] (continued)	*Overweight at baseline:* A smaller increase in BMI z-score for the intervention group compared to the control group (β = -0.030) (p =.002) *Obesity at baseline:* A smaller increase in BM z-score for the intervention compared to the control group (β = -0.046) (p <.001) *Total group:* A smaller increase in BMI z-score for the intervention group (0.017) compared to the control group (0.047) (p-value unknown) **ES -0.19**			
Centis et al. (2012) [70]	A decrease of in SDS BMI for the intervention group (-0.06) and an increase of for the control group (0.13) (p <.001) **ES -0.19** A smaller increase in BMI for the intervention group (0.16 kg/m2) compared to the control group (0.75 kg/m2) (p <.001) **ES -0.27**	A larger increase in time spent in outdoor activities for the intervention group (3.70 h/week) compared to the control group (0.93 h/week) (p =.0155) **ES 0.49** A smaller decrease in time spent in extra-school sports courses for the intervention group (-0.12 h/week) compared to the control group (-0.35 h/week) (NR) **ES 0.15**	A decrease of in TV watching for the intervention group (0.96 h/week) and an increase for the control group (1.33 h/week) (p =.0044) **ES -0.38**	NA
Chomitz et al. (2010) [81]	A decrease in BMI z-score for the intervention group (-0.04) (no control group) (p <.001) **ES -0.04**	NA	NA	NA

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Cong et al. (2012) [71] / Feng et al. (2016) [72]	A larger decrease in BMI percentile for age and gender for the intervention group (-3.07) compared to the control group (-0.1) (ns) **ES -0.10**	NA	A smaller increase in screen time behavior for the intervention group (0.61 h/day) compared to the control group (β = -0.160) (NR) (p <.05)	A smaller increase in sugar-sweetened beverages for the intervention group (from 1.91 oz/ day) compared to the control group (8.71 oz/day) (p <.05) **ES -0.42**
Crespo et al. (2012) [62]	An increase in BMI z-score for the intervention group (0.09) and a decrease for the control group (-0.03) (p =.83) **ES 0.11**	An increase in PA compared to other children of same age and sex for the intervention group (0.3) and the control group (0.28) (p =.74) **ES 0.02**	A larger decrease in frequency of TV viewing while getting ready for school for the intervention group (-0.52) compared to the control group (-0.01) (p =.92) **ES -0.41**	A smaller increase in fruit and vegetable intake for the intervention group (0.32 servings/day) compared to the control group (0.47 servings/ day) (p =.55) **ES -0.05**
	An increase in BMI percentile for the intervention group (2.47) and a decrease for the control group (-1.33) (p =.88) **ES 0.04**	A larger increase in number of sports participated in the past year for the intervention group (1.11 sports/year) compared to the control group (1.0 sports/year) (p =.035) **ES 0.10**		A smaller decrease in snack intake for the intervention group (-0.44 servings/day) compared to control group (-0.47 servings/day) (p =.38) **ES 0.01**
				A smaller decrease in sugar-sweetened beverages consumption for the intervention group (-0.4 servings/day) compared to control group (-0.49 servings/day) (p =.34) **ES 0.06**
				A smaller increase in water consumption for the intervention group (0.22 servings/day) compared to control group (0.43 servings/day) (p =.41) **ES 0.01**

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Engelen et al. (2013) [63]	NA	*Break time PA:* No difference in LPA during break time for the intervention group and a decrease for the control group (-0.1 min/break time) (p =.79) **ES 0.00** An increase in MVPA during break time for the intervention group (0.4 min/ break time) compared to a decrease for the control group (-1.4 min/break time) (p =.006) **ES 0.19** *Total PA:* A decrease daily LPA for the intervention group (-2.1 min/day) and an increase for the control group (2.7 min/day) (p =.14) **ES -0.15** An increase daily MVPA for the intervention group (0.5 min/day) and a decrease for the control group (-1.0 min/day) (p =.19) **ES 0.0**	*Break time SB:* A decrease in sedentary behavior for the intervention group (-1.1 min/break time) compared to an increase for the control group (1.0 min/break time) (p =.01) **ES -0.02** *Total SB:* A smaller decrease in minutes per day of sedentary behavior for the intervention group (-3.2 min/day) compared to the control group (-3.5 min/day) (p =.99) **ES 0.0**	NA
Hopper et al. (1996) [73]	NA	NA	NA	A smaller increase in cholesterol intake for the intervention group (35.06 mg/weekday) compared to the control group (51.78 mg/ weekday) (ns)

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Hopper et al. (1996) [73] (continued)				A smaller increase in saturated fat intake for the intervention group (1.98 mg/weekday) compared to the control group (2.61 mg/weekday) (ns) An increase of in vegetable and fruit servings per day for the intervention group (0.35 servings/day) and a decrease for the control group (-0.25 servings/day) (p <.05) **ES 0.35** A smaller decrease in grain and cereal servings per day for the intervention group (-0.48 servings/day) compared to the control group (-0.83) (ns)
Jiang et al. (2007) [64]	A smaller increase in BMI for the intervention group (0.6 kg/m2) compared to the control group (2.8 kg/m2) (p <.01) **ES -0.79**	NA	NA	NA
Kain et al. (2004) [74]	*Boys:* No change in BMI of boys in the intervention group compared to an increase in BMI of the boys in the control group (0.3 kg/m2) (p <.001) **ES -0.08** A larger decrease in BMI z-score of boys in the intervention group (-0.12) compared to the decrease in BMI z-score of boys in the control group (-0.02) (P <.001) **ES -0.10**	NA	NA	NA

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Kain et al. (2004) [74] (continued)	*Girls:* A larger increase in BMI of girls in the intervention group (0.03 kg/m2) compared to the BMI of girls in the control group (0.02 kg/m2) (p =.60) **ES 0.03** A smaller decrease in BMI z-score of girls in the intervention group (-0.04) compared to the BMI z-score of girls in the control group (-0.07) (p =.49) **ES 0.03** *Total group:* No change in BMI for the intervention group compared an increase for the control group (0.3 kg/m2) (sign) A decrease in BMI z-score for the intervention group compared to no change for the control group (p <.001)			
Li et al. (2014) [75]	A decrease in BMI for the intervention group (0.02 kg/m^2) compared to an increase for the control group (0.41 kg/m^2) (p <.001) **ES -0.10**	An increase in total MVPA for the intervention group (8.9 min/day) compared to a decrease of for the control group (-13.8 min/day) (p <.001) **ES 0.41**	NA	NA
Manios et al. (1999) [65]	A smaller increase in BMI for the intervention group (0.7 kg/m^2) compared to the control group (1.8 kg/m^2) (p =.001) **ES -0.48**	A larger increase in leisure-time MVPA for the intervention group (2.0 h/week) compared to the control group (0.4 h/week) (p <.0005) **ES 0.98**	NA	A smaller increase in energy intake for the intervention group (269.7 kcal/day) compared to the control group (296.8 kcal/day) (ns) **ES 0.00**

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Manios et al. (1999) [65] (continued)				A smaller increase in total fat intake for the intervention group (8.3 g/day) compared to the control group (9.0 g/day) (ns) **ES -0.02** A larger increase in cholesterol intake for the intervention group (71.5 mg/day) compared to the control group (22.5 mg/day) (ns) **ES 0.32** A smaller increase in protein intake for the intervention group (6.4 g/day) compared to the control group (7.8 g/day) (ns) **ES -0.06** A larger increase in carbohydrate intake for the intervention group (38.4 g/day) compared to the control group (36.3 g/day) (ns) **ES 0.02** A smaller increase in fiber intake for the intervention group (0.05 g/day) compared to the control group (0.5 g/day) (ns) E**S -0.27**
Müller et al. (2001) [82]	NA	An increase in percentage children reporting daily physical activities for the intervention group (18% more children) (no control group) (p <.05)	A decrease in hours per day of TV watching for the intervention group (-0.3 h/days) (no control group) (p <.05)	An increase by 50% in the consumption of fruit and vegetables daily for the intervention group (20% more children) (no control group) (p <.05)

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Prelip et al. (2012) [76]	NA	NA	NA	A smaller decrease in times fruit eaten per day for the intervention group (-0.04 times/day) compared to the control group (-0.29 times/day) (ns) **ES 0.18** An increase in vegetables eaten per day for the intervention group (0.13 times/day) and a decrease for the control group (from -0.20 times/day) (ns) **ES 0.20**
Sanigorski et al. (2008) [77]	A larger increase in BMI for the intervention group (1.7 kg/m2) compared to the control group (1.3 kg/m2) (p =.20) **ES 0.14** A larger decrease in BMI z-score for the intervention group (-0.09) compared to the control group (-0.02) (p =.04) **ES -0.08**	NA	NA	NA
Sharma et al. (2016) [78]	NA	NA	NA	An increase in fruit intake for the intervention group (0.13 cups/1000 kcal per day) and a decrease for the control group (-0.01 cups/1000 kcal per day) (p =.046) **ES 0.17** A larger increase in vegetable intake for the intervention group (0.09 cups/1000 kcal per day) compared to the control group (0.03 cups/1000 kcal per day) (p =.049) **ES 0.21**

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Sharma et al. (2016) [78] (continued)				A larger decrease in added sugar intake for the intervention group (-063 tsp/1000 kcal per day) compared to the control group (-0.06 tsp/1000 kcal per day) (p =.014) **ES -0.21** A larger decrease in estimated percent of daily kilocalories from sugar beverages for the intervention group (-0.88%) compared to the control group (-0.33%) (p =.106) **ES -0.16** A larger increase in total fiber intake for the intervention group (0.82 grams/1000 kcal/day) compared to the control group (0.29 grams/1000 kcal/day) (p =.051) **ES 0.17** A larger decrease in total fat intake for the intervention group (-1.22 grams/1000 kcal/day) compared to the control group (-0.41 grams/1000 kcal/day) (p =.188) **ES -0.13** A decrease in daily kilocalories for the intervention group (-17.36 kcal/day) and an increase for the control group (45.14 kcal/day) (p =.228) **ES -0.11**

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Sharma et al. (2016) [78] (continued)				A larger increase in whole grains intake for the intervention group (0.07 ounce/1000 kcal/day) compared to the control group (-0.02 ounce/1000 kcal/day) (p =.129) **ES 0.15**
Siegrist et al. (2013) [66]	A larger increase in BMI for the intervention group (0.7 kg/m2) compared to the control group (0.6 kg/m2) (p =.165) **ES 0.03** A larger increase in SDS-BMI for the intervention group (0.06) compared to the control group (0.01) (p =.057) **ES 0.05**	A larger increase in the amount of days per week being active at least 60 min/day for the intervention group (0.5 days/week) compared to the control group (0.1 days/week) (p =.109) **ES 0.20**	NA	NA
Treu et al. (2015) [79]	A larger increase in BMI for the intervention group (0.6 kg/m2) compared to a decrease for the control group (-0.3 kg/m2) (p =.330) **ES 0.07** A larger increase in BMI z-score for the intervention group (0.06) compared to the control group (0.01) (p =.157) **ES 0.05**			
Waters et al. (2017) [67]	A smaller BMI for the intervention group (17.82 kg/m2) compared to the control group (17.95 kg/m2) at follow-up (mean difference: -0.16 kg/m2) (p =.36)	A higher percentage of children in the intervention group performing active games at lunchtime (73.1%) compared to the control group (69.7%) at follow-up (OR: 1.51, 95% CI: 0.84-2.69)	A higher percentage of children in the intervention group watching TV 2 hours or less per week day (82.1%) compared to the control group (79.8%) at follow-up (OR: 0.97, 95% CI: 0.75-1.25)	A higher number of fruit serves for the intervention group (2.48) compared to the control group (2.37) at follow-up (mean difference: 0.19) (p =.05)

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Waters et al. (2017) [67] (continued)	A smaller BMI z-score for the intervention group (0.68) compared to the control group (0.72) at follow-up (mean difference: -0.05) (p =.44)	A higher percentage of children in the intervention group being outside 2 hours or more yesterday (11.7%) compared to the control group (11.2%) at follow-up (OR: 1.33, 95% CI: 0.75-2.37)	A higher percentage of children in the intervention group watching TV 2 hours or less per weekend day (61.0%) compared to the control group (60.3%) at follow-up (OR: 1.06, 95% CI: 0.89-1.27)	A higher number of vegetable serves for the intervention group (2.15) compared to the control group (2.03) at follow-up (mean difference: 0.13) (p =.10)
		A lower percentage of children in the intervention group being outside 2 hours or more on a weekend day (54.4%) compared to the control group (56.2%) at follow-up (OR: 0.88, 95% CI: 0.63-1.24)		A higher percentage of children in the intervention group consuming soft drink per day (28.0%) compared to the control group (34.0%) at follow-up (OR: 0.89, 95% CI: 0.60-1.32)
				A higher percentage of children in the intervention group consuming any fruit juice per day (61.4%) compared to the control group (67.6%) at follow-up (OR: 0.86, 95% CI: 0.66-1.13)
				A higher percentage of children in the intervention group consuming 2 or more glasses of water per day (94.3%) compared to the control group (90.7%) at follow-up (OR: 1.33, 95% CI: 0.78-2.30)
Xu et al. (2015) [68]	A larger decrease in BMI for the intervention group (-0.32 kg/m²) compared to the control group (-0.29 kg/m²) (p =.09) **ES -0.01**	A higher percentage of children in the intervention group improved in frequency jogging/running (46.0%) compared to the control group (32.4%) (OR: 1.55, 95% CI: 1.18-2.02)	A higher percentage of children in the intervention group reduced the time viewing TV or using computers (49.4%) compared to the control group (41.0%) (OR: 1.41, 95%CI: 1.09-1.84)	A higher percentage of children in the intervention group decreased their red meat consumption (46.1%) compared to the control group (35.0%) (OR: 1.50, 95% CI: 1.15-1.95)

Authors	BMI/BMI z-score results	Physical activity behavior results	Sedentary behavior results	Nutrition behavior results
Xu et al. (2015) [68] (continued)		A higher percentage of children of the intervention group improved in frequency walking (46.9%) compared to the control group (45.7%) (OR: 0.98, 95% CI: 0.74-1.25)		A higher percentage of children in the intervention group decreased their fried snack consumption (29.1%) compared to the control group (27.4%) (OR: 1.08, 95% CI: 0.81-1.44)
		A higher percentage of children of the intervention group improved in frequency ball playing (40.0%) compared to the control group (35.8%) (OR: 1.21, 95% CI: 0.93-1.58)		A lower percentage of children in the intervention group decreased their soft drink consumption (26.4%) compared to the control group (28.2%) (OR 0.89; 95% CI: 0.67-1.19)
		A higher percentage of children of the intervention group improved in their commuting mode to school (28.9%) compared to the control group (16.5%) (OR: 2.24, 95% CI: 1.47-3.40)		A higher percentage of children in the intervention group increased their vegetable consumption (48.6%) compared to the control group (47.1%) (OR: 1.20, 95% CI: 0.92-1.55)
Xu et al. (2017) [83]	A smaller increase in BMI for the intervention group (0.06 kg/m2) compared to the control group (0.08 kg/m2) (p <.001) **ES -0.06** A decrease in BMI z-score for the intervention group (-0.11) compared to an increase for the control group (0.03) (p <.001) **ES -0.10**	NA	NA	NA

Note. BMI = Body Mass Index, NA = Not applicable, ns = non-significant (p ≥ 0.05), sign = significant, NR = Not Reported, ES = Effect Size (Cohen's d), PA = Physical Activity Behavior, MVPA = moderate-to-vigorous physical activity behavior, LPA = light physical activity behavior. OR = Odds Ratio, CI = Confidence Interval.

Chapter 3

Study protocol of the quasi-experimental evaluation of “KEIGAAF”: a context-based physical activity and nutrition intervention for primary school children

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Abstract

Background

The environment affects children's energy balance-related behaviors to a considerable extent. A context-based physical activity and nutrition school- and family-based intervention, named KEIGAAF, is being implemented in low socioeconomic neighborhoods in Eindhoven, The Netherlands. The aim of this study was to investigate: 1) the effectiveness of the KEIGAAF intervention on BMI z-score, waist circumference, physical activity, sedentary behavior, nutrition behavior, and physical fitness of primary school children, and 2) the process related to the implementation of the intervention.

Methods

A quasi-experimental, controlled study with eight intervention schools and three control schools was conducted. The KEIGAAF intervention consists of a combined top-down and bottom-up school intervention: a steering committee developed the general KEIGAAF principles (top-down), and in accordance with these principles, KEIGAAF working groups subsequently develop and implement the intervention in their local context (bottom-up). Parents are also invited to participate in a family-based parenting program, i.e., Triple P Lifestyle. Children aged 7 to 10 years old (grades 4 to 6 in the Netherlands) are included in the study. Effect evaluation data is collected at baseline, after one year, and after two years by using a child questionnaire, accelerometers, anthropometry, a physical fitness test, and a parent questionnaire. A mixed methods approach is applied for the process evaluation: quantitative (checklists, questionnaires) and qualitative methods (observations, interviews) are used. To analyze intervention effectiveness, multilevel regression analyses will be conducted. Content analyses will be conducted on the qualitative process data.

Discussion

Two important environmental settings, the school environment and the family environment, are simultaneously targeted in the KEIGAAF intervention. The combined top-down and bottom-up approach is expected to make the intervention an effective and sustainable version of the Health Promoting Schools framework. An elaborate process evaluation will be conducted alongside an effect evaluation in which multiple data collection sources (both qualitative and quantitative) are used.

Background

A large number of Dutch children do not meet the national recommendations for physical activity and healthy nutrition behavior. In 2015, less than half of the children (48%) aged 4 to 12 years were moderately physically active at least 60 min per day, with activities aimed at improving or maintaining physical fitness being done at least two times per week [105]. Moreover, children in the same age category spent on average 7.3 h per day being sedentary [105, 106]. Compliance with Dutch healthy nutrition guidelines is even lower; for example, only 5% of children between the ages of 7 and 19 years met the Dutch guidelines for daily fruit consumption (2 pieces a day), and just 1% met those for vegetable consumption (250 g daily) [107]. Additionally, unhealthy foods are consumed in large quantities. For example, a study on the consumption of sugar-sweetened beverages among a sample of Dutch primary school children from diverse ethnic backgrounds showed a consumption level of 0.9 l per day [108]. This study shows that these unhealthy balance-related behaviors are more prevalent among children living in families with a low socio-economic position [6, 7, 109-111].

The environment has a great influence on children's physical activity (PA), sedentary behavior (SB), and nutrition behavior (NB) - referred to jointly as energy balance-related behaviors (EBRBs) [20]. At the micro-environmental level, the family and school environment are important settings that influence children's EBRBs [46], with the child's parents exerting the most important influence on their children's EBRBs [47, 87, 89, 112-114]. For example, parents can affect their child's EBRBs by applying certain parenting practices, like monitoring dietary intake [89]. The physical home environment also stimulates or discourages healthy EBRBs, e.g., by the availability of healthy or unhealthy foods at home [115].

On weekdays, the school environment heavily influences children's PA [116]. The mode of transportation to and from school, physical activity during school recess (playtime), and physical education (PE) add to children's levels of physical activity behavior on a school day [17]. On the other hand, the school environment generally facilitates sedentariness among children, since most educational activities are performed in a seated position [117]. Because the children often consume lunch, beverages, and snacks during school time, schools can also affect the children's nutrition behavior. Even though Dutch primary school children bring their own beverages, snacks, and lunch to school, school nutrition policies (e.g., what children are allowed to bring to school) and healthy nutrition-promoting interventions can stimulate healthy nutrition behavior at school [15, 118].

Initiatives such as The Healthy School have been put in place to change children's health behaviors via schools [32, 44]. In a more traditional approach, interventions are developed by the researchers or health promoters, based on theory and best practices. Subsequently, the interventions are implemented in a relatively top-down fashion: intervention implementers, e.g., school teachers or school staff, are required to adhere to the intervention protocol and implement the intervention as intended with strict fidelity [119]. In such a top-down approach, the complexity of school systems is not taken sufficiently into account [119]. Each school is different, and each context in which the school operates can be considered unique [120]. The effectiveness of a school-based intervention depends on multiple factors within this context, such as the characteristics

of the community (e.g., socioeconomic status), characteristics of the school staff, school needs and priorities, internal and external collaborations, the school's physical environment, and its resources [120].

In a bottom-up approach, in which an intervention is developed by the users, in this case the schools, these contextual factors are taken into account, resulting in an intervention that meets the local needs and possibilities and is compatible with the school's priorities [37, 121, 122]. This, in turn, encourages the school's ownership of the intervention and enhances sustainability in the long-term [119, 121, 123]. A purely bottom-up approach may lead to the adoption and implementation of interventions that lack theoretical or empirical evidence regarding their impact on sustained behavior change [124]. Therefore, in the current project, a combined top-down and bottom-up approach is applied in which a school-based physical activity and nutrition intervention is developed and implemented by the school, local professionals, and parents, and guidelines about evidence are provided by a steering committee.

To ensure that not only the child's school environment but also the parents are involved in the intervention, the parents are invited to participate in a family-based lifestyle parenting program. Family-based parenting interventions have proven to be effective in reducing overweight among children and improving their EBRBs [41, 125]. As it is unclear whether high-risk children benefit enough from school-based interventions targeted at all children [126, 127], this part of the project is focused on parents in need of additional support regarding lifestyle-related parenting. This may contribute to the reduction of health inequalities between healthy children and high-risk children [96, 128].

The overall aim of the context-based school- and family-based interventions is to improve the EBRBs of children living in low socioeconomic neighborhoods by creating an environment that stimulates healthy EBRBs and discourages unhealthy EBRBs. The intervention, called KEIGAAF ('KEIGAAF' is a Dutch acronym and a local term referring to 'super cool'), is based on two promising avenues: a school-based physical activity and nutrition intervention combining a top-down and bottom-up approach [22], and a family-based lifestyle coaching intervention [41]. In this paper, the development and implementation of the KEIGAAF intervention are elaborated. The study design is outlined which evaluates the intervention's effectiveness on the PA behavior, sedentary behavior, nutrition behavior, weight status, and physical fitness of children aged 7 to 10 years living in low socioeconomic neighborhoods (Additional file 3.1: Figure 3.4). To evaluate whether effects on children's outcome measures are due to the intervention, a quasi-experimental controlled evaluation study will be conducted: the results of an intervention group will be compared with a control group consisting of children attending schools where the KEIGAAF intervention is not implemented.

A process evaluation will be conducted in addition to the effect evaluation. It is essential to look at intervention effectiveness in the context in which the intervention is implemented. An understanding of what is going on locally when implementing the intervention helps to clarify what works in what situation and for whom. This knowledge is essential when transferring effective EBRB-promoting intervention elements in the future to other situations [129]. Therefore, the second aim of this study is to evaluate the implementation of the KEIGAAF intervention (what is implemented and how is it implemented) and how contextual factors influence this implementation.

Methods

Study design

The aim of the KEIGAAF project is to design and test the effectiveness of the school- and family-based intervention on the primary outcome measure (BMI z-score) and the secondary outcome measures (PA behavior, sedentary behavior and nutrition behavior, physical fitness, and waist circumference) of children aged 7–10 years living in low socioeconomic neighborhoods.

A convenience sample of intervention schools was recruited in Eindhoven, a relatively large city in the southern part of the Netherlands. Schools were eligible if: 1) they were located in a low socioeconomic neighborhood; 2) they had no plans to merge with another school or to relocate in the coming three years, and if; 3) the school staff was willing to participate actively in KEIGAAF and to collaborate with parents and local partners, for instance, sports professionals, social workers, and/or municipality officers. The steering committee of the KEIGAAF project, consisting of researchers from Maastricht University and Fontys University of Applied Sciences (School of Sports Studies) and local partners from a school board, a sports support organization, and a social welfare organization, identified nine eligible schools. All nine schools were contacted and informed about the project, and eight schools agreed to participate. Because of the active participation of the intervention schools in the development and implementation of the intervention, no randomization was applied.

Control schools were recruited in Maastricht, a city comparable to Eindhoven based on the level of urbanization and the socioeconomic status of the neighborhoods. Three schools agreed to participate in the study; these schools did not apply the KEIGAAF intervention (Figure 3.1). Due to the distance between Eindhoven and Maastricht (approximately 90 km), a low risk of contamination is expected. KEIGAAF is funded by Fonds NutsOhra, project number 101.253, and the trial is registered as NTR6716. Ethical approval was obtained from the medical ethics committee of the Maastricht University Medical Centre (METC163027, national number: NL58554.068.16).

Participants

In the Dutch education system, children attend first grade at age 4. For this study, all children from grades 4 to 6, thus between the age of 7 and 10 years, of the participating intervention and control schools were eligible for inclusion. The researcher visited the eligible classes of the participating schools and talked to the children about the study. The children were given written information about the study to take home to their parents. In the parental information letter, the parents were informed about this specific information moment. They were also given the opportunity to ask questions about the study of the researcher during planned school meetings. School principals posted a message about the study in the school newsletter and/or on the school website well in advance. Once the parents and the child decided to participate, both parents signed an informed consent. Of the eligible children, 60.4% (61.3% in the intervention group and 56.8% in the control group) consented to participate in the study.

Parents of children who attended schools with relatively high proportions of overweight and obesity as defined during baseline measures (March and April 2017) were invited to participate in Lifestyle Triple P, the family-based parenting program. This strategy was applied to prevent stigmatization. The parents were recruited via written information: a flyer was distributed among the parents, a message was posted in the school newsletter and/or on the school website, and a poster was displayed at the entrance of the school. In addition, the family-based intervention coaches and the school doctor personally recruited parents. The coaches visited the school multiple times before school started and informed the parents about the intervention. The parents who participated in the intervention were given written information about the study related to the intervention. Parents who agreed to participate in this study signed an informed consent.

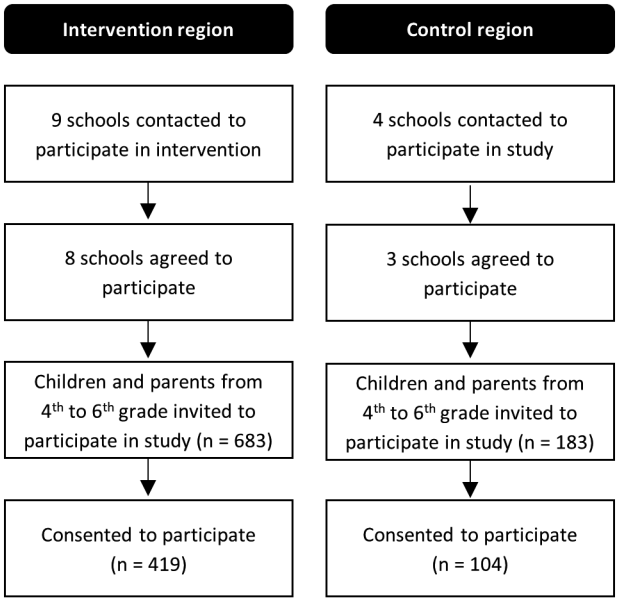


Figure 3.1. Study design

School-based intervention

The design of the school intervention follows the combined top-down and bottom-up approach previously successfully applied in the Active Living study (Figure 3.2) [22, 40]. In this mutual adaptation approach [119, 130], a steering committee develops the KEIGAAF principles, and KEIGAAF working groups at school level implement these principles in accordance with the needs of the school and its community. These principles are quite generic; the working groups have the autonomy to make almost all decisions regarding the intervention content. An action-oriented approach is applied: the intervention is continuously developed and adapted according to local needs and current systems. Adapting an intervention to local needs enhances intervention effectiveness [131].

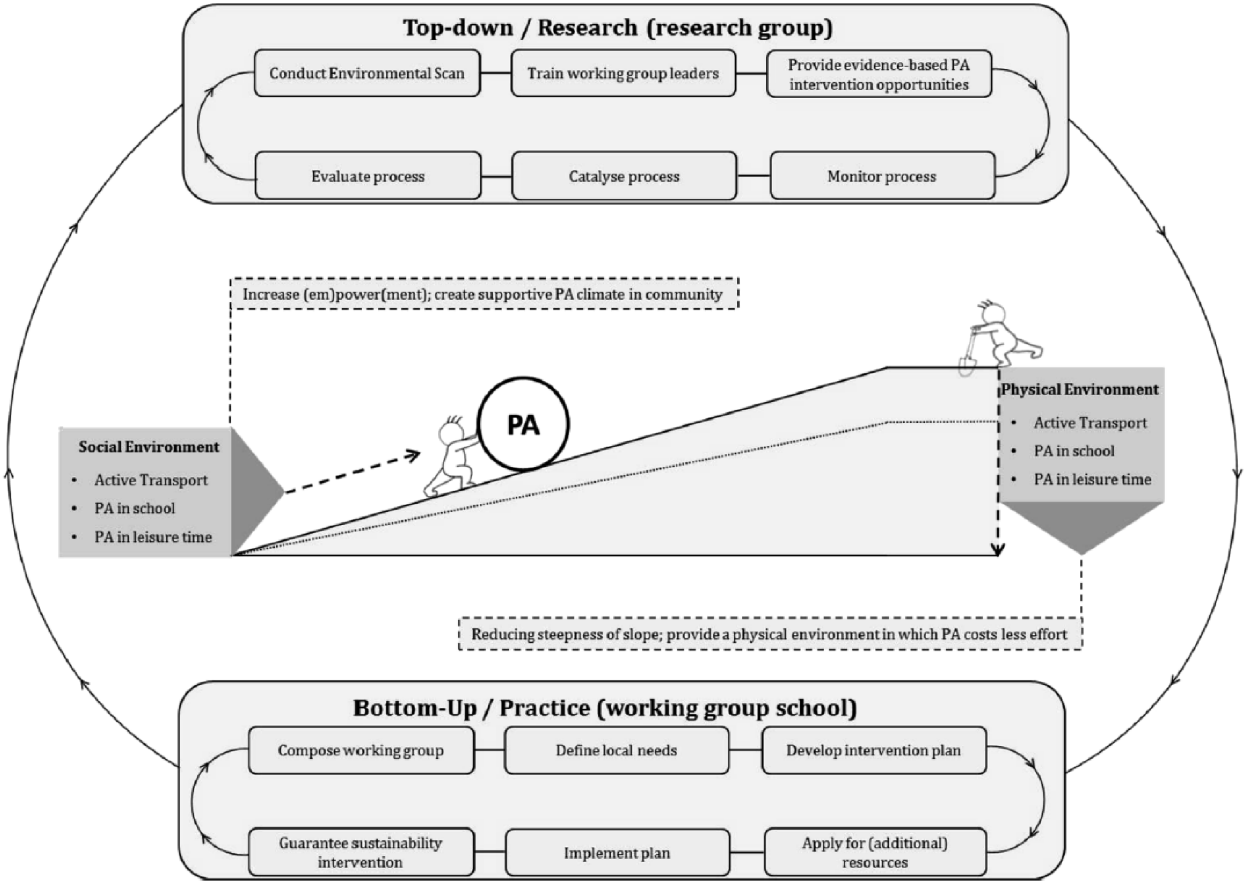


Figure 3.2. Visual presentation of the mutual adaptation approach [40].

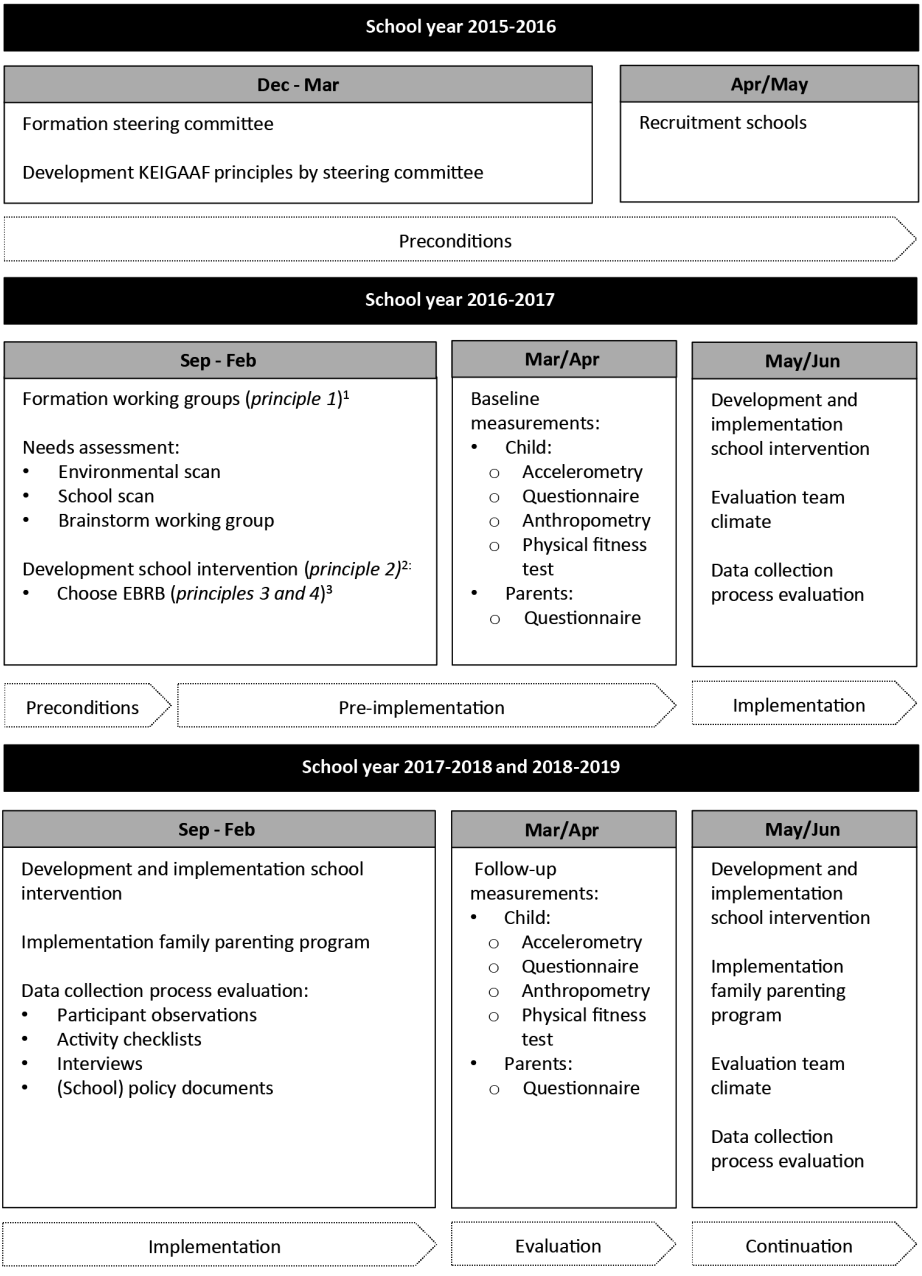
The KEIGAAF principles (see Figure 3.3), as developed by the steering committee, are:

1. Each school forms a working group, consisting of school staff, e.g., teachers, the school principal, and/ or the PE teacher; local health or sport professionals, such as a social worker; a health promotor; and/or the school doctor; and parents. This "interdisciplinary" team has more knowledge and resources than a working group consisting of school staff only.
2. The working group members collaborate in developing and implementing the KEIGAAF school intervention according to their pupils' needs and community possibilities. Intervention activities do not necessarily have to be completely new initiatives but can be actions to strengthen and combine existing activities. To develop and implement their own KEIGAAF intervention, the working group members meet regularly. During these meetings, their plans and actions are evaluated and improved.
3. The intervention is aimed at increasing children's PA, decreasing sedentariness, and improving nutrition behavior. The intervention is primarily designed to affect health behaviors of 7 to 12-year-old children.
4. The working groups decide which EBRB/EBRBs they will target primarily, and the extent and order in which this EBRB is targeted during the project period.

The eight working groups are supported by four trained health promotors from Maastricht University or Fontys University of Applied Sciences. The health promotors advise the working groups on effective interventions and discuss study results with them. They meet regularly with each other and with the steering committee to analyze feedback regarding the intervention implementation and exchange best practices. If appropriate, the best practices are adapted and transferred to other working groups. Besides the personal support, each working group receives a small budget (approximately €2500 for three years) to initiate EBRB-promoting interventions.

Planning

Schools were recruited in April and May 2016. During the first six months of the next school year (2016–2017), the working groups were formed and local needs defined. To support the working groups in defining their needs, a needs assessment was conducted (see Data collection), consisting of: a) a school scan, b) an environmental scan, and c) working group discussions. Based on local needs, iterative KEIGAAF action plans were developed. Implementation of the KEIGAAF interventions started after the baseline measurements were conducted in March and April 2017. Implementation of the KEIGAAF interventions continues until the final measurements at the end of two years (March and April 2019). The aim is to make sure that the KEIGAAF principles become embedded in the school structure and will be sustained after the final measurements.



Note. [1]Principle 1: each school forms a working group, consisting of school staff, local health or sport professionals, a health promotor, and/or the school doctor, and parents. [2]Principle 2: The working group members develop and implement the KEIGAAF school intervention according to their pupils' needs and community possibilities. [3]Principles 3 and 4: The intervention's aims are increasing children's PA, decreasing sedentariness and improving nutrition behavior. The working groups decide which energy balance-related behaviors they will target primarily.

Figure 3.3. Timeline of KEIGAAF project.

Family-based intervention

A family-based parenting program was implemented stepwise from September 2017. The family-based program (Lifestyle Triple P) mainly targets parents whose children are overweight or obese. The aim of the intervention is to improve energy balance-related parenting practices [41, 132]. In eight group sessions and four one-on-one home sessions, Lifestyle Triple P coaches coach parents in positive parenting, nutrition-related parenting practices, and PA-related parenting practices, to support parents in creating a healthy home environment. While the parents attend the Triple P Lifestyle group sessions, their children participate in active fun group play provided by sports students or physical education teachers.

Data collection

The same data is collected for both the intervention group and the control group. The primary researcher (SV-J) manages the data collection and conducts the measurements in collaboration with trained research assistants. The study is ongoing and data collection has not finished. The data collection is monitored by the Clinical Trial Center Maastricht.

Needs assessment

At the start of the project (September to November 2016), an environmental scan and a school scan were conducted. For intervention schools, the outcomes of both scans together with the results of working group discussions on local needs served as a basis for the development of the KEIGAAF school intervention by the working groups. The results of the environmental scan and school scan of the control schools were only used for the process evaluation.

Environmental scan

An environmental scan, i.e., the SPACE checklist [133], assessed the PA friendliness of the neighborhoods in which the intervention and control schools were located. The SPACE checklist is a validated and adapted version of the Neighborhood Environment Walkability Scale (NEWS) [134]. The checklist was adapted to the Dutch context [133]. The scan was conducted by a researcher and a research assistant at baseline. The same procedures as described by Van Kann and colleagues [40] were applied. The SPACE checklist will also be completed at the end of the project.

School scan

At baseline, the schools' principal, teachers, and/or the PE teacher were invited to complete a digital school scan. The school scan was based on an evaluation tool developed for primary schools [135]. This tool had already been in use for five years and was refined annually. This scan assessed the school's activities in the social and physical environment, and school policies, to stimulate PA and healthy nutrition behaviors. Themes are physical education, PA during recess, PA friendliness of schoolyard, PA

school activities, active transportation, afterschool PA, PA school policy, teacher and parental involvement in PA promotion at school, nutrition education, healthy nutrition-promoting physical environment, nutrition-promoting activities (including national), nutrition school policy, teacher and parent involvement in healthy nutrition at school. At the beginning of each school year, the school scan is distributed digitally to the schools. The school scan will be completed each year by the same person.

Children

Child measurements were collected at baseline (March and April of 2017) and will be collected after one year and two years (March and April 2018 & 2019). Data collection lasts about a week per participating school.

Accelerometry

PA and SB are measured via accelerometers (Actigraph GT3X+, Pensacola, FL, USA). The children wear the accelerometers for seven consecutive days. The accelerometers are attached to a belt worn around the child's hip. The children are instructed to wear the accelerometers all day during waking hours but to remove them before performing water-based activities, such as swimming and showering.

Questionnaire

Children complete a questionnaire individually in the classroom. The questionnaire was pretested among children of the same age attending different schools to ensure that the questions were clear and understandable. The questionnaire assesses demographics, PA at school, sports participation, NB, PA enjoyment, and food, drink, and PA preferences and is for the most part based on validated questionnaires (Table 3.1).

Anthropometry

Anthropometric measurements are taken during a physical education (PE) lesson. Standing height, weight, and waist circumference are measured by researchers or research assistants according to a standardized protocol. Shoes have to be taken off. The children are weighed with a digital weighing scale to the nearest 0.1 kg (Seca weighing scale 803). Height is measured with a stadiometer to the nearest 0.1 cm (Seca 213). Weight and height are used to calculate the Body Mass Index (BMI), which is adjusted for age and gender (BMI z-scores) using the values of a Dutch reference population [139]. Waist circumference is measured with a measuring tape to an accuracy of 0.1 cm (Seca 201). The measuring tape is placed around the umbilicus [140].

Physical fitness test

The 15 m endurance shuttle run test, known as the Progressive Aerobic Cardiovascular Endurance Run (PACER), is used to assess the children's aerobic fitness [141]. The PACER is an item of the EUROFIT test battery [142]. The test is administered during the

same PE lesson in which the children's anthropometric measurements are taken. The assessment of the test lasts between 10 and 15 min. The physical fitness test is not conducted during the time that the children wear the accelerometer.

Table 3.1. Concepts, number of items, and example questions of the child questionnaire.

Concept	N items	Items
Demographics	12	Name of school, grade (4th, 5th, 6th), birth month, birth year, gender, home address, country of birth, country of birth parents, number of siblings
PA on a school day	6	Television viewing, transportation to school and from school (walking, cycling, by step/waveboard/skateboard/skates, driven by scooter, driven by car, driven by bus, other), longest performed activity during recess (running, jumping, playing, walking, sitting and chatting, standing and chatting, playing inside, other), activity after school time yesterday (playing outside, sports, active play inside, low intensity play inside, swimming, music or drama lesson, PC/tablet/smartphone use, watching television)
Sports participation	1	Member of sports clubs (no, soccer, tennis, dancing, gymnastics/ballet, swimming, horse riding, martial art, basketball, volleyball, handball, hockey, badminton, athletics, cycling, table tennis, korfball, scouts, afterschool PA, other)
Nutrition intake on a school day [136]	12	Breakfast intake, fruit intake and vegetable intake at school (yes/no), amount of fruit intake (0.5, 1, 2, 3 or more pieces), water consumption at school yesterday (yes/no), sugar-sweetened beverages (yes/no), milk drinks (yes/no), energy drinks (yes/no), and sports drinks consumption at school (yes/no), candy (yes/no), cookie (yes/no), and snack consumption (yes/no)
PA enjoyment [137]	16	Example: When I am physically active… I enjoy it. (5-point Likert scale: 1 = totally disagree, 4 = totally agree, 5 = don't know)
Food and drink preferences [138]	16	Examples: Which of the following foods do you prefer more? (fruit or savory snacks) / Which of the following drinks do you prefer more? (soft drink or fruit juice)
PA preferences [138]	28	Example: Which of the following physical activities do you prefer more? (cycling or watching television)

Parents

Parents are requested to fill in a questionnaire during the one-week measurement period at baseline and at follow-up (March and April 2017, 2018 & 2019).

Questionnaire

The parent questionnaires are handed to the children, and the parents complete them at home. The questionnaires assess demographics, parent's PA pattern routines, PA parenting practices, family health climate, child's NB, anthropometry, and parental school involvement. At follow-up, parents of the intervention schools also receive evaluation questions concerning the KEIGAAF intervention (Table 3.2).

Table 3.2. Concepts, number of items, and example questions of the school-based parent questionnaire.

Concept	N items	Items
Demographics	22	Name of school child, child's grade (4th, 5th, 6th), gender of child, birth date of child, birth date of parent, birth date of partner, postal code, relation to child (mother, stepmother, father, stepfather, guardian, other), country of birth, highest education level (no education, primary school, pre-vocational school, secondary education, lower vocational education, higher vocational education, university), hours per week of paid employment (no paid job, 16 or less, 17 - 24, 25 - 32, more than 32 hours), member of sports club (yes/no), family situation (living together with a partner, single, other) / Partner: relation to child, country of birth, highest education level, hours per week of paid employment, member of sports club / number of children (1, 2, 3, 4 or more), number of cars (1, 2, 3 or more).
Parents' PA transportation routines (PATRns) [150]	4	Example: If I have to go somewhere nearby, I am always inclined to take the bike or to go on foot. (5-point Likert scale: 1 = completely disagree, 5 = completely agree)
PA parenting practices [151]	6	Parental logistic support and restrictions on access to sedentary activities. Example: I enroll my child in sports teams and clubs such as soccer, basketball, and dance. (4-point Likert scale: 1 = completely disagree, 4 = completely agree)
Family health climate [152]	31	Family climate regarding PA and nutrition. Example: In our family… a healthy diet plays an important role in our lives. (4-point Likert scale: 1 = completely disagree, 4 = completely agree)
Child's nutrition behavior [136]	25	Breakfast consumption, fruit intake, vegetable intake , candy intake, cookie intake, snack intake (0 to 7 days; amount of portions per day), sugar-sweetened beverages consumption, light soda consumption, fruit juice consumption, sweet milk drinks consumption, milk consumption, water and tea without sugar consumption (0 to 7 days; amount of glasses per day)
Anthropometry	3	Weight and height of child, weight and height of parent, weight and height of partner.
Parental school involvement	5	Contact with teacher (5-point Likert scale: 1 = never; 5 = every week), assisting school with school activities (5-point Likert scale: 1 = never; 5 = always), attending parental meeting (5-point Likert scale: 1 = never; 5 = always), feeling welcome at school (5-point Likert scale: 1 = not welcome; 5 = welcome), reading school information (5-point Likert scale: 1 = never; 5 = always).
KEIGAAF evaluation (added at follow-up) *only for intervention group*	6	Aware of KEIGAAF (not aware, heard of it, fully aware), general impression of KEIGAAF (5-point Likert scale: 1 = very bad; 5 = very good), involvement in KEIGAAF (5-point Likert scale: 1 = very little; 5 = very much), experiencing changes at school as a result of KEIGAAF (5-point Likert scale: 1 = very little; 5 = a lot), experiencing changes at home as a result of KEIGAAF (5-point Likert scale: 1 = very little; 5 = a lot), importance of KEIGAAF (5-point Likert scale: 1 = very unimportant; 5 = very important)

Questionnaire on family-based intervention
The questionnaire related to the family-based intervention is filled in at the start and at the end of the intervention (after three months) by participants of the Lifestyle Triple P intervention. The questionnaire assesses general parenting practices [143], nutrition parenting practices [144, 145], and PA parenting practices [89, 146, 147]. Questions to evaluate and improve the program are included in the follow-up questionnaire.

Process evaluation

An elaborate process evaluation will be conducted in which the processes involved in the implementation of KEIGAAF and contextual factors influencing these processes are illuminated. For this, a mixed-methods approach will be used: 1) an activity checklist is filled in throughout the implementation period to gain insight into what is implemented by the different KEIGAAF working groups; 2) a quantitative team climate checklist is filled in at baseline, after one and after two years. This checklist provides information about the climate for innovativeness within a working group [148, 149]; 3) school policy documents are collected, providing information about policies influencing intervention implementation; 4) participant observations of the working groups and semi-structured interviews with working group members are conducted to gain additional knowledge about factors inhibiting or facilitating implementation; and finally, 5) the data of the environmental scan and the school scan provide insight into neighborhood and school factors impeding or facilitating intervention success. Data is collected throughout the implementation period of the combined school- and family-based interventions. The timeline of the KEIGAAF project is shown in Figure 3.3.

Data analysis

Descriptive statistics will be used for baseline data. Accelerometer data will be analyzed using Actilife (Version 6.13.3). To correct for nesting of the data, multilevel regression analyses will be used to analyze it. When studying intervention effects, baseline data will be taken into account as possible confounders. Using forward selection, the random and fixed effects part will be further refined by likelihood ratio tests. Intervention effectiveness will be tested at T1 (after one year) and at T2 (after two years). A two-sided test with a type I error rate of 5% will be used. Statistical analyses will be conducted using SPSS 24.0 (IBM Corp, USA).

Quantitative process data will be analyzed with SPSS. Inductive content analysis will be performed to analyze the qualitative process data. Interviews will be transcribed verbatim, and themes and concepts arising from the data will be coded. Outcomes of the process evaluation will be linked to the outcomes of the effectiveness study to clarify the effects on the primary and secondary outcome measures.

Power calculation

Children's health outcome, i.e., BMI z-score, is the primary outcome measure in this study, while interventions are targeted on more distal health behaviors (EBRBs). EBRBs are used as additional outcome measures and considered as predictors of BMI z-scores. Therefore, baseline measurements of the participants' BMI z-score were used to calculate the power of the study. At baseline, 419 intervention children and 104 control children were included in the study. Children were in grade 4, 5, or 6. In two-level, school-based, cluster randomized trials with BMI z-score as the outcome, the intra-class correlation (ICC) was mostly 0.03 or smaller (e.g., [153-155]). Taking a three-level design into consideration, it is assumed that the ICC ranges from 0.005 for the school level and 0.025 for the class level to an ICC of 0.025 for the school level and an ICC of 0.005 for the class level. For the given sample size, the smallest detectable difference in BMI z-score after two years of intervention ranges between 0.38 and 0.44 when the power is 80%, and between 0.44 and 0.51 when the power is 90%. Using Lipsey's [58] cut-off scores, this indicates a moderate effect. Empirical results show that differences of this size are attainable for combined school- and family-based interventions [64, 65]. Although the effects are moderate, they may lead to clinical significant effects at the population level if they are sustained for several years [156].

Discussion

In this paper, we present the design of a quasi-experimental study in which we conduct an effect and process evaluation of a context-based, school- and family-based PA and nutrition intervention on children's BMI z-score, their EBRBs, and physical fitness after one and after two years. The focus on two important environmental settings within the child's environment, i.e., school and family, is considered a strength of this intervention. Ecological models, such as the socio-ecological model of Bronfenbrenner, theorize the importance of targeting multiple systems because of the interdependence of these systems [157]. Furthermore, systematic reviews on school-based interventions with parental involvement have shown the importance of targeting both settings [51, 54]; school-based interventions targeting more home-related factors seem more likely to be effective [54].

The intervention is developed by the intervention schools in collaboration with local professionals and parents, which is in line with the Health Promoting Schools (HPS) framework (also known as Coordinated School Health (CSH) [50, 122]) [158]. The HPS approach has been proven to be effective in improving children's EBRBs [32, 159]. Because of the combined bottom-up and top-down development of the KEIGAAF intervention, it is expected to be an effective and sustainable version of the HPS: the bottom-up development ensures that the intervention fits the local situation, while top-down decisions (for example, policy decisions taken by the school board) actively stimulate schools to take action, and thereby accelerate the process of actions being taken [160].

In addition to an effect evaluation, an extensive process evaluation will be conducted to provide insights into the processes of designing and implementing the

interventions and the role of the context. Few school-based intervention studies have looked at intervention effectiveness and its implementation [161], although this latter information and the link between effectiveness and implementation are important for scaling an intervention and developing future health promotion interventions.

To measure intervention effectiveness, the study has a long duration, and multiple data collection tools are used to measure the different outcomes. The use of accelerometers to measure PA and sedentary behavior is advocated [162] because physical activity questionnaires are subject to under- or over-reporting due to recall bias or social desirability [90]. The questionnaires to measure the other outcome measures are based on validated questionnaires.

This study also has some limitations, e.g., only three schools were recruited as control schools. In general, schools are hesitant to participate in additional projects because of the time pressure experienced. Additionally, recruiting an appropriate control group was difficult: there are numerous national and local efforts to prevent overweight and obesity among children in the Netherlands (e.g., EPODE, healthy schools). It should be noted that the schools located in Maastricht are subject to local health-promoting initiatives. To be able to define the potential effectiveness of the KEIGAAF approach, PA and nutrition-promoting activities implemented in the control schools will also be monitored.

A final limitation is possibly the use of a quasi-experimental study design. A randomized controlled trial is considered the gold standard for studying intervention effectiveness. However, in a project in which there is no strict control over what is implemented and how the system influences implementation, an RCT design is considered inappropriate [158]. Therefore, we consider a quasi-experimental study a good option to study intervention effectiveness.

Appendix chapter 3

Additional file 3.1

Section/item	Item No	Description	Addressed on page number
Administrative information			
Title	1	Descriptive title identifying the study design, population, interventions, and, if applicable, trial acronym	65
Trial registration	2a	Trial identifier and registry name. If not yet registered, name of intended registry	69
	2b	All items from the World Health Organization Trial Registration Data Set	69
Protocol version	3	Date and version identifier	n/a
Funding	4	Sources and types of financial, material, and other support	69
Roles and responsibilities	5a	Names, affiliations, and roles of protocol contributors	
	5b	Name and contact information for the trial sponsor	
	5c	Role of study sponsor and funders, if any, in study design; collection, management, analysis, and interpretation of data; writing of the report; and the decision to submit the report for publication, including whether they will have ultimate authority over any of these activities	
	5d	Composition, roles, and responsibilities of the coordinating centre, steering committee, endpoint adjudication committee, data management team, and other individuals or groups overseeing the trial, if applicable (see Item 21a for data monitoring committee)	n/a
Introduction			
Background and rationale	6a	Description of research question and justification for undertaking the trial, including summary of relevant studies (published and unpublished) examining benefits and harms for each intervention	67-68
	6b	Explanation for choice of comparators	67-68
Objectives	7	Specific objectives or hypotheses	68
Trial design	8	Description of trial design including type of trial (eg, parallel group, crossover, factorial, single group), allocation ratio, and framework (eg, superiority, equivalence, noninferiority, exploratory)	68
Methods: Participants, interventions, and outcomes			
Study setting	9	Description of study settings (eg, community clinic, academic hospital) and list of countries where data will be collected. Reference to where list of study sites can be obtained	69

Eligibility criteria	10	Inclusion and exclusion criteria for participants. If applicable, eligibility criteria for study centres and individuals who will perform the interventions (eg, surgeons, psychotherapists)	69-70
Interventions	11a	Interventions for each group with sufficient detail to allow replication, including how and when they will be administered	70-74
	11b	Criteria for discontinuing or modifying allocated interventions for a given trial participant (eg, drug dose change in response to harms, participant request, or improving/worsening disease)	n/a
	11c	Strategies to improve adherence to intervention protocols, and any procedures for monitoring adherence (eg, drug tablet return, laboratory tests)	n/a
	11d	Relevant concomitant care and interventions that are permitted or prohibited during the trial	n/a
Outcomes	12	Primary, secondary, and other outcomes, including the specific measurement variable (eg, systolic blood pressure), analysis metric (eg, change from baseline, final value, time to event), method of aggregation (eg, median, proportion), and time point for each outcome. Explanation of the clinical relevance of chosen efficacy and harm outcomes is strongly recommended	74-78
Participant timeline	13	Time schedule of enrolment, interventions (including any run-ins and washouts), assessments, and visits for participants. A schematic diagram is highly recommended (see Figure)	73, Figure 3.3
Sample size	14	Estimated number of participants needed to achieve study objectives and how it was determined, including clinical and statistical assumptions supporting any sample size calculations	78-79
Recruitment	15	Strategies for achieving adequate participant enrolment to reach target sample size	79
Methods: Assignment of interventions (for controlled trials)			
Allocation:			
Sequence generation	16a	Method of generating the allocation sequence (eg, computer-generated random numbers), and list of any factors for stratification. To reduce predictability of a random sequence, details of any planned restriction (eg, blocking) should be provided in a separate document that is unavailable to those who enrol participants or assign interventions	n/a
Allocation concealment mechanism	16b	Mechanism of implementing the allocation sequence (eg, central telephone; sequentially numbered, opaque, sealed envelopes), describing any steps to conceal the sequence until interventions are assigned	n/a
Implementation	16c	Who will generate the allocation sequence, who will enrol participants, and who will assign participants to interventions	n/a

Blinding (masking)	17a	Who will be blinded after assignment to interventions (eg, trial participants, care providers, outcome assessors, data analysts), and how	n/a
	17b	If blinded, circumstances under which unblinding is permissible, and procedure for revealing a participant's allocated intervention during the trial	n/a
Methods: Data collection, management, and analysis			
Data collection methods	18a	Plans for assessment and collection of outcome, baseline, and other trial data, including any related processes to promote data quality (eg, duplicate measurements, training of assessors) and a description of study instruments (eg, questionnaires, laboratory tests) along with their reliability and validity, if known. Reference to where data collection forms can be found, if not in the protocol	74-78
	18b	Plans to promote participant retention and complete follow-up, including list of any outcome data to be collected for participants who discontinue or deviate from intervention protocols	n/a
Data management	19	Plans for data entry, coding, security, and storage, including any related processes to promote data quality (eg, double data entry; range checks for data values). Reference to where details of data management procedures can be found, if not in the protocol	n/a
Statistical methods	20a	Statistical methods for analysing primary and secondary outcomes. Reference to where other details of the statistical analysis plan can be found, if not in the protocol	78-79
	20b	Methods for any additional analyses (eg, subgroup and adjusted analyses)	n/a
	20c	Definition of analysis population relating to protocol non-adherence (eg, as randomised analysis), and any statistical methods to handle missing data (eg, multiple imputation)	n/a
Methods: Monitoring			
Data monitoring	21a	Composition of data monitoring committee (DMC); summary of its role and reporting structure; statement of whether it is independent from the sponsor and competing interests; and reference to where further details about its charter can be found, if not in the protocol. Alternatively, an explanation of why a DMC is not needed	74
	21b	Description of any interim analyses and stopping guidelines, including who will have access to these interim results and make the final decision to terminate the trial	n/a
Harms	22	Plans for collecting, assessing, reporting, and managing solicited and spontaneously reported adverse events and other unintended effects of trial interventions or trial conduct	n/a

Auditing	23	Frequency and procedures for auditing trial conduct, if any, and whether the process will be independent from investigators and the sponsor	n/a
Ethics and dissemination			
Research ethics approval	24	Plans for seeking research ethics committee/ institutional review board (REC/IRB) approval	n/a
Protocol amendments	25	Plans for communicating important protocol modifications (eg, changes to eligibility criteria, outcomes, analyses) to relevant parties (eg, investigators, REC/IRBs, trial participants, trial registries, journals, regulators)	n/a
Consent or assent	26a	Who will obtain informed consent or assent from potential trial participants or authorised surrogates, and how (see Item 32)	69
	26b	Additional consent provisions for collection and use of participant data and biological specimens in ancillary studies, if applicable	n/a
Confidentiality	27	How personal information about potential and enrolled participants will be collected, shared, and maintained in order to protect confidentiality before, during, and after the trial	n/a
Declaration of interests	28	Financial and other competing interests for principal investigators for the overall trial and each study site	
Access to data	29	Statement of who will have access to the final trial dataset, and disclosure of contractual agreements that limit such access for investigators	n/a
Ancillary and post-trial care	30	Provisions, if any, for ancillary and post-trial care, and for compensation to those who suffer harm from trial participation	n/a
Dissemination policy	31a	Plans for investigators and sponsor to communicate trial results to participants, healthcare professionals, the public, and other relevant groups (eg, via publication, reporting in results databases, or other data sharing arrangements), including any publication restrictions	n/a
	31b	Authorship eligibility guidelines and any intended use of professional writers	n/a
	31c	Plans, if any, for granting public access to the full protocol, participant-level dataset, and statistical code	n/a
Appendices			
Informed consent materials	32	Model consent form and other related documentation given to participants and authorised surrogates	n/a
Biological specimens	33	Plans for collection, laboratory evaluation, and storage of biological specimens for genetic or molecular analysis in the current trial and for future use in ancillary studies, if applicable	n/a

Note. n/a = not applicable.

Figure 3.4. SPIRIT 2013 Checklist: Recommended items to address in a clinical trial protocol and related documents.

Chapter 4

A cross-sectional study on the relationship between the Family Nutrition Climate and children's nutrition behavior

This chapter has been published as:
Verjans-Janssen SRB, Van Kann DHH, Kremers SPJ, Vos SB, Jansen M, & Gerards SMPL. A cross-sectional study on the relationship between the Family Nutrition Climate and children's nutrition behavior. Nutrients. 2019;11:2433

Abstract

Background

Parents influence their children's nutrition behavior. The relationship between parental influences and children's nutrition behavior is often studied with a focus on the dyadic interaction between the parent and the child. However, parents and children are part of a broader system: the family. We investigated the relationship between the family nutrition climate (FNC), a family-level concept, and children's nutrition behavior.

Methods

Parents of primary school-aged children (N = 229) filled in the validated family nutrition climate (FNC) scale. This scale measures the families' view on the consumption of healthy nutrition, consisting of four different concepts: value, communication, cohesion, and consensus. Parents also reported their children's nutrition behavior (i.e., fruit, vegetable, water, candy, savory snack, and soda consumption). Multivariate linear regression analyses, correcting for potential confounders, were used to assess the relationship between the FNC scale (FNC-Total; model 1) and the different FNC subscales (model 2) and the child's nutrition behavior.

Results

FNC-Total was positively related to fruit and vegetable intake and negatively related to soda consumption. FNC-value was a significant predictor of vegetable (positive) and candy intake (negative), and FNC-communication was a significant predictor of soda consumption (negative). FNC-communication, FNC-cohesion, and FNC-consensus were significant predictors (positive, positive, and negative, respectively) of water consumption.

Conclusions

The FNC is related to children's nutrition behavior and especially to the consumption of healthy nutrition. These results imply the importance of taking the family-level influence into account when studying the influence of parents on children's nutrition behavior.

Introduction

Worldwide, children's body mass index (BMI) and the prevalence of overweight and obesity among children increased in the last 40 years [2]. Although the trend concerning the age-standardized BMI of children in the northwestern part of Europe is flattening, numbers remain high. In 2018, almost 12% of Dutch children between the ages of four and 11 years were overweight or obese [163]. Overweight and obesity in childhood are associated with physical and psychological morbidity in the short and long term [4]. A cause of overweight and obesity is high-energy intake, in the form of energy-dense, nutrient-poor foods and soft drinks [164]. Many children consume too much sugar, e.g., sugar-containing beverages and energy-dense snacks [165], and consume insufficient amounts of healthy foods, such as fruits and vegetables [164]. Healthy eating behaviors in childhood decrease the risk of health-related diseases at a later age, and are related to having healthy eating habits as an adult [166, 167].

During childhood, parents decide what children eat, gradually shaping the child's nutritional behavior. Parents do this by exhibiting specific, goal-directed behaviors, i.e., food parenting practices [168, 169]. Certain food parenting practices, such as controlling the availability of healthy or unhealthy foods, and parental modeling of eating behaviors, are most consistently related to children's nutrition behavior [170, 171] . On the other hand, other food parenting practices, such as pressuring to eat, monitoring, and rewarding food consumption, are not consistently related to children's nutrition behavior [170, 171]. This is probably due to the influence of general parenting on these parent–child interactions [168, 171-173]. General parenting refers to the emotional climate in which the parenting practices are expressed [168]. Children show a healthier nutrition behavior as a result of certain parenting practices (e.g., encouragement) when the parents provide a positive parenting climate [173, 174]. A positive parenting climate is characterized by nurturance, structure, and behavioral control [174].

Many studies on the relationship between food parenting practices, general parenting, and children's nutrition behavior assume a unidirectional communication in which the child is the mere recipient [13]. However, in reality, parents and children are part of a family in which family members influence each other's behaviors, indicating a reciprocal influence [175]. Focusing only on individual parenting practices and general parenting, and not considering this family-level influence can lead to important information being missed when studying the parents' influence on children's nutrition behavior [13, 176].

Very little research was conducted on the family-level influence on children's nutrition behavior. It is hypothesized that the family's emphasis on healthy nutrition and their interactions concerning nutrition behavior (e.g., parents discussing whether it is important to eat healthy as a family, consuming meals together as a family) influence whether and how much healthy nutrition is consumed by the child. These familial interactions and views are part of a family's health climate. To capture this family climate concerning healthy nutrition, Niermann and colleagues [152] developed the family nutrition climate (FNC) scale (as part of the family health climate scale). The FNC is considered "the [family's] shared perceptions and cognitions" concerning healthy nutrition behavior on a daily basis [152] (p. 31).

The FNC is a relatively new construct and, to our knowledge, only two studies were

conducted using this validated instrument to measure the relationship between the family and individual nutrition behavior [177, 178]. Both studies found a relationship between the FNC and individual nutrition behavior: families with healthy behavioral patterns (consuming high levels of healthy nutrition and showing high levels of physical activity) rated their FNC higher compared to families with unhealthier behavioral patterns [178]. In the second study, it was found that a higher score on the FNC was related to a higher consumption of children's healthy foods (i.e., fruit, vegetables, and salad) [177]. In both studies, the children were adolescents with a mean age of 14 years. It is unknown whether these results are similar for a population of younger children. Therefore, this study aimed to investigate the relationship between the FNC and the nutrition behavior of Dutch children aged 7–10 years old.

Methods

Study design and procedure

For the current study, baseline data of a quasi-experimental study were used. The protocol of this quasi-experimental intervention study was described in Verjans-Janssen et al. [179]. Ethical approval for the study was provided by the Medical Ethics Committee of the Maastricht University Medical Centre and Maastricht University (METC163027, national number: NL58554.068.16). After being informed about the study, all participants consented to participate before the start of the study. The parents of the participants signed an informed consent form.

Primary school children in grades four to six (Dutch educational system: between the ages of seven and 10 years) were eligible for inclusion. Eleven primary schools participated in the study. The schools were located in low socioeconomic neighborhoods in two cities in the southern region of the Netherlands.

The children were provided with oral and written information by a researcher. Their parents received written information about the study and were given the opportunity to ask questions during scheduled information hours or via phone or e-mail. The children were included in the study if both parents provided written consent. Of the eligible children, 60.4% consented to participate in the study.

Measurements

Data were collected in March and April 2017. Data collection tools included a child questionnaire, a parent questionnaire (both paper-based), and anthropometric measurements. The child questionnaire was filled in on paper in the classroom during school hours. The child's anthropometric measurements were taken by trained researchers at school. Parents filled in the parent questionnaire at home and returned the questionnaire via the child to school. The questionnaires are available in Dutch from the corresponding author upon request.

Children's nutrition behavior

The child's nutrition behavior was measured with the parent questionnaire. For this, items of a validated food frequency questionnaire for Dutch children was used [180]. Children's fruit, vegetable, water, candy (i.e., sweets, licorice, candy bars), savory snack (e.g., cheese, crisps), and soda intake were measured. For water intake, the consumption of tea without sugar was also included. For soda, only sugar-containing drinks were included (diet soda sweetened with artificial sweeteners was excluded from the analysis). The frequency (from zero to seven days a week) and the amount per day of these foods and drinks were measured. The amount was measured in natural units: pieces for fruit, serving spoons for vegetables, portions for candy (i.e., a handful of sweets or one normal-sized candy bar), portions for savory snacks (i.e., a handful of cheese or a bowl of crisps), and glasses for water and soda. The frequency and the amount were multiplied and divided by seven to calculate an average daily consumption.

Family Health Climate

The FNC scale is a validated questionnaire [152], which was translated into Dutch [176]. It can be completed by one family member or by multiple family members, after which an aggregated FNC score can be calculated [152, 177]. In this study, one parent filled out the FNC. The higher the score is on the FNC scale, the more importance is placed on eating healthy as a family [152]. The FNC scale consists of four subscales: FNC-value, FNC-communication, FNC-cohesion, and FNC-consensus. FNC-value (four items) encompasses the family's interest in healthy nutrition in daily life and whether healthy nutrition is a norm within the family (e.g., "In our family, a healthy diet plays an important role in our lives") ($\alpha = 0.87$). FNC-communication (five items) comprises the family's talks about healthy nutrition and support regarding eating healthy foods (e.g., "In our family, we are interested in articles (e.g., magazines) on healthful nutrition") ($\alpha = 0.81$). FNC-cohesion (five items) encompasses whether consuming meals together as a family is common and whether eating together is considered important (e.g., "In our family, we appreciate spending time together during meals") ($\alpha = 0.67$). FNC-consensus (three items) refers to the agreement within a family concerning nutrition (e.g., "In our family, we rarely argue about food- or diet-related matters") ($\alpha = 0.80$). All items were assessed on a four-point Likert scale ("strongly disagree" to "strongly agree"). The average of the four FNC-subscale scores was taken to obtain the FNC overall score (FNC-Total; 17 items) ($\alpha = 0.86$). Missing data for the FNC scale were imputed when there was 10% or less of missing items. A missing value was replaced by the mean of the available FNC subscale items for that particular participant. If a subscale had only one valid item, data were not imputed, and the participant was excluded from analysis. Imputation on the FNC scale was applied for nine participants.

Children's weight status

The children were weighed and measured during the schools' physical education lessons. They wore light sports clothes during the anthropometric measurements, but shoes were taken off. Weight was measured to the nearest 0.1 kg with a digital weighing scale (Seca 803), and height was measured to the nearest 0.1 cm with a portable

stadiometer (Seca 213). For the children with missing data due to absence on the day of measurement, data were imputed from the parent questionnaire (i.e., self-reported data); this was the case for five children. Children's BMI z-scores were calculated using a Dutch reference population and adjusting for the child's age and gender [139].

Socio-demographic characteristics

Socio-demographic characteristics of the child were measured with the child questionnaire. Children reported their date of birth, their gender, and the number of brothers and sisters. This was used to calculate the number of children within a family. Children reported the birth country of both parents, which was used to define the children's ethnicity. Ethnicity was based on the definition of Western and non-Western by Statistics Netherlands [181]; the child's ethnicity was non-Western when at least one parent was born in a non-Western country.

In the parent questionnaire, the parents reported on their educational level, parent relationship (married/having a partner or single), and weight and height. Educational level was recoded into three categories based on the International Standard Classification of Education 2011 [182]: no or primary educational level (no education or primary school), secondary educational level (pre-vocational school, secondary education, or lower vocational education), and tertiary educational level (higher vocational education or university degree). Parent's body mass index (BMI) was calculated and used to define the weight status of the parent (i.e., BMI 30: obese).

Participants

In total, 523 children participated in the study. Only data of parent–child dyads were used. Of the 523 children, 329 parents (62.9%) provided data on their child(ren)'s nutrition behavior and the family nutrition climate. To ensure that independent samples were included, the data of one sibling of a sibling pair were excluded; the sibling with the lowest birth month was excluded. In the case of twins, the child who was first in the dataset (sorted by subject identifier) was excluded. In total, 18 siblings were excluded. Only cases with complete data were included in the analyses.

Statistical analysis

Data were analyzed with SPSS version 24.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to describe the characteristics of the study population and the mean values and standard deviations of FNC-Total, the FNC subscales, and the nutrition behavior outcomes. Differences in the FNC between different types of families, based on the child's ethnicity (Western versus non-Western) and the parent's education level (low versus high), were analyzed. As the FNC data were not normally distributed, differences between these groups were analyzed with a Mann–Whitney U-Test.

Data of the nutrition behaviors were square-root-transformed due to violation of the normality assumption of the residuals in the regression analyses. Pearson

correlation analyses were conducted to obtain the correlations between the FNC-Total/ FNC subscales and nutrition behavior outcomes. Multivariate linear regression analyses were used to examine the relationship between the FNC and the individual nutrition behavior outcomes, while correcting for potential confounders: age, gender, ethnicity, and BMI z-score of the child, and parent's educational level, BMI, and age. These covariates were entered simultaneously into the linear regression models.

Two types of linear regression models were built. Firstly, regression models were built for all foods and drinks, separately, with FNC-Total as an independent variable (model 1). Secondly, the regression models were restructured by replacing FNC-Total with the FNC subscales (i.e., FNC-value, FNC-communication, FNC-cohesions, FNC-consensus), which were added simultaneously as independent variables to the models (model 2). A two-sided p-value of less than 0.05 was considered statistically significant.

Results

Characteristics of the study population

In total, 229 (69.6%) parent–child dyads were included in the analyses. The mean age of the children was 8.3 years (SD = 1.0). More girls (62.0%) than boys participated in the study. Mainly mothers filled in the questionnaire (83.8%). The mean age of the parents was 38.6 years (SD = 5.4). Of the parents, 35.4% had a secondary educational level, and 38.9% had a tertiary educational level (higher vocational degree or higher). Of the remaining parents, 22.7% finished primary education, and 3.1% (N = 7) reported having no education. Of all children, slightly more than one-quarter (27.1%) had a non-Western ethnicity, with one or both parents born in a non-Western country. Overall, 17.9% of the children and 42.8% of the parents were overweight and obese. Regarding the family situation, the majority of the parents had a partner (81.7%) and two or more children (83.4%) (Table 4.1).

Table 4.1. Characteristics of the target population (N = 229).

	Number	%	Mean	SD
Parent characteristics				
Parent				
Mother	192	83.8		
Father	37	16.2		
Age			38.6	5.4
Educational level				
No or primary education	59	25.8		
Secondary education	81	35.4		
Tertiary education	89	38.9		
Weight status				
Underweight or normal weight	131	57.2		
Overweight or obese	98	42.8		
Child characteristics				
Age			8.3	1.0
Gender				
Male	87	38.0		
Female	142	62.0		
Ethnicity				
Western	167	72.9		
Non-Western	62	27.1		
Weight status				
Underweight or normal weight	188	82.1		
Overweight or obese	41	17.9		
Family situation				
Relationship				
Living together with a partner	187	81.7		
Single	42	18.3		
Number of children				
1 child	38	16.6		
2 or more children	191	83.4		

Note. SD: Standard deviation.

Means of the child's nutrition behavior and the family nutrition climate

Children consumed on average 1.4 pieces of fruit (SD = 0.6), 1.8 portions (±90 g) of vegetables (SD = 0.9), and 2.3 glasses of water daily. On average, they consumed a little less than one portion of candy (M = 0.9, SD = 0.7), a little less than half a portion of savory snacks (M = 0.4, SD = 0.4), and 1.4 glasses of soda (SD = 1.3) daily (Table 4.2). The average scores on the FNC subscales were high (>3), except for FNC-communication (M = 2.9, SD = 0.6), see Table 4.2. Parents scored highest on FNC-cohesion (M = 3.7, SD = 0.4). FNC-Total did not differ significantly for families of different ethnicity (U = 4735.0, p =.32), but it did differ significantly between less well-educated and highly educated parents (U = 4121.5, p =.04). Highly educated parents scored higher on the FNC (M = 3.3, SD = 0.4) compared to less well-educated parents (M = 3.2, SD = 0.4).

Relationship between the Family Nutrition Climate and the Child's Nutrition Behavior

FNC-Total correlated positively with healthy food consumption, i.e., fruit and vegetable intake, and negatively with unhealthy food and drink consumption, i.e., candy intake and soda consumption (Table 4.2). FNC-value correlated with the same food and drink consumption as FNC-Total, and in the same direction, i.e., positively with fruit and vegetable intake and negatively with candy intake and soda consumption. FNC-communication correlated positively with all healthy foods (fruit intake, vegetable intake, and water consumption) and negatively with soda consumption. There were no significant correlations between FNC-cohesion and nutrition behavior or between FNC-consensus and nutrition behavior.

Adjusting for child and parent characteristics, FNC-Total was a significant predictor of fruit intake (standardized β = 0.15), vegetable intake (β = 0.23), and soda consumption (β = −0.20) (Table 4.3). FNC-value was positively related to vegetable intake (β = 0.34) and negatively to candy consumption (β = −0.19). FNC-communication was positively related to water consumption (β = 0.19) and negatively to soda consumption (β = −0.24). Regarding water consumption, FNC-cohesion and FNC-consensus were also predictors, but in opposite directions (β = 0.15 and β = −0.20, respectively).

Table 4.2. Correlation coefficients between family nutrition climate and the child's individual nutrition behavior.

			Pearson Correlation Coefficients									
		M (SD)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Family Nutrition Climate											
1	Total	3.3 (0.4)	-	-	-	-	-	-	-	-		
2	Value	3.4 (0.6)	**0.83**	-	-	-	-	-	-	-		
3	Communication	2.9 (0.6)	**0.81**	**0.59**	-	-	-	-	-	-		
4	Cohesion	3.7 (0.4)	**0.56**	**0.33**	**0.21**		-	-	-	-		
5	Consensus	3.1 (0.7)	**0.68**	**0.46**	**0.30**	**0.33**	-	-	-	-		
	Individual nutrition behavior[a]											
6	Fruit (pieces/day)	1.4 (0.6)	**0.18**	**0.16**	**0.21**	0.08	0.01	-	-	-		
7	Vegetables (portions/day)[b]	1.8 (0.9)	**0.26**	**0.32**	**0.19**	0.10	0.12	0.12	-	-		
8	Water (glasses/day)	2.3 (1.7)	0.10	0.07	**0.17**	0.11	−0.10	**0.17**	**0.23**	-		
9	Candy (portions/day)[c]	0.9 (0.7)	**−0.15**	**−0.19**	−0.09	−0.12	−0.05	0.06	−0.11	0.02		
10	Snacks (portions/day)[d]	0.4 (0.4)	−0.05	−0.08	0.01	−0.04	−0.06	**0.17**	−0.06	−0.07	**0.30**	
11	Soda (glasses/day)	1.4 (1.3)	**−0.23**	**−0.21**	**−0.29**	−0.04	−0.07	−0.07	**−0.14**	**−0.39**	0.11	0.12

Note. M: mean, SD: standard deviation; bold numbers are statistically significant ($p < .05$). [a]The data for the nutrition behaviors were transformed (square root). [b]One serving spoon is approximately 50 g. [c]One portion is a handful of sweets or a normal-sized candy bar, for example. [d]One portion is a handful of cheese or a bowl of crisps, for example.

Table 4.3. Associations between the family nutrition climate (FNC) and the child's individual nutrition behavior (linear regression models).

		Model 1			Model 2		
	FNC	**Unst. B**	**(SE)**	**St. β**	**Unst. B**	**(SE)**	**St. β**
Individual nutrition behavior[a]							
Fruit	*FNC-Total*	**0.11**	**(0.05)**	**0.15**			
(pieces/day)	Value				0.07	(0.10)	0.06
	Communication				0.15	(0.08)	0.15
	Cohesion				0.15	(0.13)	0.08
	Consensus				−0.10	(0.07)	−0.10
	R^2			0.12			0.15
Vegetables	*FNC-Total*	**0.19**	**(0.05)**	**0.23**			
(serving spoons/	Value				**0.20**	**(0.05)**	**0.34**
day)[b]	Communication				−0.02	(0.04)	−0.04
	Cohesion				−0.01	(0.07)	−0.01
	Consensus				0.00	(0.04)	0.00
	R^2			0.12			0.16
Water	*FNC-Total*	0.13	(0.10)	0.09			
(glasses/day)	Value				−0.03	(0.10)	−0.03
	Communication				**0.18**	**(0.08)**	**0.19**
	Cohesion				**0.26**	**(0.12)**	**0.15**
	Consensus				**−0.17**	**(0.07)**	**−0.20**
	R^2			0.06			0.11
Candy	*FNC-Total*	−0.10	(0.06)	−0.12			
(portions/day)[c]	Value				**−0.11**	**(0.06)**	**−0.19**
	Communication				0.03	(0.04)	0.05
	Cohesion				−0.09	(0.07)	−0.09
	Consensus				0.03	(0.04)	0.06
	R^2			0.07			0.09
Snacks	*FNC-Total*	−0.04	(0.13)	−0.02			
(portions/day)[d]	Value				−0.07	(0.12)	−0.06
	Communication				0.13	(0.10)	0.11
	Cohesion				−0.04	(0.16)	−0.02
	Consensus				−0.09	(0.09)	−0.08
	R^2			0.05			0.06

		Model 1			Model 2		
	FNC	**Unst. B**	**(SE)**	**St. β**	**Unst. B**	**(SE)**	**St. β**
Soda	*FNC-Total*	**−0.31**	**(0.10)**	**−0.20**			
(glasses/day)	Value				−0.06	(0.10)	−0.06
	Communication				**−0.23**	**(0.08)**	**−0.24**
	Cohesion				0.04	(0.13)	0.02
	Consensus				0.02	(0.07)	0.02
	R^2			0.13			0.15

Note. Model 1: FNC-Total as independent variable. Model 2: FNC-value, FNC-communication, FNC-cohesions, and FNC-consensus as independent variables. All models were adjusted for child's age, gender, body mass index (BMI) z-score, and ethnicity, and parent's educational level, BMI, and age. Bold numbers are significant, $p < .05$. Unst. = unstandardized, St. = standardized. [a]The data for the nutrition behaviors were transformed (square root). [b]One serving spoon is approximately 50 g. [c]One portion is a handful of sweets or a normal-sized candy bar, for example. [d]One portion is a handful of cheese or a bowl of crisps, for example.

Discussion

The current study investigated the relationship between the FNC and the nutrition behavior of primary school-aged children. We found that FNC-Total was a positive predictor of the consumption of healthy nutrition (i.e., fruit and vegetable intake) and a negative predictor of the consumption of one unhealthy nutrition (i.e., soda consumption). The results were in line with our expectation that the FNC is mainly a predictor of children's healthy nutrition consumption. Our results show that a family-level influence is present on children's nutrition behavior. Other research already showed that family members influence each other's nutrition behaviors. For example, families have similar dietary intakes [183, 184], especially regarding the consumption of healthy nutrition [183]. Our study specifically shows the influence of shared values, routines, and interaction patterns concerning healthy nutrition within a family (defined as the family nutrition climate) on the child's nutrition behavior.

In this study, the parents rated FNC-cohesion the highest, indicating that consuming meals together as a family was common and considered important. Family meals are related to a healthier nutrition behavior of children [185]. However, in our study, we only found a significant association between FNC-cohesion and water consumption. It can be that, although family meals were common, these moments did not consist of interpersonal contact. Research showed that distractions during family meals, such as having the television on, is negatively related to group enjoyment during the meals (even when the family is not paying attention to the television) [186]. The quality of the time spent together during family meals, e.g., talking about each other's day and discussing the importance of healthy nutrition during family meals, is likely a more important part of the family nutrition climate and of more influence on children's nutrition behavior than merely sitting together at the dinner table. In our study, we indeed found a stronger association between the communication within the family concerning healthy nutrition and FNC-Total than between FNC-cohesion and FNC-Total.

FNC-Total was associated the strongest with children's vegetable consumption. In the Netherlands, children consume vegetables mainly during dinner in the form of cooked vegetables [187, 188]. Dinner is most of the times consumed at home with the family and more regularly compared to breakfast and lunch [189, 190], which explains the strong association between FNC-Total and children's vegetable consumption. Research showed that parents highly value the consumption of vegetables by their child because of the health benefits [191]. Our results showed that FNC-value was the only significant predictor of the child's vegetable intake.

While vegetables are mainly consumed during meals, fruit, candy, and snacks are mainly consumed in between meals [165, 188]. However, this does not imply that the family influence is not present regarding the consumption of fruit. On the contrary, FNC-total was also related to the child's fruit consumption, but to a lesser extent than vegetable consumption. This can be explained by the fact that Dutch primary school-aged children consume at least 70% of their fruit intake at home, and about 20% at school [188]. Since the schools in this study participated in the "European Union (EU) school fruit" program, in which children were provided with fruit at least three days a week during morning recess [192], there was also an influence of the school environment on the children's fruit consumption.

The third association between FNC-Total and children's nutrition behavior involved children's soda consumption. The FNC refers to the importance of a healthy diet within the family. Although soda is not a healthy food, the FNC was associated with soda consumption; however, this was in the preferred direction (i.e., lower soda intake). This desirable family influence on soda intake was present because Dutch primary school children consume soda mainly at home. Furthermore, 11.3% of the daily soda consumption takes place during dinner [165], which is mainly consumed at home and with the family, as mentioned earlier. Our results showed that the family influence on soda consumption was present in the communication within the family concerning healthy nutrition (FNC-communication). Based on these results and the positive relationship between FNC-communication and water consumption, we hypothesize that the family supports each other in refraining from soda and talks about water as being a healthy drink.

This positive relationship between FNC-communication and children's water consumption and between FNC-cohesion and children's water consumption countered the negative relationship between FNC-consensus and children's water consumption. These contrasting results explain the non-significant relationship between FNC-Total and children's water consumption. Although a higher score on FNC-consensus was assumed to positively relate to a healthier nutrition behavior, the negative association between FNC-consensus and water consumption might be explained by the framing of the items, i.e., "In our family, we rarely argue about food- or diet-related matters". The unexpected relationship could either imply that there is no arguing about drinking water or that water consumption is insufficiently considered to be part of "food- or diet-related matters".

There was no association between FNC-Total and candy and savory snacks. It may be that the family influence on the consumption of these foods is less present compared to the other foods. One-third of the time, Dutch primary school-aged children consume candy and snacks at a friend's place or when outside [165] and, thus, away from

the family environment. Another explanation may be that snacks and candies are not healthy foods and are, thus, not taken into consideration when thinking about consuming healthy nutrition within the family.

Our results are in line with the study on the FNC and adolescents' nutrition behavior [19]. Niermann and colleagues [152] found a positive association between the aggregated FNC and adolescents' healthy dietary behavior, consisting of the intake of salads, vegetables, and fruits. The effect size of their association was medium. The associations found in the current study were less strong, while the influence of the family on the nutrition behavior of younger children was expected to be stronger. A likely explanation for the stronger associations found in the study by Niermann et al. [152] is that they included more highly educated parents (41.9% of the mothers and 58.4% of the fathers). In our study, highly educated parents had a significantly higher FNC-Total score compared to less well-educated parents. Additional interaction analysis was conducted to see whether educational level had an influence on the relation between the FNC and the children's nutrition behavior, but no significant interaction between FNC-Total and the parent's educational level was found (data not shown). However, our sample was rather small, and further research is required to investigate whether different types of families (e.g., based on ethnicity, educational level, socioeconomic status) differ in the FNC and how this difference is related to the children's nutrition behavior.

The family can be considered a social dynamic system consisting of different subsystems (e.g., individuals, spouse subsystem, parent–child subsystem) that interact with each other. To understand a family's properties and their influence, the different parts of a family cannot simply be combined because they are interdependent (e.g., family functioning depends on an interplay of communication patterns and role fulfillment) [13, 193]. Given the complexity of the family influences on the children's energy balance-related behaviors, it is quite challenging to study this family system [13]. The FNC is a part of this complex family system and, by the use of the FNC-scale, we aimed to capture some of the influence of this complex family system on children's nutrition behavior. The rather weak associations found between the FNC and the children's nutrition behaviors in this study can be explained by the fact that the FNC operates on a more distal level within the family system [13]. However, these weak associations do not imply that this family-level influence is less relevant. On the contrary, the FNC is an important part of the family system, which is associated with the children's nutrition behavior, as shown in our study, via mediated paths (e.g., through intrinsic motivation), as shown in the study of Niermann et al. [177], and as a higher-level moderator (i.e., stronger relationships were found between food parenting practices and children's BMI z-score when the family nutrition climate was healthier), as shown in the study of Gerards et al. [176].

Strengths and limitations

To our knowledge, this is the first study to investigate the relationship between the FNC and the nutrition behavior of primary school-aged children. The strengths of this study were the diversity of the sample regarding the children's ethnicity and the educational

level of the parents.

A limitation of the study was the underrepresentation of paternal views on the FNC. Paternal views on FNC may differ from maternal views [194]. The underrepresentation of fathers in studies is a common limitation of observational studies on parenting and children's obesity-related behaviors, especially nutrition behavior [195]. This possibly limits the generalizability of the results. Another limitation possibly affecting generalizability of the results might be the slight overrepresentation of girls in the sample. However, in the study on the association between the FNC and adolescents' consumption of healthy foods, the correlations did not differ significantly between boys and girls [177].

Other limitations were the cross-sectional design and the use of a self-reporting instrument to measure the children's nutrition behavior. Longitudinal studies should be conducted between the FNC and the children's energy balance-related behaviors to study the stability of the FNC over time and how the FNC influences the children's energy balance-related behaviors over time. We also recommend objective measurements of the children's nutrition behavior, such as the use of wearables [196], because self-reporting instruments for nutrition behavior are prone to social desirability.

Finally, it is debatable whether our choice of nutrition behaviors is the best representation of children's healthy and unhealthy nutrition behaviors, since other behaviors such as breakfast consumption or other foods and drinks such as milk are also part of the children's daily nutrition behavior.

Implications and recommendations

Our results add to the existing knowledge of the family influence on children's nutrition behavior. The results underline the importance of addressing the whole family system instead of focusing merely on the parent–child subsystem [13, 197]. Addressing the family environment should be done by involving all family members [177]. The healthy family environment can be assessed by the individual evaluations of the FNC. Ideally, the FNC is measured by assessing the views of all family members (the parents, the child, and siblings) [152].

To inform intervention developers, we recommend further research into the interaction between the more proximal parent-level influences (e.g., parenting practices) and the more distal family-level factors (e.g., the FNC) and their interacting influence on the children's nutrition behavior. To be able to study these interacting influences, we advocate studying general parental influences, i.e., general parenting, and more specific parenting, i.e., nutrition parenting practices, as well as the broader family context, i.e., the family nutrition climate.

To measure general parenting, we recommend the use of the validated comprehensive general parenting questionnaire for caregivers of 5–13-year-old children of Sleddens et al. [143]. This questionnaire was developed after a thorough search of the literature and assesses five parenting constructs: nurturance, structure, behavioral control, overprotection, and coercive control [143]. Unfortunately, there is little consensus on how to best measure food parenting practices [198]. There are at least 71 instruments measuring food parenting practices [199]. In most cases, these

instruments measure a small part of the spectrum of food parenting practices [199]. Fortunately, a comprehensive food parenting practices item bank is currently being developed, which will allow a more consistent and comprehensive measurement of food parenting practices in the future [198]. For the measurement of the family-level influence, we recommend the use of the FNC.

Conclusions

The climate within a family concerning healthy nutrition (e.g., valuing healthy nutrition within a family, and communicating about eating healthy as a family) is a predictor of the children's nutrition behavior, especially the consumption of healthy foods. These results indicate the importance of considering family-level influences when aiming to improve children's nutrition behavior.

Chapter 5

Implementation of KEIGAAF in primary schools: a mutual adaptation physical activity and nutrition intervention

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Abstract

School health promotion is advocated. Implementation studies on school health promotion are less often conducted as effectiveness studies and are mainly conducted conventionally by assessing fidelity of "one size fits all" interventions. However, interventions that allow for local adaptation are more appropriate and require a different evaluation approach. We evaluated a mutual adaptation physical activity and nutrition intervention implemented in eight primary schools located in low socioeconomic neighborhoods in the Netherlands, namely the KEIGAAF intervention. A qualitative, multiple-case study design was used to evaluate implementation and contextual factors affecting implementation. We used several qualitative data collection tools and applied inductive content analysis for coding the transcribed data. Codes were linked to the domains of the Consolidated Framework for Implementation Research. NVivo was used to support data analysis. The implementation process varied greatly across schools. This was due to the high level of bottom-up design of the intervention and differing contextual factors influencing implementation, such as differing starting situations. The mutual adaptation between top-down and bottom-up influences was a key element of the intervention. Feedback loops and the health promotion advisors played a crucial role by navigating between top-down and bottom-up. Implementing a mutual adaptation intervention is time-consuming but feasible.

Introduction

Given the significant amount of time children spend at school, the school environment has an important influence on children's energy balance-related behaviors (EBRBs), i.e., sedentary behavior, physical activity (PA), and nutrition behavior. The World Health Organization advocates school health promotion [32]. However, not all school health promotion initiatives are successful. Systematic reviews and meta-analyses on the effectiveness of school-based physical activity (PA) and nutrition interventions on children's energy balance-related behaviors and body mass index (BMI) found mainly mixed or inconclusive results [24-26, 28-30, 33, 34, 200, 201].

To understand why interventions succeeded or failed, insight into what really happens during implementation is indispensable [202]. The number of studies regarding the implementation of school-based PA-promoting interventions is currently limited as compared with the number of effectiveness studies [161]. When school-based health-promoting intervention studies investigate implementation, it is often studied conventionally by assessing fidelity to the standardized intervention components [37]. This type of evaluation is appropriate for "one size fits all" evidence-based programs.

However, "one size fits all" evidence-based interventions do not take into account contextual differences between settings. In contrast, interventions which allow local adaptation to ensure contextual fit do take these differences in context into account and are considered to be more appropriate, implementable, effective, and ultimately sustainable [119, 203]. It is recommended that school health-promoting interventions should be sufficiently flexible to fit a specific context [32, 119, 203, 204], and thus allow local adaptation. Mutual adaptation interventions are interventions in which adaptation of top-down principles and bottom-up development and implementation take place concurrently [119]. These interventions lead to different outputs and are implemented differently in different settings. To study the implementation of such an intervention and factors influencing implementation, a flexible evaluation approach and sensitivity regarding contextual influences and changes are required [37, 131, 205-207].

In this paper, we evaluated a mutual adaptation physical activity and nutrition intervention that was implemented in primary schools in the Netherlands [179], i.e., the KEIGAAF intervention. KEIGAAF is a Dutch acronym for "Chances in Eindhoven for a family-based approach by Fontys" (in Dutch, Kansen in EIndhoven voor GezinsAAnpak met Fontys) and refers to a local term for "super cool" [179]. We studied how KEIGAAF was implemented in primary schools and which contextual factors influenced implementation.

Materials and Methods

Study design

To study the implementation of KEIGAAF in the intervention schools, a qualitative, multiple-case study was conducted [208]. This process evaluation was part of a larger study, which also evaluated the effectiveness of KEIGAAF on children's BMI z-score,

physical activity, and nutrition behavior [179]. The process evaluation was conducted prior to the effectiveness study.

Eight intervention schools were recruited in April and May 2016 in Eindhoven, a city in the south of the Netherlands. These schools were located in low socioeconomic neighborhoods. Eligibility criteria and recruitment strategies are described in detail in the study protocol [179].

The KEIGAAF intervention

The KEIGAAF intervention was not a prepackaged program, but an approach that consisted of an interplay between top-down and bottom-up influences reinforcing each other in order to optimize the implementation of school-based PA and nutrition activities by ensuring contextual fit [40, 179]. The overall aim was to create a school environment that stimulates children to be active and have healthy eating behaviors.

The top-down part of the KEIGAAF approach consisted of a steering committee of health behavioral experts and representatives of local organizations, who provided the basic principles of the intervention (see Figure 5.1) and supported the bottom-up part, for example, with scientific advice or financial resources. The bottom-up part consisted of local working groups that defined local intervention needs with respect to PA engagement and healthy nutrition and were responsible for the implementation of the intervention.

The working groups were encouraged to follow the steps proposed in the model by Van Kann et al. [40] which consisted of the following: (1) compose a working group, (2) define local needs, (3) develop an activity plan, (4) apply for resources (additional ones), (5) implement PA and healthy nutrition-promoting activities, and (6) guarantee sustainability. Although these steps suggest a linear process, in reality it is a dynamic process with multiple feedback loops. The local working groups were supported by health-promoting (HP) advisors who advised the working groups on actions and effective activities. The HP advisors exchanged best practices and served as a link between the steering committee and the working groups.

The working groups were advised on implementing a comprehensive and integrated set of PA and healthy nutrition-promoting activities. School health promotion is considered comprehensive and integrated when children's health behaviors are promoted through health education, by the school's physical and social environment, and beyond the school gates (thus also before and after school time) by engaging families and the wider community [14, 32].

The KEIGAAF intervention started in April 2016 and lasted until June 2019 [179]. The intervention period consisted of a preparation period of about one year (April 2016 to April 2017) and an implementation period of two years (May 2017 to June 2018 and September 2018 to June 2019). When referring to year one, year two, and year three, we are referring to the preparation year (2016/2017), and the first (2017/2018) and second (2018/2019) year of implementation, respectively.

Figure 5.1. Basic intervention principles as provided by the steering committee.

1. Each participating school forms a working group, in which school staff, local health or sports professionals, and at least one parent take part. The working group is responsible for implementing PA and healthy nutrition-promoting activities.
2. The aim of the activities is to improve the energy balance-related behaviors (EBRBs) (i.e., the physical activity behavior, sedentary behavior, and nutrition behavior) of children aged 7 to 12 years.
3. The working group decides which EBRBs they will target first, in which order, and to what extent.
4. For this, the working group develops an activity plan and implements the activities according to the needs of the children and the possibilities within the local context.

Study setting and study population

The context of the intervention schools served as the study setting. By context, we mean "the set of circumstances or unique factors that surround a particular implementation effort" [209] (p. 52). To study contextual factors, we used the Consolidated Framework for Implementation Research (CFIR) [209], which is a tool to study factors that can influence intervention implementation [209, 210]. It consists of five general domains which interact in complex ways to influence implementation effectiveness. These five domains are characteristics of the outer setting (the economic, political, and social context to which the organization belongs), the inner setting (attributes of structural, political, and cultural context), the individuals involved in the intervention (characteristics of the implementers), the intervention (divided into unadapted and adapted intervention), and the implementation process [209].

In this study, the outer setting was considered the external context of the school that could influence implementation, for example, national and local policies or collaborations with external organizations. The inner setting was considered the school environment, for example, involvement of school staff and the principal. The individuals involved in the implementation of the intervention were the working group members, i.e., schoolteachers, external professionals, parents, and the HP advisor.

In addition to the individuals involved in implementation, the study population consisted of all actors in the eight intervention schools, for example, schoolchildren, teachers and parents who were not involved in the working group but were part of the intervention setting. Observations focused on the entire context (i.e., outer and inner setting, and the entire study population). Interviews were conducted with a selection of the study population and members of the steering committee (described on the next page).

Data collection

Data were collected in and around the schools. Data collection started in September 2016 and ended in June 2019 (Figure 5.2). For this, a flexible data collection approach was applied, i.e., data collection tools were added or removed during implementation to gain the best insights into the implementation process and the contextual influence. Ultimately, multiple qualitative evaluation methods were used to study implementation. The main researcher (SV-J) was involved in the implementation process as HP advisor. This engagement in practice enabled her to gain insight into the implementation process and sense the interplay between top-down and bottom-up influences, while supporting the implementation process [119]. Intuitive findings of the researcher concerning implementation were confirmed by the use of multiple qualitative measurement tools across multiple stakeholders. The Medical Ethics Committee of the Maastricht University Medical Centre approved the study (METC163027, national number: NL58554.068.16).

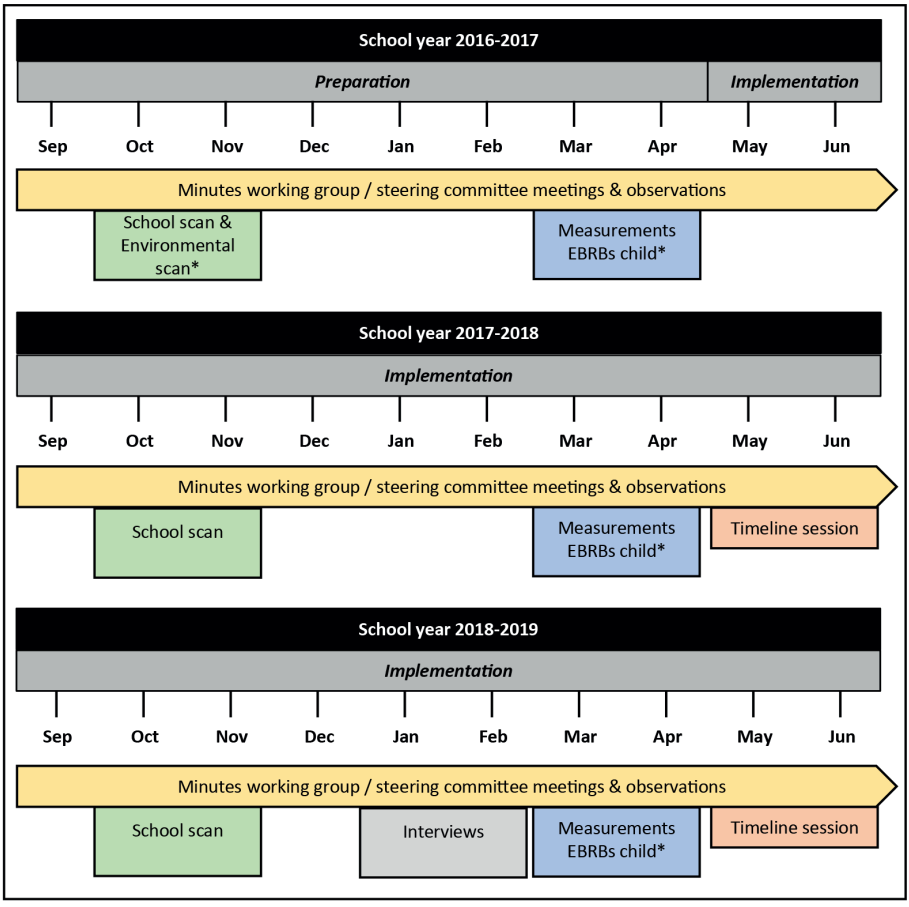
Minutes of working group meetings and participatory observations

From the start of the intervention until the end of the intervention, minutes were collected of each working group meeting (N = 113) and of the meetings of the steering committee (N = 8). Minutes of the working group meetings were mainly prepared by the HP advisor, and sometimes by another member of the working group (e.g., a teacher or a health professional). The minutes of these meetings provided in-depth information about the implementation plan ranging from informing the principals to developing and implementing plans and the (supporting) role of the steering committee in implementation. After each working group meeting, the HP advisors made notes about their observations of the meeting (N = 89). Notes could concern the process (e.g., problems encountered by the members during implementation), interactions (e.g., communication between a working group member and a new partner), or other contextual influences (e.g., changes at the municipal level), but also included "soft" measurements, such as the atmosphere during meetings. These participatory observation notes were not shared with the working groups. In addition, a researcher regularly visited the participating schools to observe activities implemented there. Special attention was paid to contextual fit. These observations were recorded as notes. The participatory observation notes mainly served as secondary data to verify results found in the other data sources. They were used to give meaning and explanation to identified processes.

School scan

At the start of the intervention, the starting situation of the schools concerning the promotion of PA and healthy nutrition was assessed. At the beginning of the preparation year (school year 2016 to 2017), the school principal or a teacher filled in a school scan, which was an online questionnaire. The questionnaire was based on theoretical frameworks concerning the comprehensiveness of primary schools' efforts towards PA and healthy nutrition promotion [14, 32, 135]. The school scan assessed the school's physical education (PE), nutrition education, PA, and healthy nutrition-promoting policies; whether and how the physical school environment stimulated PA and healthy

nutrition behavior; the involvement and support of staff; and parental involvement in the school's PA and healthy nutrition promotion. At the beginning of each school year, the school scan was filled in online by the principal or the chair of the working group (i.e., a teacher).



Note. Only data collection tools used for implementation and the process evaluation are shown. EBRBs = energy balance-related behaviors. *Data used for effect evaluation (not for process evaluation).

Figure 5.2. Timeline of data collection for process evaluation.

Timeline sessions

Initially, the working group members filled in a team climate checklist at the end of the preparation period to assess the climate for innovativeness within the working groups [179]. The team climate and changes within the team climate were expected to affect the implementation process. However, it did not appear feasible to measure follow-up due to a high participant turnover. Thus, this measure was considered inappropriate

for this context. Instead, the narrative timeline technique was used at the end of the first and second year of implementation to evaluate activities implemented in that particular school year and to discuss perceived highlights and perceived failures during implementation with the working groups [211]. Participants concluded with a discussion about "what to do next". The data were used to analyze the implementation process and factors influencing implementation. The HP advisor who assisted the working group acted as a participant in the timeline session. Another HP advisor moderated the session. The timeline sessions were recorded, and participants provided oral consent before the start of each session. In total, 16 timeline sessions were conducted, and 60 working group members participated in these sessions. The timeline sessions were conducted at school. Session duration ranged from 39 to 70 min.

Semi-structured interviews

In year three, a selective sample of principals (N = 5) and working group chairs (N = 4) was asked to participate in individual interviews to gain more insight into implementation at different levels (operational level and management level) and factors influencing implementation. This sample was chosen based on the diversity in implementation of the KEIGAAF approach. Additionally, members of the steering committee (N = 5) were asked to participate in individual interviews. All participants agreed to participate. The interviews were scheduled at the convenience of the participant and took place at the participant's place of work. Before conducting the interview, a semi-structured interview guide was developed using the CFIR [209] (Additional file 5.1). The interviews were recorded, and participants provided oral consent prior to the interview. The interview duration ranged from 28 to 57 min.

Data coding and analysis

Recorded data were transcribed verbatim. Inductive content analysis was performed when coding the data [212]. Two researchers (SV-J and AV) coded 10% of the transcribed interviews independently (one semi-structured interview and two timeline evaluations). These interviews were chosen at random. The two researchers discussed emerging themes and concepts, as well as constructed a preliminary codebook. After agreeing on the first version of the codebook, the first author (SV-J) continued the coding of the remaining interviews and adapted the codebook accordingly. Adaptations to the codebook were discussed with the second researcher. Subsequently, the codes were linked to the five domains of the CFIR [209]. Codes represented information concerning the implementation process (research Question 1), intervention factors, or the contextual factors, i.e., outer setting, inner setting, and characteristics of the individuals (research Question 2). Examples of codes linked to the process are "internal communication", "modus operandi working group", and "collaborations". Examples of codes linked to the intervention are "KEIGAAF research" and "added value KEIGAAF'. Examples of codes linked to the context are "modus operandi school board" (outer setting), "school staff support" (inner setting), and "characteristics working group member" (individuals). Throughout the analysis, an iterative process was applied. The

interpretation of the results was compared with the verbatim data. Data coding and analysis were supported by the use of NVivo 12.

Results

Implementation of the KEIGAAF Intervention

The timeline of the implementation of the KEIGAAF intervention is outlined in Figure 5.3.

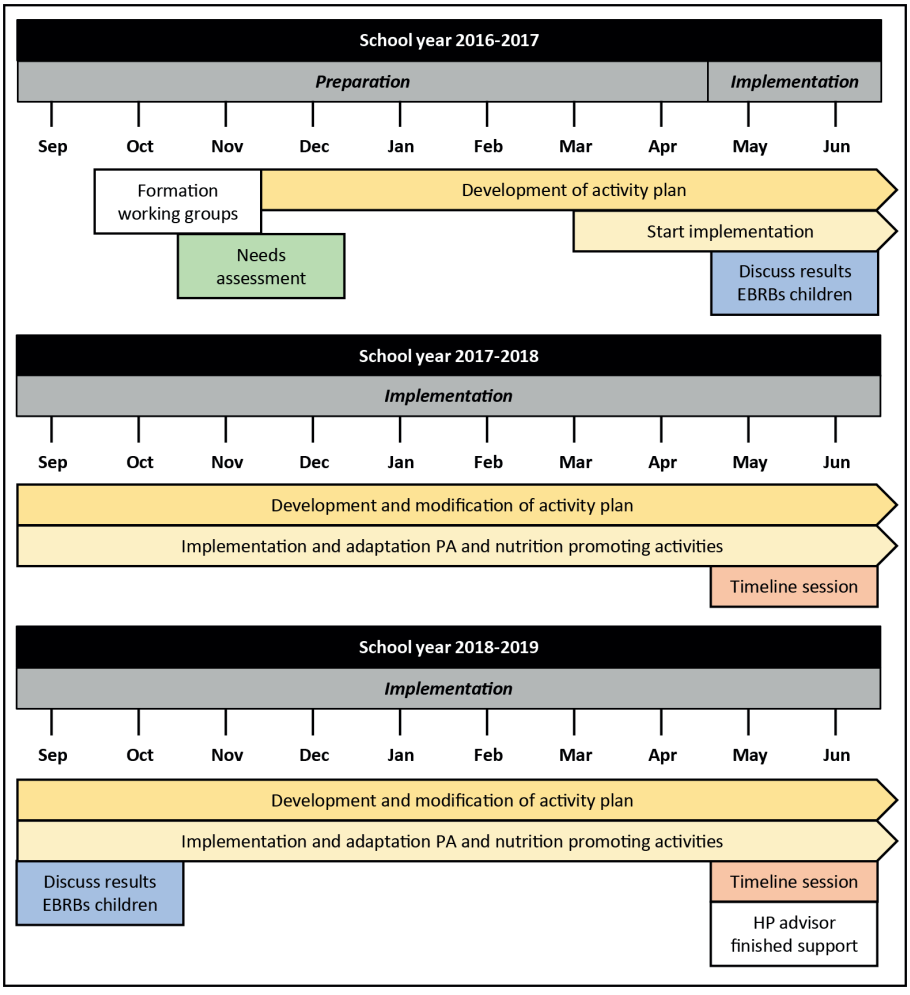


Figure 5.3. Timeline of the implementation process of the KEIGAAF intervention.

In general, the participating schools used similar basic processes concerning the implementation of the PA and nutrition-promoting activities, as they all followed most of the steps proposed by the model of Van Kann et al. [40]. All schools composed a working group (Step 1), defined local needs (Step 2), developed an activity plan (Step 3), and implemented PA and healthy nutrition-promoting activities (Step 5). All schools, except one, made use of the KEIGAAF budget to implement the activities (Step 4). Additionally, seven schools received financial resources from their school board to promote PA and nutrition at school. This school board was a member of the steering committee. The other school belonged to a different school board (not a member of the steering committee). Three schools also applied for and received financial resources from the national Health Promoting Schools committee during the intervention period. All schools, except two, guaranteed sustainability of their implemented activities (Step 6).

Formation of working group

At the beginning of the intervention period, the school principal and a physical education teacher was informed on the KEIGAAF intervention by the main researcher and the project leader. The school principal was instructed to form a working group. At the beginning, the working groups consisted mainly of teachers. Gradually, as the intervention developed, these teachers involved one, or more, parents in the working group. Four working groups did not succeed in involving a parent or involving a parent for a longer period of time. The working groups collaborated with one or more external professionals during the intervention period to implement activities. However, for four working groups, this collaboration with external professionals was minimal. Collaborations were primarily based on existing collaborations between school and an external organization. New collaborations between a school and external organizations were mainly initiated by the HP advisor or by the external organization after being informed about KEIGAAF by a member of the steering committee (e.g., a colleague). Principal involvement in the working group differed between schools. Principals were either directly involved as a member (two working groups), or more indirectly involved (four working groups), or the (main) principal was not involved at all (two working groups). Overall, the composition and size of the working groups differed per school (ranging from three to ten members) and the working groups were highly dynamic during the entire intervention period. Nevertheless, in almost all working groups there was at least one member (besides the HP advisor) who was involved during the whole intervention. Additionally, all working groups, except for one, were supported by the same HP advisor for the entire intervention period.

Development of activity plans

In the beginning, the HP advisor chaired the meetings of the working group and initiated the meetings. The HP advisor also ensured that needs were assessed at the beginning of the intervention period by brainstorming with the working group about needs and potential solutions. Additionally, the advisor discussed the results of the school scan and an environmental scan on the PA-friendliness of the school environment. The latter scan

was conducted by the main researcher and a research assistant (more details about this scan can be found in the protocol paper [179]). The needs assessment provided the basis for the activity plans. The speed at which these plans were developed and the transition from the preparation phase to an implementation phase took place differed per working group. One working group was already in the implementation phase in the first school year, whereas the other working groups started implementation in the new school year (2017 to 2018). For four working groups, it took quite some time to consider and understand KEIGAAF as an intervention in which the working groups were responsible for developing and implementing activity plans rather than a predefined program of PA and nutrition activities. Additionally, working groups that considered their school's existing PA promotion to be adequate took longer to develop an activity plan to promote PA. In general, the working group members were very practice oriented. As a result, the activity plans of the working groups were not very extensive and elaborated, and in most cases, short- and long-term aims of the activities and actions were not explicitly defined. However, three working groups did develop a more structured and deliberate activity plan for year three based on evaluations and experiences in the previous years. Although this practice-oriented thinking of the working groups did not facilitate plan development, it did facilitate implementation in four schools.

Implementation of activity plans

All working groups implemented PA and nutrition activities (Additional file 5.2: Table 5.1), but the degree and intensity differed. PA activities took less time to implement than nutrition activities because of their nature. Most PA activities were relatively simple activities or actions to implement (e.g., new PA material or supporting PA during recess) and were considered fun for the children, while nutrition activities were mainly policies and rules (e.g., not consuming sugar-sweetened beverages) that required support from multiple actors (school staff, parents, and children). In general, the implementation of the intervention was characterized by many feedback loops. Working groups went back and forth in the development and implementation of activity plans and modifying plans and activities based on evaluations and reactions of the target population. The HP advisor and research results supported this process. The HP advisor ensured that the basic intervention principles were met, advised working groups about evidence-based activities and best practices, and advised on how activities could be adapted to enhance contextual fit. To this end, every three months the HP advisors discussed the progress and implementation of the working groups and shared information. The HP advisor also played a key role in feeding back research results to the working groups (i.e., the data of the school scan and the environmental scan, and the results concerning the EBRBs of the children). At the same time, the HP advisor used the insights concerning the process (i.e., from participatory observations and from the timeline sessions) to modify their supporting strategies. For example, one school was not very active in implementation and maintained the brainstorm phase in year two. The HP advisor of this school anticipated this and took a more active role in developing the intervention plan and implementing it. As a result, the school implemented its plan in year three. Although this active involvement of the HP advisor facilitated implementation, it was not considered advantageous for intervention sustainability. The steering committee

was informed on the process by two HP advisors. On the basis of these observations by the HP advisors, supporting strategies of the steering committee were adapted to local needs. For example, members of the steering committee informed colleagues on the intervention and requested them to collaborate with the schools in the working groups, and because of a less active implementation of the intervention, one member of the steering committee decided to motivate and support two working groups in implementing an active curriculum.

Guarantee sustainability

The working groups were advised to implement sustainable activities. In most cases, the HP advisor had to remind the working groups about this sustainable characteristic of activities and advised them to incorporate new practices into current practices. In addition to guaranteeing sustainability of the activities, the HP advisor also aimed to guarantee sustainability of the working group. Therefore, the HP advisor gradually handed over the role of chair to another working group member (a teacher). The readiness of a working group to continue independently of the HP advisor differed per school. For three working groups, the HP advisor was still the chair and initiator of the meetings at the end of the intervention period.

Factors influencing the implementation of the KEIGAAF intervention

We refer to Figure 5.4 for a general overview of the factors per domain of the CFIR that facilitated or hindered implementation of the intervention.

Intervention: unadapted

Practical support of HP advisor and financial support

The practical support of the HP advisor was considered a facilitating factor in implementation by most working groups. Although some working groups were intrinsically motivated to implement the intervention, other working groups required the guidance and encouragement of the HP advisor. The HP advisor sought the best strategy to guide and encourage a working group. A good match between these strategies and the needs of the working group facilitated implementation. School health promotion was considered important by the working groups, but not a priority. Four working groups considered the KEIGAAF budget provided to them as a supporting factor in the implementation.

Feedback loops

The feedback loops in the intervention supported implementation. Three working groups experienced that the timeline sessions were very helpful in deciding on or improving their activity plans. In contrast to the usefulness of the timeline sessions, the results of the behavioral measurements of the children were demotivating for some schools because, in the short term, the children did not improve in their behavioral

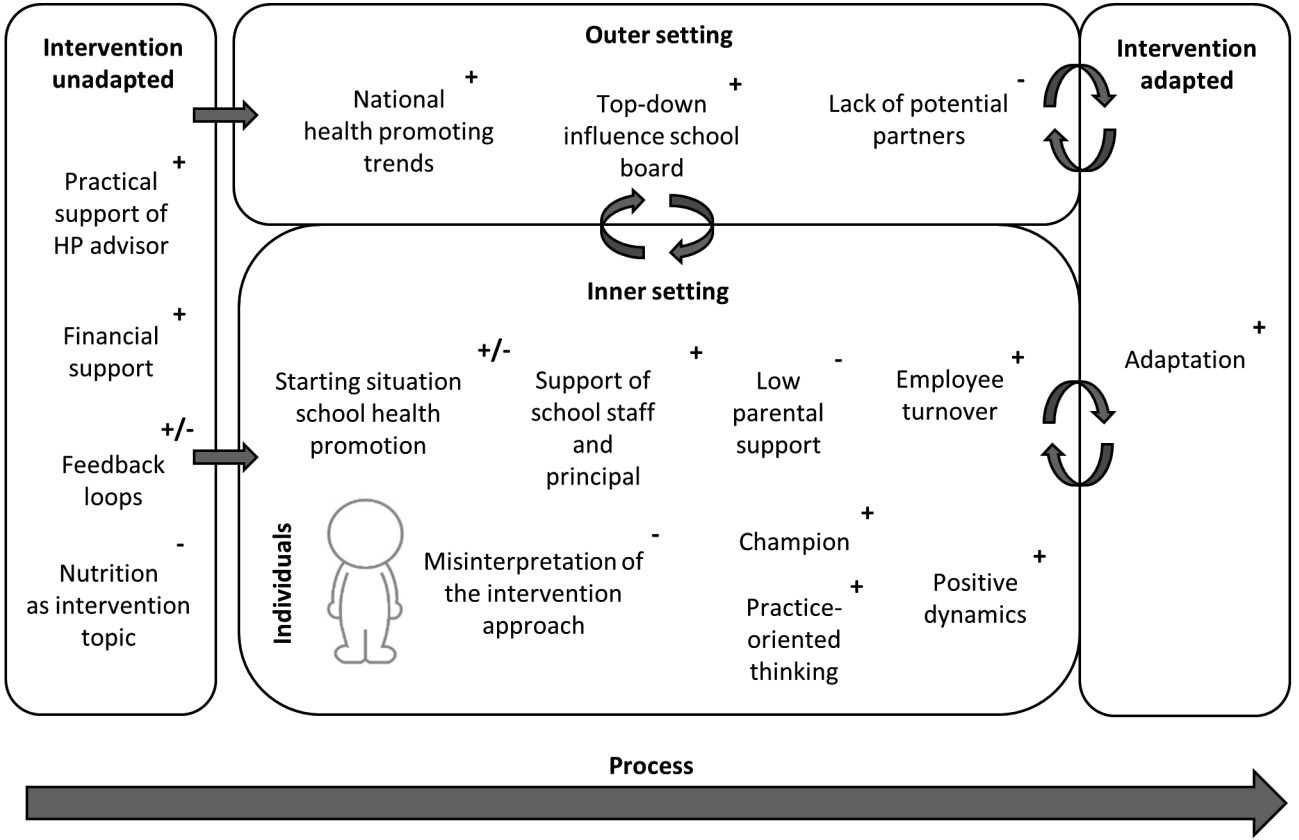


Figure 5.4. Facilitating (+) and hindering (-) factors in the implementation of PA and healthy nutrition-promoting activities in the schools per domain of the Consolidated Framework for Implementation Research (CFIR) (adapted from [209]).

outcomes. One working group wanted to share good results with the parents to show the effectiveness of their efforts. However, they decided not to do so as no improvements in EBRBs were found at the first follow-up measurement. In general, the schools used the enthusiasm of the children (and in some cases the reactions of parents and teachers) as an indicator of intervention success.

Nutrition as intervention topic

Nutrition was considered a more difficult topic to address at school than physical activity. To promote healthy nutrition at school, support from multiple actors was needed. Especially parental support was considered important by the working groups, since parents provide the children's snacks, lunch, drinks, and birthday treats. Support from school staff and principal support were also important for working group members to ensure that school nutrition policies and activities were implemented throughout school and in a consistent manner. However, parental and staff support was not self-evident in all schools, which inhibited implementation. At one school, not all parents supported the school's policies concerning healthy nutrition, and thus gave the children sugar-sweetened beverages when they were expected to drink water. Some schools even felt unable to implement school nutrition policies because there was a lack of parental support. Staff support for nutrition policies and activities was lacking in three schools. In these schools, implementation of nutrition policies was delayed, nutrition activities were not implemented throughout the entire school, or there was no aim to promote healthy nutrition due to an expected lack of support. In schools where the principal perceived the children's nutrition behavior to be the parents' responsibility no nutrition policy was implemented. The principals of those schools did want to create awareness among the children about healthy nutrition, but this resulted in inconsistencies in healthy nutrition promotion by the teachers. In contrast, desirable nutritional changes among children were seen in the schools that implemented clear, formalized school nutrition policies.

Outer setting

National health-promoting trends

In the Netherlands, schools are stimulated to become a healthy school [213]. To this end, a national committee awards a Health Promoting Schools (HPS) certificate to schools that meet the guidelines related to a particular HPS topic (e.g., PA or nutrition). In general, the guidelines of the HPS certificates state that the schools have to educate children about the health topic, identify health problems related to the topic, create a supportive social and physical school environment, and implement health policies [213]. The municipal health service is responsible for the local implementation of the HPS approach. In the intervention region, there were limited financial resources for the local public health sector to support schools in promoting health. A health promoter of the municipal health service advised school health coordinators on the requirements for the HPS certificates in group meetings. The guidelines of the national HPS committee concerning the HPS certificates enabled all schools to set priorities. Other national trends, such as the EU school fruit program [214] or national initiatives

such as National Sports Week, also facilitated the schools in the implementation of PA and healthy nutrition promotion.

Top-down influence of school boards

The schools were governed by two different school boards, which were the two largest within the municipality. Seven intervention schools belonged to the same school board. Five years ago, this school board initiated a project to increase the children's PA behavior by providing high-quality physical education. To this end, they employed qualified PE teachers at the schools. Additionally, the board financially supported schools in assigning a health coordinator within the school who was responsible for obtaining at least two HPS certificates. The school board's demand to obtain the HPS certificates supported the KEIGAAF approach by accelerating the implementation of PA and nutrition-promoting activities. Six of the seven schools wanted to adhere to the school board's demands concerning obtaining these certificates. As a result, these schools had obtained at least one HPS certificate at the end of the intervention period. The school that belonged to another school board did not feel this pressure to obtain one of the HPS certificates. They even believed that obtaining the HPS certificates was of no advantage to them. They were less active in the development of their activity plans and implementation. It took them longer to specify priorities.

Lack of potential partners

The intervention region is divided into seven districts. The participating schools were located in five different districts of the city. In the northern districts, there were different actors as compared with the southern district. Schools located in the northern districts perceived a lack of potential partners in health promotion in their neighborhood. Actors that were potential partners did not match the school's working method. Even in regions with a potential partner, collaborations between school and potential partners were limited. As a result, most schools, implemented the activities only on the school premises, and the members of the school staff were the main implementer of the activities. In general, working group members lacked the capacity to form these collaborations or did not see the necessity to do so. Three schools did succeed in working together with local partners in the implementation of their intervention. This was because the principal, a parent, or the HP advisor initiated this collaboration. A lack of potential partners or limited collaborations between school and potential partners hindered the implementation of comprehensive PA and healthy nutrition promotion.

Inner Setting (Schools)

Starting situation of schools

The defined needs and the activity plans developed by the working groups were dependent on the school's starting situation concerning PA and healthy nutrition promotion. A good starting situation for implementation was a situation in which the working group considered that the current situation had to change. This was mainly the case when there was limited PA or healthy nutrition promotion at school, while the working group perceived that the children needed to improve their EBRBs. When the

working group considered that their school was already making much effort regarding PA and nutrition promotion, implementation was hindered. Hardly any of the schools focused on their own current practices concerning PA promotion with the aim to improve these practices; they were considered normal and consequently overlooked as a potential unit of change.

Low parental support

All schools expressed that a lack of parental involvement in school activities (whether health-related or not) was a common problem. This low parental involvement was also evident in the number of parents participating in the working group; only four schools had at least one parent participating in the working group during the whole intervention period. Schools were hesitant to ask parents to participate in the working groups.

Support of school staff and principal

School staff support facilitated the integration of activities and policies within the school. Some working group members motivated the school staff to support implementation. Creating school staff support was easier when the number of teachers in the working group was high relative to the total number of school staff. The support of the principal was also a facilitator in the implementation of the intervention. All initial principals decided to participate in the intervention. However, there was a high turnover in principals at most schools. In these schools, the new principal had not decided upon participation. This did not necessarily mean that implementation was hindered in these schools. Most of these new principals were very supportive of the intervention. The principals of the seven schools of the same school board were all instructed to obtain the HPS certificate by the school board, and most of them wanted to adhere to that obligation. The schools that were most active in implementation had a principal who supported the working group (e.g., by providing hours), agreed on decisions made by the working group, and demanded that the rest of the school staff support the implementation of this plan. To promote the feeling of ownership of KEIGAAF by the school staff, it was best if the principal was autonomy supportive instead of controlling.

Employee Turnover

Besides a high turnover in school principals, all schools experienced employee turnover during the intervention period. This also resulted in working group members being replaced, added, or removed. At some schools, this employee turnover inhibited implementation because of poor communication between the leaving employee(s) and the new employee(s) or uncertainty about division of tasks. However, in most schools, the employee turnover facilitated the implementation of the intervention, because the new members were more proactive, had more decisional power, or because the changes could be more easily implemented given the new teachers' unfamiliarity with the old practices.

Individuals (Working Group)

Misinterpretation of the intervention
Misinterpretation of the intervention approach and the intervention objectives inhibited implementation. For example, one working group did not develop their own intervention plan, but waited for activities to be delivered and implemented by external organizations, and two working groups thought that they were expected to implement new things, while an objective could also be to bring about more coherence into the existing school PA and healthy nutrition promotion.

Practice-oriented thinking
The practice-oriented thinking of the working groups was considered inherent to the way of working in schools. This attribute of schools did not facilitate the development of a deliberated and sustainable plan, but it did facilitate implementation in most schools.

Champion
A factor facilitating the integration of the activities within a school was the presence of a champion. This champion was characterized by enthusiasm, felt a great need to improve the children's health behavior, quickly switched from a thinking mode to an acting mode, and focused on opportunities instead of obstacles. Primarily, the champion informed and involved other school staff. Three schools had clear champions. This was a teacher and the chair of the working group. Working groups that did not have a champion and did not feel an intrinsic need to improve the children's health behavior but were more externally steered (e.g., requirement of the school board) to participate in the KEIGAAF working groups were less active throughout the intervention period.

Positive dynamics
Good interaction between working group members, including constructive communication between the working group members and the HP advisor, facilitated the process of developing and implementing. Working groups that were characterized by enthusiastic, proactive members who felt a need to change things and invested time in this, collaborated well, and divided implementation tasks had more output as compared with working groups that were less enthusiastic or proactive.

Intervention: adapted

Adaptation
The KEIGAAF intervention was characterized by a high degree of adaptation and local tailoring. This facilitated the implementation of activities that were suitable for the local context. It also enhanced feelings of ownership and sustainability of the bottom-up approach (i.e., the working groups). At the end of the intervention period, six schools decided to continue with KEIGAAF. Although the content of the intervention was very flexible, there was no flexibility in the application of working groups. The working groups

were considered one of the main elements of the mutual adaptation intervention. The practice of working groups worked well for five schools but was less suitable for three schools. These schools preferred a more top-down approach. For example, one school required external organizations to offer an intervention, while the other school made all the decisions for the school's PA promotion via the principal, who did not want to be actively involved in the working group. As a result, these working groups hardly developed an activity plan (if one was developed at all).

Discussion

We studied how a mutual adaptation intervention aimed at promoting children's physical activity and nutrition behavior was implemented in eight primary schools located in low socioeconomic neighborhoods. Although the eight schools were located in the same municipality, the schools differed greatly in the implementation of PA and healthy nutrition-promoting activities. This was caused by the high level of bottom-up design of the intervention and differences in the contexts of the schools. Secondly, we studied which contextual factors influenced implementation. Schools had differing starting situations concerning PA and healthy nutrition promotion and they differed in received parental support, staff and principal support, and in employee turnover. Moreover, differences in characteristics related to the working group members, i.e., interpretation of the approach, the degree of practice-oriented thinking, the presence of one or more champions, and the dynamics within the working group, but also the differing degrees of influence of factors within the outer setting (i.e., support from the school board, national health-promoting trends, and the presence of and the capacity to collaborate with potential partners) resulted in different implementation processes. Other studies also found these contextual factors to facilitate and hinder implementation of school health-promoting interventions [121, 122, 215-221].

The implementation of the KEIGAAF intervention was the result of an interplay between top-down influences and bottom-up development and implementation which led to adaptation to the local context [119]. This mutual adaptation was a key element of KEIGAAF, with the feedback loops and the HP advisors playing a crucial role in this adaptation. For example, feedback on the schools' physical and social health-promoting environment was used to define local needs and behavioral outcome measures to catalyze implementation processes. However, the latter appeared inappropriate for the schools. Reporting short-term, null effects of the first interventions on behavioral outcomes was considered demotivating by the working groups. Instead, children's enjoyment was a preferred indicator for implementation success by the working groups. Therefore, it would have been better to evaluate and report back on children's enjoyment and preferences [222]. To support working groups in implementing context-appropriate activities, the advisor had to find the right balance between top-down and bottom-up influences for each school. This meant that for the one working group, the HP advisor had to take a more active role in implementation, while for the other working group merely informative support was appropriate. For example, a working group that experienced difficulties with the implementation of the intervention outside of school

hours and the school premises due to a lack of partners or inability to find potential partners required support from the HP advisor to find, inform, and connect partners to the working group. Whereas another working group already had a strong external network and required a different type of support, for example, assistance in obtaining parental support. In that case, the HP advisor supported finding the right strategies to involve parents. Thus, the HP advisor also played an important role in overcoming barriers experienced during implementation. However, some barriers were difficult to overcome, for example, working groups that continued to misinterpret the KEIGAAF approach. In such a case, the HP advisor eventually decided to decrease support because it was not the right time for the working group and school to implement the intervention. Since this balance between top-down influences and bottom-up design differed per school and throughout the process, the advisor had to have adaptive management skills and be context sensitive. Being context sensitive meant having all senses open and observing physical structures and organizational dynamics [223] prior to and during intervention implementation. To achieve this, engagement in practice was essential [119].

Interestingly, the need for mutual adaptation between top-down intervention principles and bottom-up changes in school-based health promotion had already been acknowledged in 1976 [44]. However, applying an adaptive intervention instead of implementing a predefined set of activities is still not common practice in school-based interventions. This can be explained by a certain degree of "lack of control" as well as fear of "cherry picking" (e.g., implementing convenient intervention elements) affecting the key components of an intervention. However, intervention adaptation (i.e., local tailoring) is not a threat to intervention effectiveness when intervention functionality is maintained [204]. Adaptation is even considered necessary to maximize the effects [204].

There is currently no guidance on how to adapt evidence-based interventions for new contexts [45], but we know that the ability to mutually adapt top-down effective principles and bottom-up changes "is a special niche and it's not easy to do" [119] (p. 179). It takes skills, perseverance, and time. Informing the schools about an intervention with an unknown output was a challenging process which had to be repeated multiple times throughout implementation. The HP advisor had to familiarize themself with the school and had to gain the trust of the working group [215]. Both investments were essential, but time-consuming. This is outweighed by the high potential of sustainability of the output of the intervention because of a high perceived ownership by the schools due to contextual fit [119, 121]. Important lessons we have learned from implementing the KEIGAAF intervention are listed in Figure 5.5.

For HP advisors:

- Take sufficient time to become familiarized with the school and its larger context and provide the schools sufficient preparation time.
- Adaptation of top-down principles and activities to the local context is a key element in a mutual adaptation approach. Be open to the full spectrum of top-down and bottom-up influences and navigate between these influences. This navigation differs per school and is not an easy task to perform; it requires context-sensitivity and adaptive management skills.
- Support working groups by:
    - Explaining the combined top-down and bottom-up approach and the role of the working group and school in this approach;
    - Advising on the ideal composition of the working group (i.e., teachers, external professionals and parents);
    - Supporting in plan development, i.e., by informing on best practices, by supporting in developing clear short- and long-term goals, by advising on (the importance of) comprehensiveness and sustainability of school health promotion;
    - Connecting the working group with external partners;
    - Informing on strategies to involve parents and engage school staff;
    - Supporting in and advising on monitoring and evaluation;
    - Supporting in applying for (additional) financial resources;
    - Obtaining top-down support, e.g., from the school board and the school principal, by informing the school board and the principal on the importance of school health promotion and the role they can have in school health promotion.

  The type and degree of support required by a working group/school depends on the context.

For researchers:

- Take sufficient time to become familiarized with the school and its larger context and adapt the research approach to this context to obtain maximal insights.
- Assist schools in evaluating their process and report intermediate child-related outcomes, such as enjoyment and preferences, to the schools. It takes time for behavioral effects to become visible, and null or negative results can demotivate schools.

Figure 5.5. Important lessons learned from implementing the KEIGAAF intervention.

Strengths and limitations of the study

This is one of the few studies examining the implementation of school-based PA and nutrition-promoting activities with a focus on context [224]. The combination of the use of different evaluation tools, such as the timeline sessions and the school scan, and our continuous presence in practice provided us with a deep understanding of this context. The engagement of the researcher in practice was a strength of this study but can also be seen as a limitation because of a loss of objectivity. To increase the objectivity of the interpretation of the results, a second researcher was involved in the data coding and analysis. The flexibility in the research approach was another strength of the study [205]. For example, initially the team climate in the working groups (e.g., a safe environment to share ideas) was measured using validated questionnaires at the end of the preparation year with the intention of repeating this measurement at the end of years two and three, because this outcome was expected to impact the process. However, follow-up was impossible due to a high participant turnover. Thus, this measure was not repeated. Additionally, more insight into the process was needed and the minutes of the meetings and observations did not provide enough detail, thus the timeline sessions were used.

There are also some limitations to this study that should be mentioned. First, it was not possible to fully assess the implementation process (e.g., full insight into the integration of the activities in school or the spill-over effects of activities from school to home) or to study every contextual factor (i.e., contextual factors broader than the school context) due to time and resource limitations. In addition, we aimed to minimize participant burden [205]. Second, the results regarding the process and contextual factors are specific for this intervention region and are not generalizable to other regions. This is an inherent aspect of the KEIGAAF intervention. When implementing the KEIGAAF intervention in other regions, it is up to the researchers and HP advisors to gain insight into the contextual factors of that region that potentially influence implementation. A final limitation of the study was that the duration was relatively short to be able to measure sustainability. The KEIGAAF approach was intended to be actively developed and implemented in schools with the support of the HP advisor in years one and two. In year three, the support of the HP advisor was intended to diminish. That last year would then give us a first insight into the potential sustainability. However, this was not realistic because implementation was a continuous process of trial-and-error, and integration and adjustment of plans, activities, and actions required more time than the three years of evaluation. Only preliminary insights into the sustainability of the output of the approach could be acquired. Further research is needed concerning the sustainability of the output of the KEIGAAF intervention, especially when a context requires a more top-down approach.

Conclusions

This study showed that a mutual adaptation physical activity and nutrition intervention was implemented differently in eight primary schools located in low socioeconomic neighborhoods in the same municipality due to the high level of bottom-up design of

the intervention and the differences in influence of facilitating and hindering contextual factors. Important lessons were learned from implementation. One of these lessons was that implementation of this mutual adaptation intervention is time-consuming but feasible. Adaptation of key intervention principles to the school context and current practices is essential. Health promotion advisors play a crucial role in this adaptation by navigating the middle path between top-down and bottom-up influences in a particular school context, as well as feedback loops between other supporting activities and implementation.

Appendices Chapter 5

Additional file 5.1

Interview Guide KEIGAAF

Theoretical Framework
Consolidated Framework for Implementation Research [209]

Basic questions working group chair/school principal:

1. What is KEIGAAF according to you?
2. What is your role in the KEIGAAF approach? / How are you involved in the KEIGAAF approach?
3. What is the most important reason for you to participate in KEIGAAF?
4. What is the aim of the KEIGAAF approach, according to you?
5. What is your opinion on the KEIGAAF approach?

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6. How is the KEIGAAF approach organized within your school?
7. Was there a moment in time that the KEIGAAF approach was becoming successful? If so, can you describe this moment?
8. Was there a moment in time that the KEIGAAF approach was not so successful? If so, can you describe this moment?
9. Which difficulties do you experience with implementing the KEIGAAF approach?
10. What facilitates implementation of the KEIGAAF approach?

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11. How does a succesfull KEIGAAF approach look like, according to you? Does your approach meet that description? Why/why not?
12. Who or what is crucial for school health promotion at your school? Are these factors present?
13. What would you like to advise schools who are willing to implement the KEIGAAF approach?

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14. Will the KEIGAAF approach be continued at your school? If so, how and in which form? And what will your role be in this continuation?
15. What is necessary to continue the KEIGAAF approach?

Basic questions member of steering committee:

1. What is KEIGAAF according to you?
2. What is your role/the role of your organization in the KEIGAAF approach? / How are you/is your organization involved in the KEIGAAF approach?
3. What is the most important reason for you to participate in KEIGAAF?
4. What is the aim of the KEIGAAF approach, according to you?
5. What is your opinion on the KEIGAAF approach?

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6. What is the function of the steering committee in the KEIGAAF approach?
7. Could you describe the collaboration with the other members of the steering committee in the KEIGAAF approach?
8. Do you have sight at the implementation of the KEIGAAF approach at the schools? If so, how (successful) is the KEIGAAF approach implemented at school? / (What influences this successful/unsuccessful implementation?)
9. Was there a moment in time that the KEIGAAF approach was becoming successful? If so, can you describe this moment?
10. Was there a moment in time that the KEIGAAF approach was not so successful? If so, can you describe this moment?
11. Which difficulties do you experience with guiding the KEIGAAF approach?
12. What facilitates guidance of the KEIGAAF approach?

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13. How does a successful KEIGAAF approach look like, according to you? Does the KEIGAAF approach at the schools meet that description? Why/why not?
14. Who or what is crucial for school health promotion? Are these factors present?
15. What would you like to advise schools who are willing to implement the KEIGAAF approach?

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16. Will the KEIGAAF approach be continued? If so, how and in which form? And what will your role be in this continuation?
17. What is necessary to continue the KEIGAAF approach?

Additional file 5.2

Table 5.1. Schools' physical activity promotion at the end of the intervention period.

	School 1	School 2	School 3	School 4
Physical education				
	60 minutes PE provided by PE-teacher	2x 45 minutes PE of which 45 minutes PE provided by PE-teacher and the other 45 minutes by schoolteacher *Sports clinics during PE*	2x 45 minutes PE of which 45 minutes PE provided by PE-teacher and the other 45 minutes by schoolteacher *Sports clinics during PE*	60 minutes PE provided by PE-teacher and 45 minutes outdoors PE provided by schoolteacher *Sports clinics during PE*
Physical activity during school				
During recess	*PA activities during recess three times/ week* PA material during both breaks	*PA activities during recess one time/ week* *PA material during both breaks*	*PA activities during recess one time/ week* PA material during both breaks	*PA activities during recess one time/ week* *PA material during both breaks*
During educational hours	*Active curriculum* *Activity breaks*	*Activity breaks* *Active curriculum* *Energizers*	*Activity breaks*	*Activity breaks* *Active curriculum*
Occasional activities	*Sports day*	Sports day Sports week National outside play day	Sports day Sports week	Sports day Sports week *PA and healthy nutrition week* *Daily Mile*
PA before and after school				
Continuous activities	*Afterschool PA monthly* *Active transport activity once a month*	Afterschool PA weekly	Afterschool PA monthly Active transport activity once a month	*Afterschool PA monthly*
Occasional activities	*Active transport-week*	Local ice-skating event Local marathon	Active transport-week Local marathon Local ice-skating event	Local marathon Local ice-skating event

	School 1	School 2	School 3	School 4
Staff involvement in school PA policies/activities				
	High degree of stimulation of PA activities during recess	*Moderate degree of stimulation of PA activities during recess*	*High degree of stimulation of PA activities during recess*	*High degree of stimulation of PA activities during recess*
	High degree of active transport stimulation	*Moderate degree of active transport stimulation*	High degree of active transport stimulation	Very high degree of active transport stimulation
	High degree of implementation of school PA policies	Moderate degree of implementation of school PA policies	High degree of implementation of school PA policies	Moderate degree of implementation of school PA policies
Parental engagement in school PA activities				
	Activities during recess, implementing sports days and active transport stimulation	Sports days.	Activities during recess, implementing sports days and active transport stimulation	Sports days and active transport stimulation

	School 5	School 6	School 7	School 8
Physical education				
	2x 45 minutes PE of which 45 minutes PE provided by PE-teacher and the other 45 minutes by schoolteacher	50 minutes PE provided by PE-teacher and 45 minutes outdoors PE provided by schoolteacher *Sports clinics during PE*	2x 45 minutes PE of which 45 minutes PE provided by PE-teacher and the other 45 minutes by schoolteacher Sports clinics during PE	2x 45 minutes PE of which 45 minutes PE provided by PE-teacher and the other 45 minutes by schoolteacher Sports clinics during PE
Physical activity during school				
During recess	*PA material during both breaks*	*PA activities during recess one time/ week* *PA material during long break*	PA activities during recess four times/ week *PA material during both breaks*	PA activities during recess one time/ week *PA material during both breaks*
During educational hours	Activity breaks	*Active curriculum* *Standing learning Activity breaks*	*Active curriculum* *Standing desks / Standing learning*	Active curriculum
Occasional activities	Sports day	Sports day	Sports day Sports week	Sports day
PA before and after school				
Continuous activities	-	After school PA monthly	After school PA weekly	After school PA monthly

	School 5	School 6	School 7	School 8
Occasional activities	Local marathon	Local marathon Local ice-skating event *School soccer tournament* *Active transport-week*	Local marathon *Three day walk through neighborhood*	Local marathon Local ice-skating event Three day walk through neighborhood
Staff involvement in school PA policies/activities				
	Moderate degree of stimulation of PA activities during recess	*Moderate degree of stimulation of PA activities during recess.*	High degree of stimulation of PA activities during recess	Low degree of stimulation of PA activities during recess
	High degree of active transport stimulation	Moderate degree of active transport stimulation	Moderate degree of active transport stimulation	Low degree of active transport stimulation
	Moderate degree of implementation of school PA policies.	N/A (no school PA policy)	High degree of implementation of school PA policies	Moderate degree of implementation of school PA policies
Parental engagement in school PA activities				
	Sports days	Afterschool activities and sports days	Sports days	Sports days

Note. Activities and actions in italics were implemented or enhanced during the intervention period (activities and actions in normal font were already present at the start of the intervention).

Table 5.2. Schools' healthy nutrition promotion at the end of the intervention period.

	School 1	**School 2**	**School 3**	**School 4**
Nutrition education				
	Nutrition education: educational program *"Tasty and Healthy", lessons of EU-schoolfruit*	Nutrition education: lessons of "I eat it better" and EU-schoolfruit	*Nutrition education: educational program* *"Taste Lessons", lessons of "I eat it better"*	*Nutrition education: educational program* *"Taste Lessons", lessons of "I eat it better"*
Healthy nutrition during school				
Continuous activities	School fruit *Water bottles*	School fruit Water bottles	School fruit *Water bottles*	School fruit
Occasional activities	*Healthy breakfast week* Breakfast activities *Healthy nutrition week*	Breakfast activities Healthy snack week	Breakfast activity Healthy snack week	*Breakfast activities* *Healthy snack week* *Water promotion week* *PA and healthy nutrition week*
Nutrition policy	*Written nutrition policy concerning healthy snacks, lunch, drinks, birthday treats, and modeling healthy nutrition behavior by teachers*	*Written nutrition policy concerning healthy snacks, lunch, drinks and modeling healthy nutrition behavior by teachers*	*Written nutrition policy concerning healthy snacks, lunch, drinks, birthday treats, and modeling healthy nutrition behavior by teachers*	*Written nutrition policy concerning healthy snacks, lunch, drinks, birthday treats, and modeling healthy nutrition behavior by teachers*
Healthy nutrition before and after school				
	Cooking workshop	-	-	Healthy nutrition and birthday treats at out-of-school care center
Staff involvement in school nutrition policy/activities				
	High degree of implementation of school nutrition policies More than half of staff members support the school nutrition policies	*Moderate degree of implementation of school nutrition policies* All staff members support the school nutrition policies	*High degree of implementation of school nutrition policies* All staff members support the school nutrition policies	*High degree of implementation of school nutrition policies* All staff members support the school nutrition policies

	School 1	School 2	School 3	School 4
Parental engagement in school nutrition activities				
	Parents involved in school nutrition education, nutrition policy and nutrition activities	*Parents involved in school nutrition policy*	-	*Parents involved in school nutrition education, nutrition policy and nutrition activities*

	School 5	School 6	School 7	School 8
Nutrition education				
	Educational program "Tasty and Healthy" Lessons of EU-schoolfruit	*Educational program "Taste Lessons"* *Lessons of "I eat it better", EU-schoolfruit and national Breakfast event*	Lessons of EU-school fruit Cooking workshops	*Educational program "Tasty and Healthy"* Lessons of EU-schoolfruit
Healthy nutrition during school				
Continuous activities	School fruit Vegetable garden	School fruit *Water jugs*	School fruit Vegetable garden	School fruit *Water bottles*
Occasional activities	Breakfast activities Tap water day	Breakfast activities Tap water day *Healthy snack week* *Fruit action month* *Healthy birthday treats session*	-	Breakfast activities
Nutrition policy	Unwritten nutrition policy concerning lunch and drinks	*Written nutrition policy concerning healthy snacks, lunch, drinks, birthday treats, and modeling healthy nutrition behavior by teachers*	Written nutrition policy concerning healthy snacks, lunch, drinks and birthday treats	*Written nutrition policy concerning healthy snacks, drinks, birthday treats, and modeling healthy nutrition behavior by teachers*
Healthy nutrition before and after school				
	Water tap at nearby playground	-	-	-
Staff involvement in school nutrition policy/activities				
	Moderate degree of implementation of school nutrition policies	*High degree of implementation of school nutrition policies*	High degree of implementation of school nutrition policies	*High degree of implementation of school nutrition policies.*

	School 5	School 6	School 7	School 8
Parental engagement in school nutrition activities				
	School nutrition education	*School nutrition policy*	*School nutrition activities*	*School nutrition policy*

Note. Activities and actions in italics were implemented or enhanced during the intervention period (activities and actions in normal font were already present at the start of the intervention).

Chapter 6

Involving parents to help improve children's energy balance-related behaviors through a school-based intervention

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Abstract

The Challenge Me intervention aimed to indirectly involve parents in a school-based intervention, by challenging primary school children to perform physical activity (PA) and nutrition-related activities with their parents. The aim of this study is to gain insight in whether this was a feasible strategy to engage children and parents, especially those of vulnerable populations. An exploratory cross-sectional study design was applied. Four primary schools implemented the intervention. Data consisted of challenges completed (intervention posters) and child and family characteristics (questionnaires and anthropometric measurements). Associations between challenges performed and child and family characteristics were assessed using linear regression analysis. Of the 226 study participants, 100% performed at least one challenge, and 93% performed at least one challenge involving parents. Children who performed more PA challenges were often younger, a sports club member, lived in higher socioeconomic status neighborhoods, of Western ethnicity and from larger families. Regarding nutrition challenges involving parents, younger children performed more challenges. There was no difference in intervention engagement regarding gender, weight status, PA preference, healthy nutrition preference, or the Family PA and Family Nutrition Climate. Challenge Me has potential in involving parents in a school-based intervention. However, certain characteristics were associated with higher involvement.

Introduction

Recent studies show a rise in overweight and obesity among children and adolescents to 18% worldwide in 2016 [225], with one in five school-aged children in Europe being overweight or obese [37, 226]. Also in the Netherlands, childhood obesity rates are high. In 2019, 12% of children aged 4 to 12 were overweight or obese [227]. Overweight or obesity in childhood is especially problematic, since this often continues into adolescence and adulthood and is related to an increased risk of negative health consequences, such as type II diabetes, hypertension, respiratory disease and various types of cancer [37, 226, 228]. Overweight and obesity are preventable and treatable [229], especially at a young age [97, 228], by improving healthy nutrition behaviors and increasing physical activity (PA) (also called energy balance-related behaviors (EBRBs)) [47, 230, 231]. To target children's EBRBs [45, 47], multiple settings [232], such as the school [201] and home environment should be involved in interventions [47, 201].

Since children spend a large proportion of their weekdays at school, and schools reach many children, schools have been a popular intervention setting for decades [49, 201, 233]. However, the influence of the home setting on children's EBRBs is profound, especially for young children, since parents determine the food availability at home, and influence children's nutrition and PA behavior by practices like modelling and rule setting [51, 53, 234, 235]. Therefore, it is important to also focus on the home setting when implementing school-based energy balance-related interventions [51, 233].

Most effective changes in the home setting are accomplished through interventions with direct parental involvement (e.g., parents attending educational sessions, or counselling sessions) [53, 201, 234, 236, 237]. However, directly involving parents is often resource- and labor-intensive, making these types of interventions less feasible [236]. Also, the recruitment [238] and prolonged engagement of parents in these types of interventions have proven to be challenging [37, 54, 238]. Only about one-third of invited families participate in any intervention activity [37, 239], 40 to 60% of whom drop out [239]. In addition, the participants of parental involvement interventions tend to be mostly high socioeconomic status (SES) parents [240], and it is particularly challenging to engage parents with a low SES [37, 240], a lower educational level, single parents and those of ethnic minority groups [239]. This is discouraging, since these parents/families are most in need of interventions. For example, research from a large Dutch cohort study has shown that there are socioeconomic and ethnic inequalities in child health [241]. At a young age, non-Western children were more likely to be overweight compared to Dutch children, with mother's educational level being one of the contributing factors in explaining this higher prevalence in overweight in these children [242]. Beyond socioeconomic health disparities, child characteristics and the supportiveness of the home environment to perform healthy behaviors are also important predictors of children's PA and nutrition behavior. For instance, children's nutrition behavior is determined by their preference for healthy and/or unhealthy foods, and their PA and sedentary behavior is associated with their activity preferences [138]. Also, children raised in an environment in which healthy nutrition [152] and sufficient PA [152, 243] are less valued are more at risk for developing unhealthy EBRBs. Therefore, vulnerability of the population is not restricted to well-known socioeconomic differences, but also includes specific child preferences and the health climate regarding EBRBs in the home

environment.

To involve more parents, and particularly those of vulnerable populations, the strategy of indirect parental involvement is an alternative. Even though indirect parental involvement is assumed to be less effective in changing health behaviors compared to direct parental involvement, it can lead to greater adoption and implementation rates [237]. In indirect parental involvement, parents are engaged in a way that the intervention implementers do not communicate or engage directly (i.e., face to face, or personally) with them. Instead, parents are informed via school media, or children function as the messenger. Examples of indirect parental involvement are the provision of information (newsletters, tip sheets), invitations to participate in or attend activities (events, educational sessions) and prompts or assignments directed at the child and/or parent with the aim of involving parents [53]. Previous research has shown that some of these strategies are more promising than others, for example prompting children to engage in intervention activities together with their parent(s) seems more promising than providing newsletters or invitations for optional intervention activities [51, 53]. The difference between these strategies could be described as passive (not requiring a specific action or response on the part of the parents) indirect involvement versus active (performing activities) indirect involvement.

To our knowledge, there is little to no research on the participation rates of the strategy of the latter type of indirect parental involvement in school-based interventions, while this information is crucial to be able to draw conclusions on potential strategies to involve parents in (school-based) interventions [237]. Given the fact that children of vulnerable populations are less active, more sedentary and have unhealthier diets [6, 7, 190], it is possible that these children and their parents are less interested in energy balance-related interventions. Therefore, gaining insight in participation rates of children and parents in interventions using an indirect parental involvement strategy is needed. Moreover, empirical evidence is lacking on who is engaged in this strategy and therefore, it is warranted to know whether vulnerable children and parents engage in these interventions using this strategy. In the current study, we evaluated the potential of Challenge Me to engage children and parents, especially those of vulnerable populations. Challenge Me was a parental involvement intervention in which children are challenged to perform PA and nutrition-related activities by themselves and with their parents. The main aim of the current study is to examine whether conducting challenges is a feasible intervention strategy to engage children and parents in school-based energy balance-related interventions. With engagement, we refer to participation in the intervention, i.e., performing the intervention activities, and not enrolment. Additionally, a second aim is to gain insight in whether children in need for improvements, i.e., vulnerable populations, are engaged in the intervention using this indirect-involvement strategy. For this aim, we focused on child demographics, child characteristics (preferences) and the climate towards health behaviors in the home environment.

Materials and Methods

Design

An exploratory cross-sectional study design was conducted. The Medical Ethics Committee of the Maastricht University Medical Centre and Maastricht University provided ethical approval for this study (METC163027, national number: NL58554.068.16).

Challenge Me intervention

Intervention development

The intervention, called Challenge Me, challenged children to perform PA and nutrition-related challenges together with their parent(s) or guardian(s). Challenge Me has been developed as part of a larger evaluation [179][34], and is specifically focused on improving parental involvement. In the larger evaluation study, eight primary schools, located in low SES neighborhoods (based on scoring of The Netherlands Institute for Social Research [244]) in a city in the south of The Netherlands, participated. During the development and implementation of Challenge Me in the local context, researchers collaborated with a local youth work organization. This local organization developed the challenges, with input from local health, education and sports professionals. Challenge Me consisted of several easy-to-perform activities, introduced weekly at school by people locally well-known by means of instruction videos (i.e., the schools' own PE teacher, local free runners, a famous vlogger and a television chef from the region). A selection of the challenges was designed to involve parents. The local nature of the intervention enhanced a fit with the schools' local context, which we anticipated would improve program use, recognition and commitment by the children and consequently the involvement of parent(s).

The result of this design process was an intervention consisting of a total of eighteen challenges (Table 6.1). Challenges were categorized in 'child-only' (nine challenges performed by a child on his/her own, together with other children or in class) and 'parental involvement' (nine challenges that required parental assistance). Challenges could further be categorized as PA-focused (e.g., 'Run as far as possible with your entire class, in 2 min/'Go exercise for 30 min together with your parent(s)/guardian(s)'), or nutrition-focused (e.g., 'Find a healthy dinner recipe and bring this with you to school'/'Make a healthy breakfast for someone in your household'). To ensure active involvement of the children and parents in the intervention, children had to provide proof of completing a challenge, which was specified per challenge (e.g., by taking a picture of their exercise). The class that performed the most challenges (corrected for the number of children in each class) was awarded a prize. The prize was a PA workshop, provided by the local youth work organization.

The local youth work organization distributed the materials. The materials included a Challenge Me poster on which the various challenges were listed (Additional file 6.1: Figure 6.1), an instruction form for the teacher, stickers (used to mark a challenge as completed) and four instruction videos. The local youth organization also appointed an

employee specifically tasked with the implementation and monitoring of Challenge Me. This local youth worker also provided all necessary instructions in participating classes, to limit additional workload of teachers.

Table 6.1. Overview of 'Challenge Me' challenges.

	Child-only	**Parental Involvement**
PA	Run as far as possible with your entire class, in 2 minutes. Try to perform as many bottle flips as possible in 1 minute. Jump rope as long and often as you can, together with your PE teacher. Go to the town-/city center and play a game of 'the floor is lava'. Participate in an activity of your local youth organization. Challenge a local youth worker for a battle. Challenge him/her in something you are good at. Watch instruction video: Free running.	Help your parent/guardian with the housekeeping. Ask your dad/mom/guardian/grandpa/ grandma /neighbor what game they liked to play when they were young, and play that game. Go exercise for 30 minutes together with your parent(s)/guardian(s). Go walking, rollerblading, or stepping, together with your parent(s)/guardian(s). *Do a 'bob for a job' in your neighborhood.* *Come to school using a means of transport other than a car.*
Nutrition	Find a healthy dinner recipe and bring this with you to school. Make a vlog about healthy/unhealthy food in your surroundings.	Cook a healthy soup. Make a healthy breakfast for someone in your household. *Make a work of art out of a piece of fruit.*

Note. PA = physical activity. Challenges are numbered at random, no order of completion was specified. Challenges in Italic require parental involvement dependent on the age of the child (older children are expected to be able to perform the challenge without help from the parent).

Implementation

Recruitment for the intervention took place at school level. Intervention schools (N = 8) already participated in a larger evaluation study [179]. These schools were invited to implement the Challenge Me intervention. Of these, four school decided to participate. Four schools declined to participate because of time constraints. Teachers of participating schools were orally informed by the local youth worker about Challenge Me and its aims, and received instructions on how to perform the intervention. The same youth worker also informed the children about the intervention and monitored the progress of the intervention.

The participating schools implemented the intervention in grade six to eight (children aged 9 to 12), except for one. This school only implemented the intervention in grade eight. Each class received a Challenge Me poster. Challenges were expected to be performed during a four-week period (January–February 2019). Every week, the teacher showed one of the provided introduction videos provided by the local youth worker to kick-start the week. Depending on the challenge, challenges were performed at home, or in the neighborhood. Children and parents participated in the intervention voluntarily. Based on the proof provided by the child, the teacher decided whether

a challenge had been completed successfully. At the end of the four weeks, the local youth worker collected all the posters and decided which class had won.

Study participants

Children from grades six to eight (aged 9 to 12) were eligible for inclusion in the study [179]. Parents received an informed consent form via the child [179]. In short, the informed consent form stated the purpose of the study, and how collected data would be handled. It also emphasized that participation in the study was voluntary, and that participants could always withdraw without stating any reason for doing so. For children to participate in the study, both parents had to provide written consent. This was based on the regulations of the Central Committee on Research involving Human Subjects [245].

Data collection

For this exploratory study, data from the larger evaluation study were used [179]. Data were collected in March–April 2019, after the completion of the Challenge Me intervention in all four schools. During that period, both children and their parents received a questionnaire. Children received and filled in the questionnaire in the classroom, during regular school hours, with one researcher and at least one research assistant present to provide instructions. Parent questionnaires were handed out to the children in an envelope. Parents filled in the questionnaire at home, and returned it to school via the child. Children's height and weight were measured within the same week as the child questionnaire.

Performance of challenges

The posters provided data on which challenges were completed by whom. Data were pseudonymized and digitalized. Challenges were grouped in various categories (Table 6.1)—PA: PA child-only and PA parental involvement; nutrition: nutrition child-only and nutrition parental involvement. Outcome measures were the percentage of challenges performed.

Child characteristics

Child characteristics were assessed via a questionnaire. Children reported their date of birth, gender (boy/girl), country of birth, country of birth of their mother and father, the number of brothers and sisters and whether they were a member of a sports club (yes/no). The child's age was calculated based on the date of birth. In addition, Western or non-Western ethnicity of the child was determined, based on the country of birth of both parents. A child was considered as having a non-Western ethnicity when at least one parent was born in a non-Western country, based on the definition of Huntington [246]. The number of siblings was determined, based on the number of brothers and/

or sisters.

Nutrition and PA preferences were also measured via a questionnaire, using an instrument developed by Rodenburg et al. [138]. This instrument ranks food, drink and leisure-time activity preferences by means of comparison. Items were visualized by means of an infographic of a child holding a food or drink item, or portraying an activity, accompanied by the description of the food, drink or activity. The items were compared in pairs, and children were asked to indicate the food, drink or activity of their preference. The food items were fruit, vegetables, sweet snacks (e.g., candy and cookies) and savory snacks (e.g., crisps, nuts, cheese). The drinks items included sugar-sweetened beverages, light drinks (i.e., drinks that were artificially sweetened), tea without sugar, fruit juice and water (water was added to the items at a later stage). Leisure-time activity consisted of eight items, namely cycling, using the computer, watching television, playing sports, dancing, arts and crafts, reading and playing outside. In total, the instrument consisted of 44 comparisons. Items were re-categorized into active activities (cycling, playing sports, dancing and playing outside), and healthy nutrition (fruit, vegetables, tea without sugar and water). Even though fruit juice may be perceived as healthy [47], it is high in energy density and sugar content and could contribute to weight gain and overweight [47, 247]. Because of this controversy, fruit juice was left out of analysis.

Children's height and weight were measured by trained research assistants, using a measurement protocol. Children were measured during a physical education class, wearing light sports clothes and without shoes. Standing height was measured using the Seca 213 stadiometer (Seca, Hamburg, Germany), to the nearest decimal in centimeters. The Seca 803 digital weighing scale (Seca, Hamburg, Germany) was used to measure the child's weight to the nearest decimal in kilograms. Children's BMI z-score was calculated from their weight and height, while adjusting for their age and gender, using a Dutch reference population [139].

Family characteristics

Family characteristics were measured in the parent questionnaire, and consisted of postal code, level of education, family situation (partner/single) and Family Health Climate (FHC). The postal code was used to determine residential status score [244]. The residential status score ranged between −1.56 and 0.13 in the intervention region. The national mean residential status score is 0.2 [244]. Educational level of the parent was recoded into two categories [182]: (1) low (no education, primary school, secondary school, pre-vocational school or lower vocational education); and (2) high (higher vocational education or university). For two-parent families, a combined score was made, i.e., (1) low (both parents having a low level of education); (2) mixed (one parent low educated and one parent high educated); and (3) high (both parents having a high level of education).

In the parent questionnaire, parents filled in the validated Family Health Climate scale (FHC) [152], which was translated into Dutch [176]. The FHC is a 31-item questionnaire measuring shared family perceptions and cognitions concerning health behavior, i.e., nutrition (FHC-NU) and physical activity (FHC-PA). The climate concerning PA and healthy nutrition is further divided into four and three concepts respectively, namely

FHC-NU value, cohesion, communication and consensus, and FHC-PA value, cohesion and information. Items belonging to these concepts are statements, introduced by 'In our family…', and are answered on a four-point Likert-scale ranging from one (definitely false) to four (definitely true). FHC-NU value (four items) measures the importance of healthy nutrition within a family ('…a healthy diet plays an important role in our lives') (α = 0.62). FHC-NU cohesion (five items) includes the importance of eating together as a family ('… everyone enjoys having meals together') (α = 0.82). FHC-NU communication (five items) covers how normalized it is to talk about nutrition, and how family members support each other in eating healthy ('…we remind each other to pay attention to a healthy diet') (α = 0.82). FHC-NU consensus (three items) encompasses the level of agreement among family members concerning nutrition ('…we usually agree on meals and food choices') (α = 0.79). A high FHC-NU score implies a high value attached to healthy nutrition within a family. FHC-PA value (five items) comprises the value attached by all family members to being physically active ('...it is normal to be physically active on a regular basis') (α = 0.82). FHC-PA cohesion (five items) includes joint physical activities and experienced fun during such activities ('…we enjoy exercising together') (α = 0.88). Finally, FHC-PA information (four items) measures searching, sharing and using PA-related information as a family ('…we read newspaper or magazine articles on fitness, physical activity and exercise') (α = 0.80). The higher the FHC-PA score, the more integrated PA is within a family's daily life [152].

Statistical analyses

All results were analyzed using SPSS 24.0 (IBM Corp., Armonk, NY, USA). Missing items of the FHC-PA and FHC nutrition scales (i.e., PA value, cohesion and information, and nutrition value, cohesion, communication and consensus) were imputed with the mean score of the other items of the same concept. Data were only imputed when a maximum of 10% of items per concept were missing. No other missing values were imputed.

Descriptive statistics were used to assess child and parent engagement and child and family characteristics of the intervention participants. Associations between percentage of challenges (per category) performed and child and family characteristics were assessed by conducting linear regression analysis.

First, the association between child and family characteristics as predictor variables and the percentage of challenges performed as outcome measures were analyzed using bivariate linear regression analysis. The predictor variables used were the age, BMI z-score, gender, ethnicity (Western/non-Western), sports membership (member/non-member), preference PA and preference healthy nutrition of the child and the residential status score, the number of siblings, the combined educational level (low/mixed/high) and the FHC-PA and FHC-NU of the family.

Second, multivariate linear regression analyses were performed for the PA-related outcome measures (i.e., percentage PA child-only challenges, PA parental involvement challenges) by simultaneously using PA-related child characteristics as predictor variables in the model, i.e., age, gender, ethnicity, sports membership and preference PA. The same was done to assess the associations between the nutrition-related outcome measures (i.e., percentage nutrition child-only challenges, nutrition parental involvement challenges) and nutrition-related child characteristics, i.e., age, gender,

ethnicity, sports membership and preference healthy nutrition. To assess the association between PA-related outcome measures and PA-related family characteristics, i.e., residential status score, number of siblings, parental educational level (low/mixed/high) and FHC-PA, predictor variables were entered simultaneously in this model while being corrected for all PA-related child characteristics. The same was done for the association between nutrition-related outcomes measures and nutrition-related family characteristics. A p-value of < 0.05 was considered statistically significant.

Results

Child and family characteristics

In total, 406 children were eligible for inclusion in the study. Of these, 226 children (55.7%) participated in the study. Children had a mean age of 10.9 years (Table 6.2). Slightly more girls (55.8%) participated than boys, and more children were of Western ethnicity (62.7%). The majority of the children were members of a sports club (77.9%). Children preferred active activities slightly more (mean score: 15.7 out of 28). Regarding nutrition, there was a slight preference for unhealthy food and drink items (mean score: 7.5 out of 14). Of the parents, 186 (82.3% out of 226) returned their questionnaire. Mainly mothers filled in the questionnaire (82.9%), and most of them had a partner (84.4%). Almost half of the families consisted of two children (47.7%). In the majority of the families (50%), both parents had a low educational level and in 29.9% of the families, both parents had a high educational level. On average, families scored 2.8 on FHC PA, and 3.1 on FHC nutrition (range FHC score: 1 to 4).

Table 6.2. Child and family characteristics.

		N	%	Mean	SD
Child characteristics					
Age				10.9	1.0
BMI z				0.09	1.1
Gender	Boy	100	44.2		
	Girl	126	55.8		
Ethnicity	Western	141	62.7		
	non-Western	84	37.3		
Sports membership	Member	173	77.9		
	non-member	49	22.1		
Preference PA (0-28)	Active			15.7	3.3
Preference nutrition (0-14)	Healthy			6.2	2.8

		N	%	Mean	SD
Family characteristics					
Filled in by	Mother	141	82.9		
	Father	26	15.3		
	Other	3	1.8		
Family situation	Parent with partner	157	84.4		
	Single parent	29	15.6		
Residential status score				-0.9	0.8
Siblings	0	24	10.9		
	1	105	47.7		
	2	48	21.8		
	3	28	12.7		
	4-7	15	6.9		
Parental level of education	Low	92	50.0		
	Low/High mixed	37	20.1		
	High	55	29.9		
FHC-PA (1-4)				2.8	0.4
FHC nutrition (1-4)				3.1	0.4

Note. Percentages are presented based on complete cases. SD = standard deviation, PA = physical activity, FHC = Family Health Climate.

Performance of challenges

Of the 226 children participating in this study, all children (100%) performed at least one challenge and 211 children (93%) performed at least one parental involvement challenge (Table 6.3). Overall, PA challenges were performed more often than nutrition challenges. Only two children (0.9%) did not perform any of the PA-related challenges, whereas 85 children (37.6%) did not perform any of the nutrition-related challenges. Of the PA child-only challenges, the 'Run as far as possible with your entire class, in 2 min' challenge was completed by most children (N = 171, 75.7%) (Additional file 6.2: Table 6.7). Of the PA parental involvement challenges, the 'Come to school using a means of transport other than a car' challenge was completed by most children (N = 176, 77.9%).

Regarding nutrition challenges, challenges involving parents were performed more often compared to child-only challenges, with 126 children (55.8%) performing at least one nutrition parental involvement challenge compared to 65 children, and 28.3%, performing at least one child-only nutrition challenge. Of the nutrition parental involvement challenges, 'Make a work of art out of a piece of fruit' was performed most often (34.5%), and of the nutrition child-only challenges 'Find a healthy dinner recipe and bring this with you to school' was performed most often (24.8%).

Table 6.3. Number of children who performed the challenges, per category

	0 challenges performed (0%)		At least one challenge performed (1-99%)		All challenges performed (100%)	
Category	**N**	**%**	**N**	**%**	**N**	**%**
PA	2	0.9	224	99.1	0	0
PA child-only (7 challenges)	17	7.5	205	90.7	4	1.8
PA parental involvement (6 challenges)	22	9.7	200	88.5	4	1.8
Nutrition	85	37.6	139	61.5	2	0.9
Nutrition child-only (2 challenges)	162	71.7	59	26.1	5	2.2
Nutrition parental involvement (3 challenges)	100	44.2	111	49.2	15	6.6

Note. N = number of children. PA = physical activity.

Associations between child and family characteristics and challenges performed

Child characteristics significantly associated with the number of challenges performed were age, ethnicity and sports membership (Tables 6.4 and 6.5). Younger children performed more challenges, specifically PA child-only challenges and nutrition challenges involving parents (Table 6.4). Children of Western ethnicity performed more PA parental involvement. Children who were a member of a sports club performed more PA child-only challenges.

Characteristics of the family significantly associated with the challenges performed by the child were residential status score, the number of siblings and a mixed parental level of education (Tables 6.4 and 6.6). Children raised in high SES neighborhoods (higher residential status score) were more likely to perform PA child-only challenges, and PA parental involvement challenges were performed more often by children of larger families. When compared to a low level of parental education, children of families with a mixed level of parental education completed more nutrition challenges, mainly child-only. This significant association was not found when comparing a mixed level of parental education to a high level of parental education.

Table 6.4. Bivariate associations between child and family characteristics and challenges performed.

Characteristic	Reference	PA β	PA child-only β	PA parental involvement β	Nutrition β	Nutrition child-only β	Nutrition parental involvement β
Age		**-.153***	**-.227***	.016	**-.154***	-.063	**-.165***
BMI z		-.010	-.064	.065	.048	.036	.042
Gender	Boys	.047	.052	.018	.098	.009	.122
Ethnicity	Western	**-.151***	-.102	**-.146***	-.078	-.050	-.074
Sports membership	Non-member	**.226***	**.221***	.128	.110	.112	.082
Preference active activities		.091	.073	.073	NA	NA	NA
Preference healthy nutrition		NA	NA	NA	.000	-.055	.030
Residential status score		.046	.079	-.019	.008	-.041	.032
Siblings		**.142***	.046	**.200***	.065	.040	.063
Parental educational level	(both) Low educated						
Mixed		.095	.091	.054	**.167***	.147	.139
(both) high educated		.054	.125	-.065	.125	.130	.094
FHC-PA		-.021	.038	-.083	NA	NA	NA
FHC nutrition		NA	NA	NA	.007	.036	-.010

Note. β = standardized beta coefficient. PA = physical activity. FHC = family health climate. NA = not applicable. *Significant result ($p < 0.05$) shown in bold print.

Table 6.5. Multivariate associations between child characteristics and challenges performed.

		PA	PA child-only	PA parental involvement	Nutrition	Nutrition child-only	Nutrition parental involvement
Characteristic	**Reference**	**β**	**β**	**β**	**β**	**β**	**β**
Age		**-.136***	**-.208***	.019	-.131	-.052	**-.142***
BMI z		-.008	-.065	.069	.050	.040	.044
Gender	Boys	.030	.047	-.004	.115	.040	.127
Ethnicity	Western	-.119	-.056	**-.148***	-.052	-.030	-.052
Sports membership	Non-member	**.182***	**.180***	.101	.109	.103	.085
Preference active activities		.095	.070	.084	NA	NA	NA
Preference healthy nutrition		NA	NA	NA	-.032	-.064	-.007

Note. β = standardized beta coefficient. PA = physical activity. NA = not applicable. *Significant result ($p < 0.05$) shown in bold print.

Table 6.6. Multivariate associations between family characteristics and challenges performed (adjusted for child characteristics).

Characteristic	Reference	PA β	PA child-only β	PA parental involvement β	Nutrition β	Nutrition child-only β	Nutrition parental involvement β
Residential status score		.082	**.175***	-.063	-.063	-.097	-.029
Siblings		.140	-.002	**.247***	.091	-.030	.138
Parental educational level	(Both) low educated						
Mixed		.075	.036	.090	**.214***	**.205***	.169
(Both) high educated		-.067	-.020	-.094	.133	.142	.097
FHC-PA		-.002	.047	-.059	NA	NA	NA
FHC nutrition		NA	NA	NA	-.038	-.028	-.035

Note. β = standardized beta coefficient. PA = physical activity. FHC = family health climate. NA = not applicable. *Significant result ($p < 0.05$) shown in bold print. Multivariate regression analysis adjusted for child characteristics: age, BMI z-score, gender (boy/girl), ethnicity (Western/non-Western), sports membership (yes/no), preference active activities, and preference healthy nutrition.

Discussion

This study investigated the parent and child engagement in Challenge Me, an intervention targeting parents indirectly in a school-based intervention using PA- and nutrition-related challenges for children. Many children (N = 406) were exposed to the intervention. Of the 226 study participants, all (100%) participated in the intervention. Of these children, 93% performed at least one parental involvement challenge. This study showed that there was no difference in engagement in the intervention activities by children with a lower or higher BMI z-score, children with a higher or lower preference concerning active activities or healthy nutrition, or boys or girls. Also, children of families with an unhealthier or healthier climate concerning PA and nutrition did not differ in engagement in the intervention.

Nevertheless, other characteristics associated with the performance of certain types of challenges could be distinguished. For example, PA challenges were performed more often by children who were already a member of a sports club, and younger children. These active children might be more used to performing PA after school time and be more motivated to do so, and are thus more likely to perform the challenges compared to children who are not used to sports or PA activities that much. The fact that younger children performed more PA activities is not surprising, given the age-related decline in PA that is visible in children in high-income countries [248], which already starts at the age of seven [249].

Western children performed more PA parental involvement challenges compared to non-Western children. This is in line with previous research, showing that non-Western children perform significantly less PA (overall) than Western children [250-252]. However, additional analyses showed that this association between child ethnicity and the performance of PA parental involvement challenges was mediated by sports membership. The association between ethnicity and sports membership was significant ($\beta = -0.23$, 95% CI −0.31; −0.09, $p < 0.01$), with a higher percentage of children of Western ethnicity being a member of a sports club compared to children of non-Western ethnicity (83.0% versus 65.5%). Potentially, cultural differences between Western and non-Western families play a role in whether or not children participate in sports. It is unknown whether such cultural differences in PA and performance of PA and sports as a family exist in The Netherlands [251].

Our results also showed that children from larger families (i.e., having more siblings) performed more PA parental involvement challenges. Potentially, multiple siblings participated in the intervention, which meant a higher exposure to the challenges within the family. However, further research to support these findings needs to be done. Even though the FHC measures family cognitions on nutrition and PA behavior specifically, FHC did not show any associations with parental involvement in nutrition or PA challenges performed. This could indicate that the challenges would be suited for all families, regardless of their current PA and nutrition family climate. However, both on FHC PA and FHC nutrition, families scored relatively high and variance was low, potentially limiting the probability of finding an association. Lastly, children living in higher SES neighborhoods performed more PA child-only challenges compared to children living in lower SES neighborhoods. This could be explained as lower SES neighborhoods being perceived as less safe by parents [253], and could therefore be

seen as less suited for children to perform PA on their own in their neighborhood. Additionally, previous research has shown that high SES home environments are more supportive of PA in terms of availability of equipment [254]. We had expected that these factors would also influence the association between parental education level and the performance of PA challenges, with a higher performance of challenges in families of a high parental educational level, as educational level is an indicator of SES. However, we did not find children of high-educated parents performing more PA challenges (data not shown). We did see that children of families with a mixed educational level performed more nutrition child-only challenges compared to children of low-educated parents (but not compared to high-educated parents). However, we are unable to explain this association.

Even though earlier studies often found a difference in performance of PA between boys and girls [250, 255-257], our study did not show an association between gender and certain types of challenges performed. It can be that the gender-neutrality of the challenges played a role in this. While boys prefer activities like soccer and basketball, girls prefer activities like dancing, gymnastics and exercising to music [258]. However, none of the challenges had any of these elements incorporated in them. Gender-stratified analyses were performed for the association between child and family characteristics and challenges performed (per category), which showed a difference in key characteristics for boys and girls. For example, being a member of a sports club was significantly associated with the performance of PA child-only challenges for boys, yet this association was not significant for girls (data not shown). Interactions between variables and the performance of further sensitivity analysis were outside of the scope of this study, but should be studied further in the future to better understand who actively participated in the intervention and adjust the intervention accordingly.

Comparing the type of challenges performed, we found that in general, the children performed more PA challenges than nutrition challenges. Potentially, children regarded the PA challenges as more fun or as easier to perform. Children performed more or less the same percentage of PA child-only challenges and PA parental involvement challenges. By contrast, the nutrition challenges that were performed more often were the parental involvement challenges. Especially younger children performed more nutrition parental involvement challenges. To perform nutrition challenges (e.g., 'Cook a healthy soup'), help from the parents was required: parents had to buy the ingredients or they needed to help with the preparation of the ingredients, e.g., the cutting of ingredients, which might be particularly true for the younger children in our study [234]. For the same reasons (e.g., parents buying groceries, and thus being in control of the food availability at home), nutrition behavior of the child might be more dependent on and influenced by the parents than PA behavior.

As a lower level of PA [231, 259] and unhealthy nutrition [231] could lead to a negative energy balance, and consequently to overweight and/or obesity, an association between BMI z-score and performance of PA and healthy nutrition challenges was expected. However, BMI z-score did not affect the number of challenges performed, suggesting that Challenge Me would be suited for children of all weight statuses.

Based on the results, it is recommended to take the above-mentioned child and family characteristics associated with certain types of challenges performed, i.e., child age, ethnicity, SES and family size, into account. For example, besides gender-neutral

challenges, age-appropriate and culture-specific parent-child challenges might improve uptake of the intervention in the target group, including the vulnerable population. The intervention had potential to engage many children and parents, however, to achieve behavior change, we hypothesize that a longer implementation period is needed. Intervention effects could be enhanced by promoting PA and healthy nutrition via various channels, and integrating the promotion of healthy behavior into the standard school curriculum or daily routine [49]. Research is needed to study the effects of this type of indirect parental involvement interventions on children's EBRBs, on children's cognitive factors, like awareness and attitude, and on the home environment (e.g., parent-child play, healthier home climate).

Strengths and limitations

To our knowledge, this is one of the few studies specifically aimed at investigating the engagement of children and parents in a school-based indirect parental involvement intervention. The reach of the intervention was extensive, and response rates among the participants high, with all children and over 80% of parents returning their questionnaire. Besides exploring the engagement in the intervention, we also aimed to specifically report on the characteristics of the children and parents participating in the challenges, as this information is currently underreported yet much needed to further understand and develop parental involvement interventions. Even though our study specifically reports on the characteristics of the study participants, we did not collect enough data to compare these characteristics to the characteristics of the school population and draw conclusions on the sample representativeness. To improve the match between the intervention and the characteristics, interests and needs of the children and their families, we suggest involving the target audience when developing the challenges [260]. This was not done when developing Challenge Me, resulting in some challenges being performed poorly. For example, 'Make a vlog about healthy/unhealthy food in your surroundings' was expected to be in line with children's interest, but turned out to be an unpopular challenge.

Also, our study did not provide insights in the order in which the challenges were performed. All participating classes were free to determine the order in which they wanted to perform the challenges. However, the order in which challenges were introduced by the locally well-known person could have influenced children's interest during the intervention, and subsequently their performance of the challenges. If children had already lost interest in the beginning, it is possible that later planned challenges could therefore have not been performed, regardless of their content and suitability to the target group. Challenge Me posters solely provided information on whether a challenge was performed or not, based on the evidence provided by a child to their teacher. However, it is unknown how strict teachers were in ticking off these challenges, and whether this varied between teachers. Also, it is hypothesized that teachers had a strong influence on the implementation of the intervention, and consequently on how enthusiastically children reacted to and engaged in the program. For future research, it is recommended to gain more contextual insights in the implementation of the intervention, i.e., what was the influence of characteristics of teachers, whether children

motivated each other to perform challenges, and what the uptake was of an indirect-parental involvement intervention in the home setting. It is particularly interesting to establish whether one parent, both parents or even the whole family (e.g., siblings and/or other caregivers) participated, and how they valued the intervention. Subsequently, future research should be done on the long-term engagement of children and parents in such interventions.

Conclusions

This study was an important first step towards gaining insight in a strategy to enhance parental involvement in energy balance-related interventions. The use of parent-child challenges has potential in increasing parental involvement in school-based interventions. All children participated in the Challenge Me intervention and 93% of the children had involved a parent, yet certain child and family characteristics should be taken into account when further developing parent-child challenges (such as the development of age-appropriate and culture-specific challenges) to ensure that all children and parents, including families of vulnerable populations, participate in these types of parental involvement interventions.

Appendices Chapter 6

Additional file 6.1

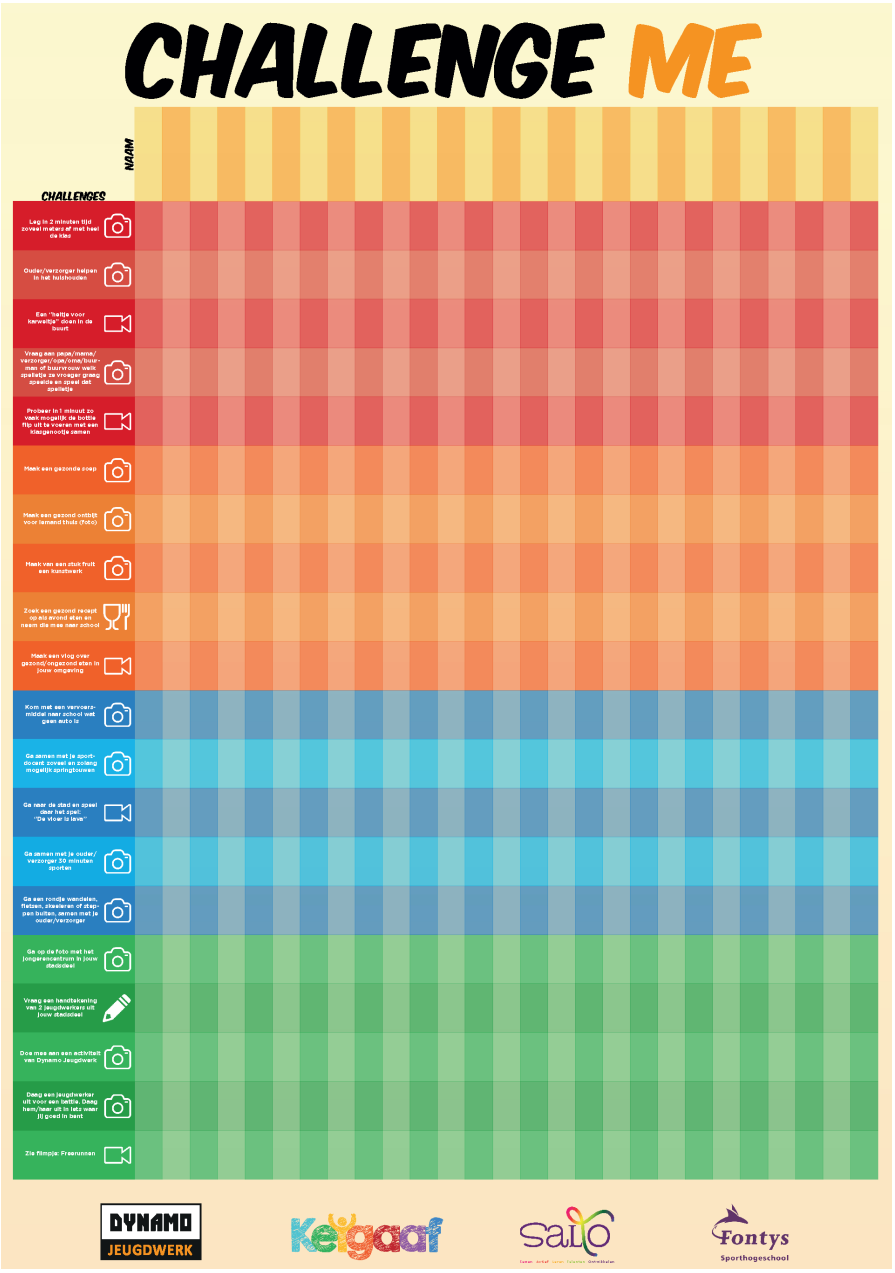


Figure 6.1. Challenge Me poster.

Additional file 6.2

Table 6.7. Number of children performing each challenge.

Category	Challenge	N	%
PA Child only	Run as far as possible with your entire class, in 2 minutes.	171	75.7
	Try to perform as many bottle flips as possible in 1 minute.	150	66.4
	Jump rope as long and often as you can, together with your PE teacher.	125	55.3
	Go to the town-/city centre and play a game of 'the floor is lava'.	99	43.8
	Participate in an activity of your local youth organisation.	37	16.4
	Challenge a local youth worker for a battle. Challenge him/her in something you are good at.	69	30.5
	Watch instruction video: Free Running	133	58.8
PA Parental Involvement	Help your parent/guardian with the housekeeping.	118	52.5
	Ask your dad/mom/guardian/grandpa/grandma/neighbor what game they liked to play when they were young, and play that game.	49	21.7
	Go exercise for 30 minutes together with your parent(s)/ guardian(s).	39	17.3
	Go walking, rollerblading, or stepping, together with your parent(s)/guardian(s)	61	27.0
	Do a 'bob for a job' in your neighborhood.	27	11.9
	Come to school using a means of transport other than a car.	176	77.9
Nutrition Child only	Find a healthy dinner recipe and bring this with you to school.	56	24.8
	Make a vlog about healthy/unhealthy food in your surroundings.	13	5.8
Nutrition Parental Involvement	Cook a healthy soup.	69	30.5
	Make a healthy breakfast for someone in your household.	54	23.9
	Make a work of art out of a piece of fruit.	78	34.5

Chapter 7

Effects of the KEIGAAF intervention on the BMI z-score and energy balance-related behaviors of primary school-aged children

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Verjans-Janssen SRB, Gerards SMPL, Kremers SPJ, Vos SB, Jansen MW, & Van Kann DHH. Effects of the KEIGAAF intervention on the BMI z-score and energy balance-related behaviors of primary school-aged children. International Journal of Behavioral Nutrition and Physical Activity. 2020;17:105.

Abstract

The aim of the current study was to evaluate the one- and two-year effectiveness of the KEIGAAF intervention, a school-based mutual adaptation intervention, on the BMI z-score (primary outcome), and energy balance-related behaviors (secondary outcomes) of children aged 7-10 years.

A quasi-experimental study was conducted including eight intervention schools and three control schools located in low socioeconomic neighborhoods in the Netherlands. Baseline measurements were conducted in March and April 2017 and repeated after one and 2 years. Data were collected on children's BMI z-score, sedentary behavior (SB), physical activity (PA) behavior, and nutrition behavior through the use of anthropometric measurements, accelerometers, and questionnaires, respectively. All data were supplemented with demographics, and weather conditions data was added to the PA data. Based on the comprehensiveness of implemented physical activities, intervention schools were divided into schools having a comprehensive PA approach and schools having a less comprehensive approach. Intervention effects on continuous outcomes were analyzed using multiple linear mixed models and on binary outcome measures using generalized estimating equations. Intervention and control schools were compared, as well as comprehensive PA schools, less comprehensive PA schools, and control schools. Effect sizes (Cohen's d) were calculated.

In total, 523 children participated. Children were on average 8.5 years old and 54% were girls. After 2 years, intervention children's BMI z-score decreased (B = -0.05, 95% CI -0.11; 0.01) significantly compared to the control group (B = 0.20, 95% CI 0.09; 0.31). Additionally, the intervention prevented an age-related decline in moderate-to-vigorous PA (MVPA) (%MVPA: B = 0.95, 95% CI 0.13; 1.76). Negative intervention effects were seen on sugar-sweetened beverages and water consumption at school, due to larger favorable changes in the control group compared to the intervention group. After 2 years, the comprehensive PA schools showed more favorable effects on BMI z-score, SB, and MVPA compared to the other two conditions.

This study shows that the KEIGAAF intervention is effective in improving children's MVPA during school days and BMI z-score, especially in vulnerable children. Additionally, we advocate the implementation of a comprehensive approach to promote a healthy weight status, to stimulate children's PA levels, and to prevent children from spending excessive time on sedentary behaviors.

Introduction

Childhood overweight and obesity are related to an increased risk of premature mortality and cardiometabolic morbidity in adulthood [4]. In recent decades, childhood overweight and obesity prevalence has increased globally, but the trend has plateaued since around 2000 in many high-income countries [1, 2]. However, prevalence is still high and intervention is warranted. In the Netherlands, about 13.1% of children (aged 4-12 years) were overweight, of whom 3.3% were obese in 2017 [261]. Overweight is the result of an imbalance in physical activity and dietary intake. Only half (55.5%) of Dutch children (aged 4-12 years) meet the physical activity (PA) recommendations of 60 minutes of moderate-to-vigorous PA per day and muscle-strengthening activities three times per week [261]. Dietary behaviors of Dutch children are similarly suboptimal. Only two in five Dutch children (aged 4-12 years) consumed sufficient amount of fruit and vegetables [261]. Dutch children frequently consume foods and beverages that are high in calories (due to high levels of sugar and fat) and low in nutritional value, e.g., about 17% of the daily energy intake is from energy-dense snacks and drinks [165, 188, 262]. Of the beverages consumed by children aged 4 to 8 years, 45% contain sugar [188]. These unhealthy PA and dietary behaviors are particularly prominent in children of low socioeconomic position families [6, 7, 190].

Given that school-aged children spend a significant amount of their time at school, the school is a popular intervention setting. Schools can improve PA levels of children by offering opportunities for children to engage in PA throughout the school day (e.g., during recess, through physical education) [15]. Although Dutch primary schools do not provide lunches, have no vending machines or school canteens [15], schools can still improve children's nutrition behavior. They can do this by implementing food policies concerning the home-packed lunches and drinks (mostly consisting of sandwiches, water, milk or a sugar-sweetened beverage, and sometimes candy or biscuits) and providing healthy foods (e.g., a policy promoting water or providing fruit) [15, 118, 263]. Evidence concerning the effectiveness of school-based PA and nutrition interventions on children's energy balance-related behaviors and Body Mass Index is inconclusive [24-30, 33, 34, 92, 200]. Explanations for the mixed results could be that each school context is unique with different needs, resources and perspectives on PA and healthy nutrition promotion [120]. To be feasible, acceptable and to reduce the risk of problems during implementation, interventions should fit this unique context [264] and local adaptation should be allowed during intervention implementation [204]. Additionally, to maximize effects of school-based interventions, they should be comprehensive. A comprehensive school health-promoting approach is an approach that promotes PA and healthy nutrition behavior by educating schoolchildren, providing a stimulating physical and social environment, and by engaging the parents and the wider community [14, 37]. Comprehensive school health promotion interventions have the potential to reduce children's BMI, increase PA, improve fruit and vegetable consumption and water intake [32, 92], and reduce the intake of unhealthy foods and drinks [92].

We implemented a school-based PA and nutrition intervention with a high level of flexibility in the design to enhance contextual fit [179]. Ideally, the intervention resulted in a comprehensive PA and nutrition-promoting approach [179]. The KEIGAAF (a Dutch acronym for 'Chances in Eindhoven for a family-based approach by Fontys') intervention

was implemented in primary schools located in low socioeconomic neighborhoods in the Netherlands. In this study, the main objective was to evaluate the effects of the intervention on the Body Mass Index (BMI) z-score (primary outcome measure), sedentary behavior (SB), PA behavior, and nutrition behavior (secondary outcomes) of children aged 7-10 years after one and 2 years. Secondly, we investigated whether schools with a comprehensive PA and nutrition-promoting approach showed better results on the primary and secondary outcomes. We hypothesized that the intervention shows desirable effects on BMI z-score, SB, PA, and nutrition behavior (i.e., breakfast, fruit and vegetables, snack, sugar-sweetened beverages, and water consumption) after 2 years, and that applying a comprehensive PA and nutrition-promoting approach would result in more beneficial outcomes, compared to a less comprehensive approach.

Methods

Study design

A quasi-experimental study was conducted to evaluate the effects of the KEIGAAF intervention on children's BMI z-score and energy balance-related behaviors. Eleven primary schools – eight intervention schools and three control schools – located in low socioeconomic neighborhoods in the south of the Netherlands participated in the study. The control schools were located in a different municipality, which resembled the intervention region based on level of urbanization and socioeconomic status of the schools' neighborhoods. The study design, recruitment of study participants, and data collection tools used have been described in detail in the protocol paper of Verjans-Janssen et al. [179]. The medical ethics committee of Maastricht University Medical Centre provided ethical approval for the study (METC163027, national number: NL58554.068.16) and the study is registered in the Netherlands Trial Register (NTR6716).

The KEIGAAF intervention

The KEIGAAF intervention was implemented between April 2016 and June 2019. The general aim of the intervention was to promote PA behavior and healthy nutrition behavior among the children. To do this, a mutual adaptation approach was used in which top-down principles and influences interacted with bottom-up development and implementation of PA and healthy nutrition-promoting activities. A steering committee of health behavioral experts and representatives of local organizations (a school board, a sports support organization, a social work organization, the municipal health service organization, and a youth work organization) provided basic intervention principles (top-down) to local working groups who developed local activity plans and implemented these activities (bottom-up). In short, these intervention principles were: (1) each school formed an interdisciplinary working group, consisting of school staff, local (health) professionals, parents, and a health promotion advisor (the composition differed per school); (2) the working groups developed and implemented the intervention

according to the needs of the children and the possibilities within the community; (3) the intervention was aimed at improving PA and nutrition behavior; and (4) the working groups decided which behavior to target first, to what extent, and what order. The eight working groups were supported by the same health promotion advisor during the entire intervention period, except for one. In total, there were four health promotion advisors. In this mutual adaptation approach, the local context and ownership was honored while basic intervention principles and broader system influences were acknowledged [119, 179, 265]. This process of mutual adaptation differed per school [265]. More details on the design of this approach can be found elsewhere [179, 265].

The health promotion advisors, and health behavioral experts from research institutes, advised the schools in implementing a comprehensive approach of PA and healthy nutrition-promoting activities. A comprehensive approach is an approach in which practice and policies are aligned and when PA and healthy nutrition behavior are promoted by educating children, providing a supportive social and physical environment and stimulating healthy energy balance-related behaviors before and after school time (i.e., by involving parents and the wider community) [14, 37, 266]. Implementation of the intervention in the schools was a dynamic process consisting of many feedback loops: the process was improved continuously based on evaluations, advice of the health promotion advisor and the feedback of research data. This dynamic process resulted in different intervention activities per school. Examples of implemented activities were the use of new PA equipment during school recess, provision of water bottles to children, implementation of monthly after-school sports activities, and applying a policy concerning healthy birthday treats at school. Intervention activities were new or strengthened existing activities. A list of implemented PA and healthy nutrition-promoting activities of the schools can be found in Additional file 7.1 (Table. 7.5). Implementation of the KEIGAAF intervention has been described in detail elsewhere [265].

Study participants

At baseline, all primary school children in grades four to six (aged 7 to 10 years) were eligible for inclusion. No additional inclusion or exclusion criteria were defined. The primary researcher informed the children orally about the study and provided an information letter to their parents. Parents could ask the primary researcher questions during planned school meetings. For a child to participate, two parents had to provide written consent. Children and parents participated in the baseline measurements (T0) conducted in March and April 2017, and the follow-up measurements after one (T1) and 2 years (T2), i.e., March/April 2018 and 2019. Collecting data in the same period reduced the risk of seasonal variation in BMI and PA behavior [267, 268].

Measurements

The same data were collected for the intervention group and the control group. Data were collected on the children's BMI z-score as primary outcome measure and SB, PA

behavior and nutrition behavior as secondary outcome measures.

BMI z-score

To measure children's BMI z-score, trained research assistants assessed children's weight and height using a measurement protocol. Children were weighed and measured during a physical education lesson. Children wore light sports clothes and shoes were taken off before measurements were made. A stadiometer (Seca 213, Hamburg, Germany) was used to measure standing height with an accuracy of 1 millimeter, and a digital weighing scale (Seca 803, Hamburg, Germany) was used to measure the child's weight to the nearest 0.1 kilograms. Weight and height were used to calculate BMI. BMI was recoded into BMI z-score standardized for age and gender, based on a Dutch reference population [139]. International cut-off points were used to define if children were underweight (BMI z ≤ -1.65), had a normal weight (-1.65 < BMI z < 1.04) or were overweight (1.04 < BMI z < 1.64) or obese (BMI z ≥ 1.65) [230].

Parents also filled in their child's height in centimeters (no decimals) and weight in kilograms (no decimals) in the parent questionnaire. These data were used to impute missing baseline data on a child's BMI z-score. This imputed BMI z-score was used as covariate in the analyses on the effectiveness on PA behavior and dietary behavior, but not as outcome measure. Data were imputed for seven children (five intervention and two control).

Sedentary and physical activity behavior

The ActiGraph GT3X+ accelerometer (ActiGraph, Pensacola, FL, USA) was used to measure children's SB and PA behavior. Children wore the accelerometer strapped around their waist for seven consecutive days during waking hours. The accelerometer was removed when performing activities involving water (e.g., swimming and showering). Accelerations were recorded at a sampling frequency of 30 Hz using 10s time intervals. ActiLife version 6.13.3 was used to filter accelerometer data. Wear time was validated using Choi's classification criteria [269]. Additionally, a valid wear day was defined as providing at least 480 minutes of valid wear time per day between 06.00 AM and 11.00 PM. For this study, only data recorded on schooldays were included. The first wear day was excluded to reduce bias due to reactivity to the accelerometer measurement [270]. Additionally, non-regular school days (such as festive days where the children attended school only half a day) were excluded to ensure that the data reflected PA behavior on a regular school day. Children were included in the analysis when they had at least two school days with valid accelerometer data at the time of measurement. To classify the accelerometer data into SB, light PA (LPA) and moderate-to-vigorous PA (MVPA), Evenson's cut-off points were used (SB: ≤ 100 counts per minute (CPM), LPA: 101 < CPM < 2295 and MVPA: ≥ 2296 CPM) [271]. The data were aggregated into average SB, LPA, and MVPA per child. Additionally, the vector magnitude CPM (the sum of counts over the three axes) was used as outcome measure. The data on SB and PA were supplemented with data on weather conditions during the measurement periods to adjust for potential weather influences on PA behavior in the analyses [272]. For this, data on the average temperature, and total hours of sunshine and precipitation

between 06.00 AM and 11.00 PM of the Royal Dutch Meteorological Institute were used. These data were also aggregated into daily averages within this time period.

Nutrition behavior

Children's nutrition behavior at school was assessed using a child questionnaire, while children's daily nutrition behavior was assessed using a parent questionnaire. Children filled in a paper questionnaire individually at school during school hours. Children filled in whether they had consumed breakfast in the morning (on the current school day), and whether they had consumed fruit, vegetables, candy, cookies, savory snacks, sugar-containing beverages, energy drinks, sports drinks, or water during the previous school day. The answer options were yes/no and the questions were based on the Local and National Youth Monitor of the Netherlands, but were made understandable for children (i.e., by using simple language and adding images) [273]. The items fruit consumption and vegetable consumption were combined into the variable 'fruit or vegetables', which was given a score of 'yes' when fruit and/or vegetables were consumed on a regular school day and 'no' when none of these items was consumed. The same was done for the variable 'sugar-containing beverages' (consisting of the items daily consumption of sugar-containing beverages, energy drinks, and sports drinks) and the variable 'candy, cookies or savory snacks'.

One parent was asked to fill in a paper questionnaire at home. The parent reported on the child's average nutrition behavior during a normal week in the previous month. For this, items from a validated food frequency questionnaire were used [180]. For this study, data on the consumption of fruit, vegetables (raw and cooked), candy (e.g., sweet, licorice, candy bars), savory snacks (e.g., cheese, crisps), sugar-sweetened beverages, fruit juice, sweet milk drinks, and water were included. The food frequency was measured using answer options ranging from zero to seven days (i.e., the number of days per week). The daily amounts of fruit and vegetables were measured in natural units: pieces and serving spoons, respectively. One serving spoon of vegetables was considered 50 grams. The average daily consumption of fruit and vegetables was calculated. For this, the frequency and amount were multiplied and divided by seven. The nutrition data were not normally distributed, therefore the data were recoded into binary outcome measures based on the frequencies and amounts of fruit and vegetables consumed and the frequencies of the consumption of snacks (including candy and savory snacks), sugar-sweetened beverages (including sugar-sweetened beverages, fruit juice, and sweet milk) and water (including tea without sugar). Fruit and vegetables were recoded into adherence to the recommendations for fruit and vegetables, respectively (yes/no). Snacks, sugar-sweetened beverages, and water were recoded into daily consumption (no: ≤ six days per week, yes: seven days per week). To assess the adherence to the recommendations for fruit and vegetables, the national recommendations of the Dutch Nutrition Centre were used: 1.5 pieces of fruit per day for children ≤ 8 years and two pieces for children ≥ 9 years, and 100-150 grams vegetables per day for children ≤ 8 years and 150-200 grams for children ≥ 9 years [274]. There are no national recommendations for snacks, sugar-sweetened beverages, and water, other than to 'limit the consumption of snacks and sugar-sweetened beverages and consume 1-1.5 liters of liquids per day (ideally water, but milk is also allowed)' [274].

Socio-demographic characteristics

Socio-demographic characteristics of the child and the parent were assessed using the questionnaires. Children reported their date of birth (to calculate their age), their gender, the country of birth of both parents (to determine ethnicity), and the zip code of their home address. Based on the definition of Statistics Netherlands of ethnicity, the child's ethnicity was considered non-Western when at least one parent was born in a non-Western country (a country in Africa, Latin America, Asia (excluding Indonesia and Japan), or Turkey) [181]. The zip code of the home address was used to define the socioeconomic status (SES)-score of the child's residential neighborhood from the Netherlands Institute for Social Research. This score is based on the educational level, income, and employment status of the residents. A high score indicates a high SES in that neighborhood [244].

The parent reported their year of birth (to calculate age), educational level, family situation (living together, single, other), height and weight (to calculate BMI) and zip code of the home address for this study. Missing child data on the home zip code were supplemented by using the data on zip code provided by the parent. Educational level was recoded into three categories based on the International Standard Classification of Education 2011 [182]: no or primary educational level (no education or primary school), secondary educational level (pre-vocational school, secondary education, or lower vocational education), and tertiary educational level (higher vocational education or university degree). Parents' reported height (in centimeters, no decimals) and weight (in kilograms, no decimals) were used to calculate their BMI and define their weight status (i.e., BMI <20: underweight, BMI 20–25: normal weight, BMI 25–30: overweight, and BMI >30: obese).

Comprehensiveness of PA and nutrition-promoting approach

Data on the intervention school's PA promotion and healthy nutrition-promoting activities implemented in the intervention period were obtained by conducting timeline sessions and using an online school scan [179, 265]. A list of PA and healthy nutrition-promoting activities of the schools at the end of the intervention period can be found in Additional file 7.1 (Table 7.5 and 7.6). The activities were divided into the main categories of a comprehensive health-promoting approach: (1) PA/healthy nutrition education; (2) PA/healthy nutrition during school; (3) PA/healthy nutrition before and after school; (4) PA/healthy nutrition policy; (5) staff involvement in PA/healthy nutrition promotion; and (6) parental engagement in PA/healthy nutrition-promoting activities (Figure 7.1) [14]. Schools were considered comprehensive (yes/no) when activities were implemented in all categories, there was coherence between practice and policies, and when the message was spread consistently via different channels (i.e., by the teachers, other school staff, the children, and their parents) in and outside the school environment [266]. Besides the use of timeline sessions (an evaluation method to assess implementation) and an online school scan, minutes of the working group meetings and participatory observations were used to decide on the level of comprehensiveness concerning PA and nutrition promotion [179, 265]. None of the intervention schools were comprehensive concerning nutrition promotion.

For example, only three schools implemented healthy nutrition-promoting activities before and after school and these activities had a low reach. Additionally, there was low variation between the intervention schools regarding the nutrition-promoting activities implemented during the intervention period (Additional file 7.1). Therefore, it was not possible to divide the intervention schools into groups based on their level of comprehensiveness concerning nutrition promotion.

Comprehensive PA approach

1) Physical education
2) PA during school (i.e., during recess and educational hours)
3) PA before and after school (i.e., active transport and after-school PA/sports)
4) PA policy
5) Staff involvement in PA promotion (e.g., stimulating PA during educational hours)
6) Parental engagement in PA-promoting activities (e.g., helping during school sports days, stimulating active transportation)

Comprehensive nutrition approach

1) Nutrition education
2) Healthy nutrition during school (e.g., provision of healthy nutrition at school)
3) Healthy nutrition before and after school (e.g., after-school cooking lessons)
4) Healthy nutrition policy
5) Staff involvement in healthy nutrition promotion (e.g., stimulating water intake during educational hours)
6) Parental engagement in healthy nutrition-promoting activities (i.e., providing healthy nutrition to be consumed at school and collaborating with school in developing and implementing healthy nutrition policies)

Figure 7.1. Components of a comprehensive PA and healthy nutrition approach (based on [14]).

Statistical analysis

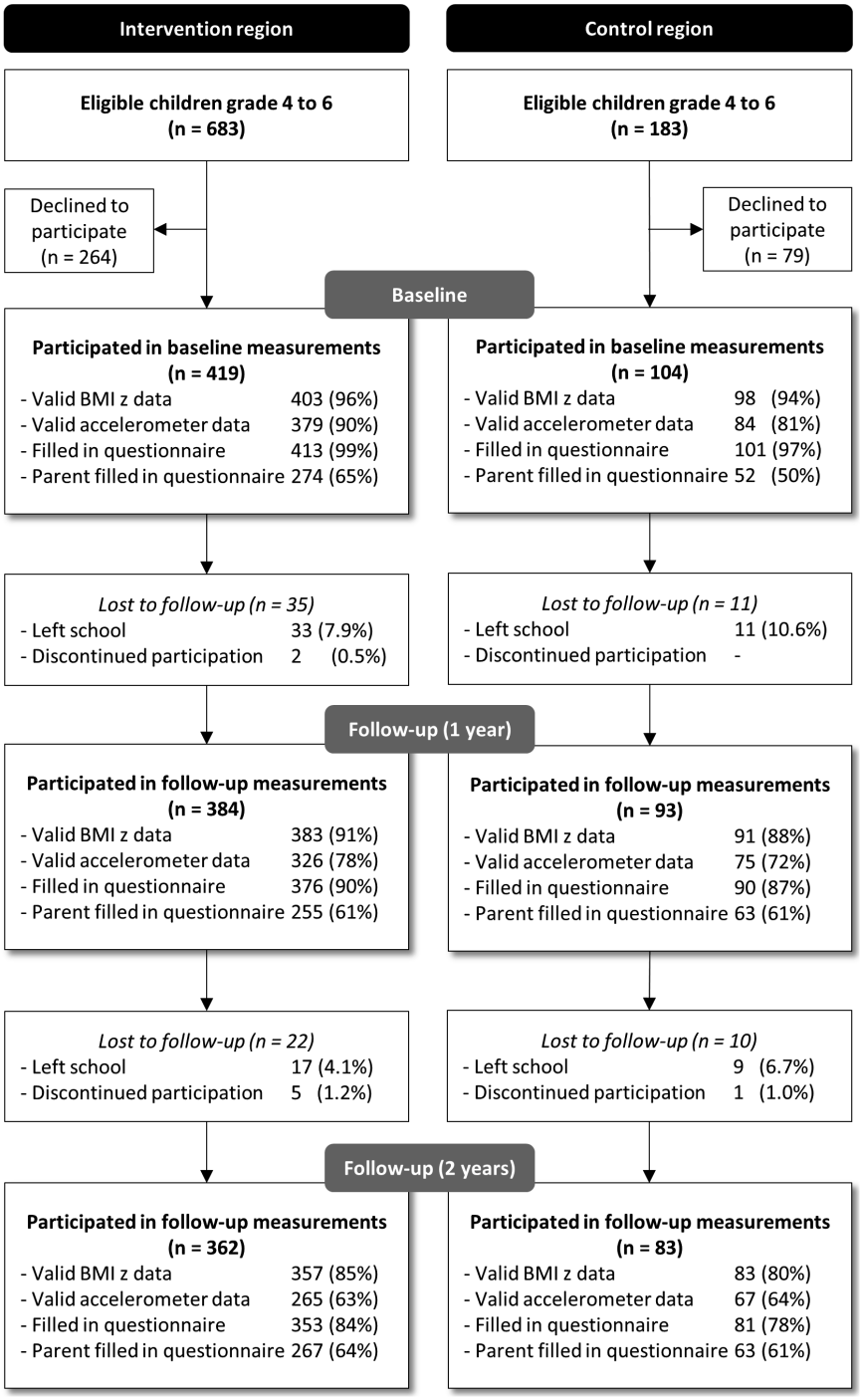
Descriptive statistics were performed to compare the baseline characteristics of the children and parents in the intervention and control group. T-tests and Chi-square tests were conducted to compare the groups on continuous and categorical baseline demographic characteristics respectively, and the primary and secondary outcome measures. When the assumption of normality or the assumption of equal variances between groups was not met, the Welch's test and the Mann Whitney U test were used, respectively. We analyzed the intervention effects on continuous outcomes using multiple linear mixed models and on binary outcome measures using generalized estimating equations (GEE), and accounted for the repeated measures within individuals. Mixed models are able to handle missing data in a longitudinal dataset without needing to perform multiple imputations [275]. Based on the results of the Likelihood Ratio Test, a random intercept for school was added to the model. This was only necessary for the PA classifications, i.e., SB, LPA and MVPA. For each outcome variable, two models were

created: (1) effects over time for each group were analyzed by including a time variable (baseline, 1 year, and 2 years) as fixed factor in the model; (2) the differences over time between the groups were analyzed by adding the group variable (intervention/control) and the interaction between the group variable and time as fixed factors of Model 1. BMI z-score was adjusted for child ethnicity (Western/non-Western) and residential socioeconomic status (SES). BMI z-score is the preferred measure because it allows for comparison between children of different ages and between boys and girls. However, it is advised to also analyze effects on BMI to enhance comparison of intervention studies [32]. Therefore, we performed the same analyses with BMI as outcome measure. Analyses were adjusted for child age, gender, ethnicity (Western/non-Western), and residential SES. PA and nutrition outcomes were adjusted for child ethnicity (Western/non-Western), residential SES, child age, gender (boy/girl) and BMI z-score at baseline [165, 276, 277]. Additionally, the PA outcomes were adjusted for weather conditions (temperature, sunshine, and precipitation) [272]. For the GEE analyses, the logit link function and an exchangeable correlation matrix was applied. To analyze intervention effects for the comprehensive PA schools and the less comprehensive PA schools separately, we conducted the same analyses but now three groups were compared in separate analyses: (1) the comprehensive PA schools versus the control schools; (2) the less comprehensive PA schools versus the control schools; and (3) the comprehensive PA schools versus the less comprehensive PA schools. These groups were compared on all outcome measures. IBM SPSS Statistics for Windows, version 25.0 (IBM Corp, Armonk, NY, USA) was used for the statistical analyses. P values <.05 were considered statistically significant. A power calculation was conducted for the sample size at the beginning of the study [179]. For the given sample size, the smallest detectable difference in the primary outcomes measure (i.e., BMI z-score) after 2 years of intervention ranges between 0.38 and 0.44 when the power is 80%, indicating a moderate effect size [179]. To interpret the magnitude of the effects, effect sizes (Cohen's d) were calculated by dividing the estimated between-group difference by the pooled standard deviation of the outcomes [57]. Lipsey cut-off points were used to interpret the effect sizes as small (≤ 0.32), moderate (0.33-0.55), and large (≥ 0.56) effects [58].

Results

Study participants

Of the eligible children, 523 children (60%) participated in the study at baseline (Figure 7.2). Valid anthropometric data were obtained for 501 children (96%) at baseline, 474 children (91%) at the first follow-up measurement (after 1 year), and 440 children (84%) at the final follow-up measurement (after 2 years). At baseline, first follow-up, and final follow-up, 463, 401, and 332 children (89, 77, and 64%) provided valid accelerometer data, respectively. Of the participating parents, 326, 318 and 330 (62, 61 and 63%) filled in the parent questionnaire and 514, 466, and 434 children (98, 89, 83%) filled in the child questionnaire, at baseline, first follow-up, and final follow-up, respectively.



Note. Percentages are based on participants at baseline.

Figure 7.2. Flow of the participants.

There was a total loss of 78 children in the study (14% in the intervention group and 20% in the control group, non-significant). Of these, eight children (10.3%) discontinued participation and 70 children left school. Dropout analyses revealed that children who discontinued participation (N = 8) had a higher BMI z-score at baseline (M = 1.36, SD = 0.48) compared to the retained study participants (M = 1.06, SD = 0.05) (t(436) = -2.59, p =.01).

Demographics

At baseline, children were on average 8.5 years old and 54% were girls (Table 7.1). Most children had a normal weight (74%). Compared to the control region, relatively more non-Western children participated in the intervention region ($\chi 2$ (1, N = 520) = 11.38, p =.001). Additionally, the parents who had filled in the questionnaire at baseline were on average significantly older (t(400) = 3.73, p <.001) and higher educated in the intervention region compared to the control region ($\chi 2$ (2, N = 405) = 16.85, p <.001). There were no significant differences in other socio-demographic child and parent variables between children attending intervention and control schools.

Table 7.1. Characteristics of the study population

	Intervention group (N = 419)		**Control group (N = 104)**		**Total (N = 523)**	
	M (SD)	**N (%)†**	**M (SD)**	**N (%)†**	**M (SD)**	**N (%)†**
Child characteristics at baseline						
Age (years)	8.47 (1.05)		8.68 (1.07)		8.51 (1.06)	
Gender						
Boys		191 (45.6)		49 (47.1)		240 (45.9)
Girls		228 (54.4)		55 (52.9)		283 (54.1)
Ethnicity*						
Western		223 (53.5)		74 (71.8)		297 (57.1)
Non-Western		194 (46.5)		29 (28.2)		223 (42.9)
BMI z-score	0.23 (1.09)		0.22 (0.97)		0.23 (1.06)	
Weight status						
Underweight		13 (3.3)		3 (3.1)		16 (3.2)
Normal weight		293 (73.3)		76 (77.6)		369 (74.1)
Overweight		55 (13.8)		11 (11.2)		66 (13.3)
Obese		39 (9.8)		8 (8.2)		47 (9.4)

	Intervention group (N = 419)		Control group (N = 104)		Total (N = 523)	
	M (SD)	N (%)†	M (SD)	N (%)†	M (SD)	N (%)†
Parent characteristics at baseline						
Age (years)*	39.15 (5.58)		36.45 (5.91)		38.64 (5.74)	
Educational level*						
Low		80 (24.2)		34 (45.9)		114 (28.1)
Middle		124 (37.5)		26 (35.1)		150 (37.0)
High		127 (38.4)		14 (18.9)		141 (34.8)
Family situation						
Living together		272 (81.9)		55 (73.3)		327 (80.3)
Single		60 (18.1)		20 (26.7)		80 (19.7)
BMI (kg/m2)	25.03 (4.19)		26.01 (4.95)		25.19 (4.33)	
Weight status						
Normal weight		145 (57.8)		28 (56.0)		173 (57.5)
Overweight		106 (42.2)		22 (44.0)		128 (42.5)

Note. M = Mean, SD = Standard deviation, N = number of participants, BMI = Body Mass Index. *Significantly different at baseline compared with the control group. †Total N of categorical variables can vary due to missing data.

Intervention effects on BMI z-score

The intervention group and the control group did not differ significantly in BMI z-score at baseline (Table 7.1). After 1 year, the intervention group and control group both increased in BMI z-score (p =.05 and p <.001, respectively) (Figure 7.3). This increase was significantly smaller for the intervention group (B = -0.11, 95% CI -0.21; 0.00, p =.04, ES -0.09). After 2 years, the intervention group decreased in BMI z-score and the control group increased (p =.08 and p =.001, respectively). This difference was significantly different (B = -0.25, 95% CI -0.38; -0.12, p <.001) and the effect size was small (ES = -0.20). Comparable results were found when analyzing intervention effects on BMI (one year: B = -0.33, 95% CI -0.58; -0.08, p =.01, ES -0.10 and 2 years: B = -0.43, 95% CI -0.79; -0.07, p =.02, ES -0.13).



Note. BMI z-score is adjusted for child age and gender. Repeated measures linear mixed analyses were adjusted for child ethnicity (Western/non-Western) and residential socioeconomic statusscore. ES = Effect size (Cohen's d). *Significant difference (1 year: B = -0.11, 95% CI -0.21; 0.00, p = .04, 2 years: B = -0.25, 95% CI -0.38: - 0.12, p < .001). †Numbers shown are unstandardized beta-coefficient and 95% confidence interval of linear mixed model (B (95% CI).

Figure 7.3. Change in children's BMI z-score after one and two years.

Intervention effects on physical activity behavior

At baseline, the control group performed on average relatively more MVPA (8.6%, 66.2 ±29.0 minutes) compared to the intervention group (7.8%, 60.6±22.5 minutes) (p =.06). Both the intervention and the control group showed a significant increase in SB during school days and a significant decrease in LPA during school days after one and 2 years (Table 7.2). Favorable intervention effects were found on MVPA during school days after 2 years. Although the intervention group showed a significant decrease in MVPA (observed mean difference: -7.0±20.7 minutes), the control group showed a significantly larger decrease (observed mean difference: -14.4±28.7 minutes) (p =.02). The effect size was small (ES = 0.22).

Table 7.2. Change in sedentary and physical activity behavior during school days of intervention and control groups after one and 2 years (Model 1) and one- and two-year intervention effects (Model 2).

		Model 1								Model 2		
		Intervention group (N = 419)				Control group (N = 104)				Intervention group vs. control group		
		N	Mean (SD)[a]	B (95% CI)[b]	p	N	Mean (SD)[a]	B (95% CI)[b]	p	B (95% CI)[b]	p	ES
%SB	T0	379	61.34 (6.58)			84	60.03 (7.11)					
	T1	326	64.46 (6.39)	**2.23 (1.58; 2.89)**	**0.00**	75	62.66 (6.95)	**2.24 (0.49; 3.99)**	**0.01**	-0.14 (-1.64; 1.36)	0.85	-0.01
	T2	265	66.65 (6.40)	**4.89 (4.16; 5.62)**	**0.00**	67	66.39 (6.83)	**4.45 (2.47; 6.43)**	**0.00**	-0.41 (-2.15; 1.33)	0.64	-0.04
%LPA	T0	379	30.88 (5.07)			84	31.34 (5.36)					
	T1	326	28.40 (4.92)	**-1.82 (-2.34; -1.31)**	**0.00**	75	29.11 (5.13)	**-2.09 (-3.46; -0.73)**	**0.00**	0.18 (-1.00; 1.36)	0.76	0.02
	T2	265	26.53 (4.77)	**-4.19 (-4.76; -3.63)**	**0.00**	67	27.01 (5.27)	**-2.72 (-4.19; -1.26)**	**0.00**	-0.57 (-1.91; 0.77)	0.40	-0.07
%MVPA	T0	379	7.78 (2.89)			84	8.63 (3.78)					
	T1	326	7.14 (2.59)	**-0.36 (-0.67; -0.06)**	**0.02**	75	8.23 (3.18)	-0.01 (-0.74; 0.73)	0.98	-0.06 (-0.76; 0.64)	0.86	-0.01
	T2	265	6.82 (2.82)	**-0.69 (-1.02; -0.36)**	**0.00**	67	6.60 (2.34)	**-1.51 (-2.58; -0.44)**	**0.01**	**0.95 (0.13; 1.76)**	**0.02**	**0.22**
CPM	T0	379	1153.89 (288.75)*			84	1270.87 (489.96)					
	T1	326	1040.72 (259.40)	**-80.65 (-109.43; -51.88)**	**0.00**	75	1131.00 (323.44)	-97.79 (-207.32; 11.45)	0.08	35.87 (-40.17; 111.90)	0.35	0.07
	T2	265	972.08 (283.38)	**-161.14 (-193.73; -128.55)**	**0.00**	67	926.21 (227.56)	**-278.18 (-410.66; -145.69)**	**0.00**	**130.52 (43.21; 217.83)**	**0.00**	**0.26**

Note. Model 1: predictor variable is time / Model 2: predictor variable is time*condition (reference group = control group). Analyses were conducted using mixed model analysis with adjustment for clustering of data within persons and adjustment for clustering of data at school level. SB = Sedentary behavior, LPA = Light physical activity behavior, MVPA = moderate-to-vigorous physical activity behavior, CMP = counts per minute, N = number of participants, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year 2, SD = standard deviation, CI = Confidence Interval, B = unstandardized beta coefficient, p = p value. Bold numbers are significant at p <.05. * Significantly different at baseline compared with the control group, analyzed using the Welch's test. [a]Mean is the observed SB, LPA, MVPA and CPM of participants with data. [b] Unstandardized beta coefficient of linear mixed model adjusted for child age, gender, ethnicity, and BMI z-score at baseline, residential socioeconomic status score at baseline and weather conditions (i.e., sunshine, temperature, and precipitation).

Intervention effects on nutrition behavior at school

Child-reported data showed that children in intervention schools consumed significantly more fruit and vegetables at school than children in control schools at baseline (89.3% versus 75.2%, $\chi 2$ (1, N = 513) = 13.80, p <.001) (Table 7.3). No statistically significant intervention effects were found on the percentage of children consuming breakfast before school, the percentage of children consuming fruit or vegetables at school and the percentage of children consuming candy, cookies, or snacks at school after one and 2 years. After one and 2 years, statistically significant negative intervention effects were found on the percentage of children consuming sugar-sweetened beverages at school (OR = 4.86 and OR = 5.68, respectively) and water at school (OR = 0.08 and OR = 0.39, respectively). This was due to a smaller decrease and smaller increase in the percentage of children in the intervention group consuming sugar-sweetened beverages and water, respectively, compared to the control group.

Intervention effects on daily nutrition behavior

No statistically significant intervention effects were found on the parent-reported percentage of children adhering to the fruit recommendation, the percentage of children adhering to the vegetable recommendation, the percentage of children consuming snacks daily, and the percentage of children consuming water daily after 1 year. Statistically significant favorable intervention effects were found the percentage of children consuming sugar-sweetened beverages daily after 1 year (OR = 0.45), due to a statistically significant decrease in the percentage of children consuming sugar-sweetened beverages after 1 year in the intervention group (OR = 0.67) and a non-significant increase in the control group (OR = 1.54) (Table 7.4). No statistically significant intervention effects were found after 2 years on daily nutrition behavior.

Table 7.3. Child-reported change in the percentage of children consuming breakfast before or specific foods and drinks at school for the intervention and control groups after one and 2 years (Model 1) and one- and two-year intervention effects (Model 2).

		Model 1								Model 2	
		Intervention group (N = 419)				Control group (N = 104)				Intervention group vs control group	
		N	Obs %[a]	OR (95% CI)[b]	p	N	Obs %[a]	OR (95% CI)[b]	p	OR (95% CI)[b]	p
Breakfast (%yes)	T0	413	93.0			101	87.1				
	T1	376	90.2	0.70 (0.42; 1.14)	0.15	90	76.7	**0.46 (0.24; 0.91)**	**0.03**	1.52 (0.63; 3.69)	0.35
	T2	353	89.0	0.62 (0.38; 1.02)	0.06	81	75.3	**0.38 (0.19; 0.75)**	**0.01**	1.68 (0.69; 4.08)	0.26
Fruit or vegetables	T0	412	89.3*			101	75.2				
(%yes)	T1	375	89.9	1.43 (0.94; 2.18)	0.09	90	75.6	0.95 (0.50; 1.80)	0.86	1.45 (0.70; 3.12)	0.31
	T2	352	90.9	**1.60 (1.03; 2.49)**	**0.04**	81	74.1	0.92 (0.48; 1.79)	0.81	1.70 (0.78; 3.70)	0.18
Candy, cookies or	T0	412	43.2			101	42.6				
snacks (%yes)	T1	376	42.0	0.96 (0.74; 1.25)	0.76	90	35.6	0.76 (0.43; 1.32)	0.33	1.30 (0.71; 2.37)	0.40
	T2	353	37.1	0.77 (0.59; 1.01)	0.06	81	38.3	0.87 (0.49; 1.54)	0.64	0.89 (0.48; 1.66)	0.72
Sugar-sweetened	T0	412	54.1			101	47.5				
beverages (%yes)	T1	376	50.0	0.87 (0.68; 1.11)	0.24	90	13.3	**0.17 (0.09; 0.33)**	**0.00**	**4.86 (2.44; 9.68)**	**0.00**
	T2	352	38.1	**0.52 (0.40; 0.67)**	**0.00**	81	7.4	**0.09 (0.04; 0.20)**	**0.00**	**5.68 (2.37; 13.59)**	**0.00**
Water (%yes)	T0	408	57.6			101	59.4				
	T1	376	63.0	1.18 (0.93; 1.51)	0.18	90	95.6	**15.56 (5.75; 42.12)**	**0.00**	**0.08 (0.03; 0.22)**	**0.00**
	T2	352	71.6	**1.85 (1.43; 2.41)**	**0.00**	81	86.4	**5.17 (2.52; 10.58)**	**0.00**	**0.39 (0.19; 0.79)**	**0.01**

Note. Model 1: predictor variable is time (reference group = baseline measurement) / Model 2: predictor variable is time*condition (reference group = control group*baseline measurement). Analyses were conducted using GEE analysis with adjustment for clustering of data within persons. N = number of participants, I = intervention group, C = control group, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, Obs % = observed percentage, OR = Odds Ratio, CI = Confidence Interval, p = p value. Bold numbers are significant at p <.05. * Significantly different at baseline compared with the control group, analyzed using the Chi-square test. [a]Observed percentage of children that consumed breakfast on the morning of data collection and that consumed the food/drink the previous day at school. [b]Odds ratio of GEE model adjusted for child age, gender, ethnicity, BMI z-score at baseline, and residential socioeconomic status score at baseline.

Table 7.4. Parent-reported change in the percentage of children adhering to or daily consuming specific foods and drinks for the intervention and control groups after one and 2 years (Model 1) and one- and two-year intervention effects (Model 2).

		Model 1								Model 2	
		Intervention group (N = 419)				Control group (N = 104)				Intervention group vs control group	
		N	Obs %[a]	OR (95% CI)[b]	p	N	Obs %[a]	OR (95% CI)[b]	p	OR (95% CI)[b]	p
Adherence fruit	T0	263	38.4			48	27.1				
recommendation	T1	242	42.6	1.08 (0.79; 1.48)	0.63	57	22.8	0.81 (0.32; 2.05)	0.66	1.34 (0.56; 3.18)	0.51
(%yes)	T2	252	35.3	0.80 (0.58; 1.10)	0.17	58	20.7	0.64 (0.25; 1.64)	0.35	1.22 (0.50; 2.96)	0.67
Adherence vegetable	T0	250	26.0			52	23.1				
recommendation	T1	233	22.7	0.76 (0.51; 1.14)	0.19	58	12.1	0.44 (0.15; 1.27)	0.13	1.81 (0.61; 5.37)	0.29
(%yes)	T2	239	17.3	**0.54 (0.35; 0.83)**	**0.01**	54	3.7	**0.12 (0.02; 0.56)**	**0.01**	4.49 (0.99; 20.29)	0.05
Daily consumption of	T0	274	46.7			52	50.0				
snacks (%yes)	T1	255	31.0	**0.56 (0.42; 0.74)**	**0.00**	61	44.3	0.90 (0.47; 1.74)	0.75	0.60 (0.31; 1.17)	0.13
	T2	264	34.5	**0.70 (0.53; 0.93)**	**0.01**	63	28.6	0.42 (0.21; 0.85)	0.02	1.59 (0.79; 3.17)	0.19
Daily consumption of	T0	270	55.9			51	52.9				
sugar-sweetened	T1	249	43.8	**0.67 (0.49; 0.89)**	**0.01**	62	59.7	1.54 (0.77; 3.10)	0.22	**0.45 (0.22; 0.92)**	**0.03**
beverages (%yes)	T2	265	37.4	**0.53 (0.39; 0.71)**	**0.00**	63	42.9	0.80 (0.40; 1.60)	0.53	0.68 (0.33; 1.40)	0.30
Daily consumption of	T0	273	67.4			52	61.5				
water (%yes)	T1	251	70.5	1.22 (0.90; 1.66)	0.20	62	72.6	**2.00 (1.04; 3.85)**	**0.04**	0.62 (0.30; 1.27)	0.19
	T2	267	71.2	1.28 (0.95; 1.74)	0.11	62	71.0	1.85 (0.96; 3.59)	0.07	0.72 (0.35; 1.47)	0.36

Note. Model 1: predictor variable is time (reference group = baseline measurement) / Model 2: predictor variable is time*condition (reference group = control group*baseline measurement). Analyses were conducted using GEE analysis with adjustment for clustering of data within persons. I = Intervention group, C = control group, N = number of participants, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, Obs % = observed percentage, OR = Odds Ratio, CI = Confidence Interval, p = p value. Bold numbers are significant at p <.05. [a]Observed percentage of children adhering to the recommendation (for fruit and vegetables) or daily consuming the food/drink (i.e., snacks, sugar-sweetened beverages, and water). [b]Odds ratio of GEE model adjusted for child age, gender, ethnicity, BMI z-score at baseline, and residential socioeconomic status score at baseline.

Differences between the comprehensive PA schools and the less comprehensive PA schools

The comprehensive PA schools (N = 4) differed significantly from the less comprehensive PA schools (N = 4) and the control schools in effects on BMI z-score and PA behavior (Figure 7.4). The comprehensive PA schools showed a reduction in BMI z-score after 2 years, while the less comprehensive PA schools resumed to baseline levels, and the control schools showed an increase. These differences were statistically significant and effect sizes were small (ES = -0.06 and ES = -0.21). Additionally, children exposed to a comprehensive PA-promoting approach showed a smaller increase in SB and had the same levels of MVPA during school days compared to their levels at baseline, while the children in the other conditions showed larger increases in SB and a decrease in MVPA during school days over time (Figure 7.4). These differences were statistically significant and the effect sizes were small-to-moderate (Additional file 7.2: Tables 7.7 and 7.8). The comprehensive PA schools also showed statistically significant favorable changes on LPA during school days when compared to the less comprehensive PA schools (B = 2.09, 95% CI 0.83; 3.36, p <.001, ES 0.19).

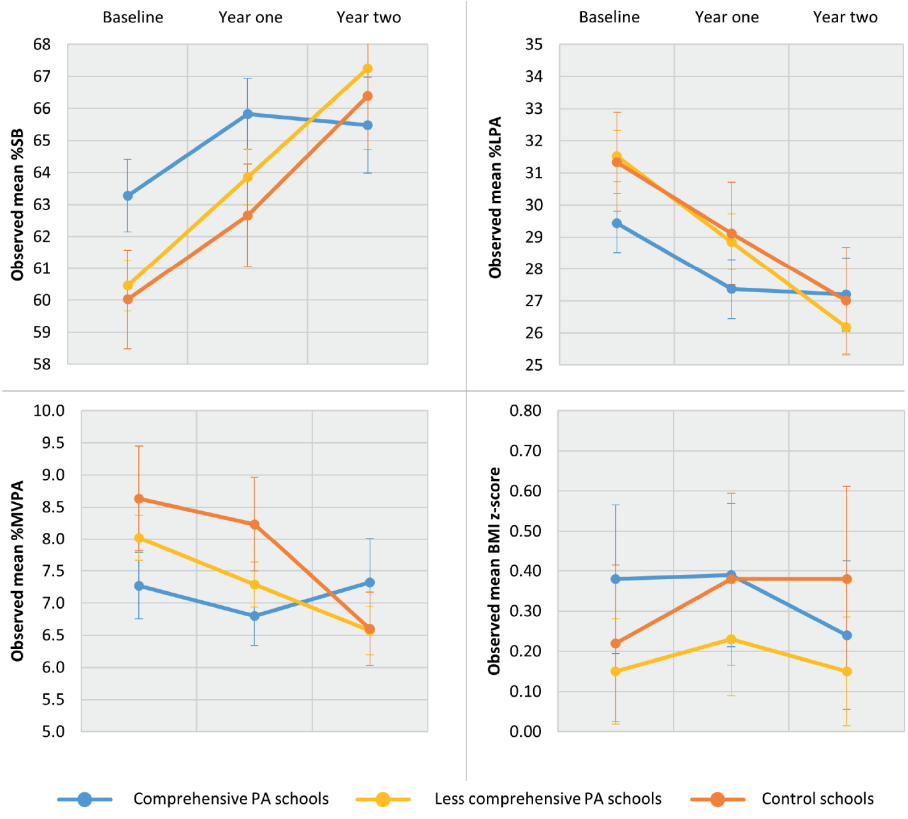


Figure 7.4. Children's %SB, %LPA, %MVPA and BMI z-score at baseline, year one and year two for comprehensive PA schools, less comprehensive PA schools, and control schools.

Additionally, the comprehensive PA schools showed some statistically significant favorable intervention effects on nutrition intake in comparison to the less comprehensive PA schools. The comprehensive PA schools showed significantly favorable effects on children's candy, cookies and snack intake, and sugar-sweetened beverages consumption at school compared to the less comprehensive PA schools after 1 year (OR = 0.50 and OR = 0.57, respectively). These effects were less or diminished after 2 years (Additional file 7.2, Table 7.9). After two years, the comprehensive PA schools showed significantly favorable effects on adherence to the fruit recommendation compared to the less comprehensive schools (OR = 2.04). In contrast, the less comprehensive PA schools had significantly more favorable effects on adherence to the vegetable recommendation compared to the control schools (OR = 5.42) (Additional file 7.2, Tables 7.10).

Discussion

The aim of the current study was to evaluate the effects of the KEIGAAF intervention on the BMI z-score, SB, PA behavior, and nutrition behavior of children aged 7-10 years after one and 2 years. Favorable intervention effects were found on children's BMI z-score after one and 2 years and on children's MVPA during school days after 2 years. After 2 years, children in the intervention group had a lower BMI z-score, while BMI z-score increased for the children in the control condition. A decline in MVPA during school days was prevented in the intervention group compared to the control group. After 1 year, favorable intervention effects were seen on children's daily consumption of sugar-sweetened beverages, while negative intervention effects were found on children's consumption of water and sugar-sweetened beverages at school. The positive intervention effect on the daily consumption of sugar-sweetened beverages was not present after 2 years. Contrastingly, after 2 years, the negative intervention effects on the consumption of water and sugar-sweetened beverages at school persisted. We found that these favorable two-year effects on BMI z-score and MVPA mainly occurred in the schools that implemented a comprehensive PA-promoting approach. Additionally, these comprehensive PA schools showed favorable intervention effects on children's SB and LPA.

The working groups of three of the four comprehensive PA schools saw a clear need for improvement at the start of the intervention. They perceived that children's PA and nutrition behavior needed improvement and that change concerning PA and healthy nutrition promotion at school was necessary [265]. These perceptions of the working groups corresponded to the actual behavior of the children. Children of comprehensive PA schools were significantly more sedentary and engaged in less light physical activity at baseline compared to the children of the less comprehensive PA schools and the children of the control schools (Additional file 7.2: Table 7.8). Baseline MVPA levels of children of comprehensive PA schools only differed significantly from children of the control group and not from the less comprehensive PA schools. BMI z-score, however, did not differ between conditions. Looking at the demographics of the comprehensive PA schools versus the less comprehensive PA schools, it was found that a significantly smaller proportion of the parents in the comprehensive PA schools were highly educated

(25.9% and 44.4% high education; respectively). Besides, significantly more children with a non-Western background were attending schools that applied a comprehensive PA approach (56.7% versus 41.3%). Given the presence of socioeconomic and ethnic inequalities in child health [241], it seems that the schools with the most vulnerable population and in need of behavioral improvement succeeded in implementing a comprehensive approach, which resulted in the most favorable intervention effects on BMI z-score and MVPA.

These results underline the importance of a long-term intervention [32, 48]. For the schools to implement a comprehensive approach, at least 1 year of preparation and 2 years of implementation were needed [265]. Activities were mainly implemented towards the end of the first year of implementation and during the second year of implementation, explaining why (the most favorable) intervention effects on BMI z-score and MVPA were mainly found after 2 years. Unfortunately, this time period was too short for schools to implement a comprehensive nutrition approach. Schools experienced children's nutrition behavior as being more difficult to change at school than physical activity [265]. This is because collaboration between school and parents is important in creating a healthy nutrition-promoting environment, but this collaboration is difficult to achieve [216]. Parents have a big influence on children's nutrition consumption, also at school, because Dutch children bring home-packed lunches and drinks to school [278]. To change children's nutrition consumption at school, schools can set rules concerning what is allowed to be consumed at school [118], but (expected) resistance from parents and staff toward these rules inhibits implementation [265].

This difficulty in implementing nutrition-related activities explains why the intervention schools were not able to achieve favorable intervention results on children's consumption of water and sugar-sweetened beverages compared to the control schools. During the two-year study period, the control schools were actively engaged in the Dutch EPODE approach [43, 279]. This approach is an intersectoral community approach aimed at reducing childhood obesity by promoting a healthy lifestyle in children [43, 279], which has proven to be effective in improving children's nutrition behavior [280]. The approach has a strong focus on the consumption of water [281], explaining the large effects found in the control group on sugar-sweetened beverages and water consumption.

We found that the KEIGAAF intervention led to a deviation from the negative trend in MVPA during school days, as well as BMI z-score observed in the control schools and shown globally [225, 248]. Children attending comprehensive PA schools actually showed an increase in MVPA of approximately 30 minutes per week from year one to year two on school days. Additional mixed model analyses revealed that intervention effects on PA were limited to the school day and not present on SB or PA when a whole week was taken into account (data not shown). This was in line with our expectation, since the intervention was mainly implemented in the school environment, but could also imply a potential compensation effect during the weekends. However, whole week analyses were slightly underpowered due to less adherence to the wear protocol during weekends and therefore these results should be interpreted cautiously. Yet, the effects on MVPA during school days were promising, because initially the PA levels declined over time. Annual declines in total PA and MVPA in children are seen worldwide and already occur at the age of eight years and peak around the age of nine [248, 249],

which was the age at which we intervened. The effect on BMI z-score is important, given the high numbers of overweight and obesity in our population at baseline. Even though the effect size was small (ES = -0.20), effects can have a great impact at population level when implemented at a larger scale [282]. For example, the mutual adaptation approach can be embedded in national school health promoting initiatives in the Netherlands, such as the Healthy School program [213].

There are few studies on comprehensive school health promotion as compared to the number of studies on classroom-only intervention studies [266]. Our comprehensive school health promotion intervention consisted of an intervention that was flexible in content, locally appropriate, and that allowed adaptation of top-down principles to local needs and adaptation of local implementation to top-down provided support (i.e., mutual adaptation) [265]. To our knowledge, only the AS! BC model in Canada [283], the APPLE project in Canada [159, 284]; the APPLES intervention in the United Kingdom [285], and the Active Living project in the Netherlands [22] used a comparable intervention approach aimed at increasing physical activity behavior and promoting healthy nutrition behavior in primary schools. Of these intervention studies, the ones that evaluated intervention effects after 2 years found positive effects on the mean steps per day on schooldays and weekends [284], fruit and vegetable consumption, caloric intake, self-reported PA levels and percentage of obese children [159]. In contrast, the interventions that were evaluated after 1 year (11 months to 16 months) found no effect on SB and PA [22, 285], BMI standard deviation score [285] or they found partial effects (i.e., an increase in average daily steps in boys, but not in girls) [161]. These results confirm that, although the implementation of a context-based, flexible intervention using a participatory approach requires a substantial amount of time to achieve effects, in the long-run they have the potential to be effective on children's weight status, PA levels and even nutrition behavior.

Adaptation and contextual fit are fundaments of a comprehensive approach [286]. Without contextual fit, an intervention is less appropriate and thus less likely to be implemented in the long-term and to eventually become embedded into current practices [203]. The importance of long-term interventions that are contextually appropriate and that implement a comprehensive approach has been stressed in many systematic reviews on school-based interventions [25, 32, 37, 48, 161]. However, there are few school-based interventions in which working groups or action teams are responsible for development and implementation compared to the number of school-based interventions in which a prepackaged program is implemented [32].

Strengths and limitations

We consider the quasi-experimental study design a strength of the study. It enabled us to implement our intervention in the 'real world' setting, which enhances the generalizability of our results [282]. However, it should be mentioned that this design had its limitations, which might increase the risk of bias. Only three control schools were included in the study compared to eight intervention schools. Besides, these control schools actively implemented a nutrition-promoting intervention. The recruitment of control schools was very challenging: schools experienced a lot of time

pressure, and participation as control school in the study was considered something additional that does not necessarily benefit the children nor the school. Moreover, the intervention group differed significantly from the control group on ethnicity, parental educational level and parental age. Other studies have shown that demographics, such as educational level and ethnicity, are associated with our outcome measures [5-7, 10, 257], and thus might have influenced our results. Another limitation of this design was the difference between the intervention and control group in children's MVPA and the percentage children consuming fruit and vegetables at school at baseline.

Moreover, dropout rates might have influenced the results of this study. At both intervention and control schools, multiple children moved to another school during the study period. Missing data were not only the result of children dropping out, but also due to children being ill during the day of measurement and/or low adherence to the accelerometer. The latter was also seen in comparable intervention studies and can be dealt with by oversampling at baseline [287].

There are also some strengths and limitations related to the study methodology. Methodological strengths of this study were the objective assessment of BMI z-score and device-based assessment of PA outcomes and the measure of both BMI z-score and the energy balance-related behaviors of children. However, it must be acknowledged that device-based measures do have some limitations. The ActiGraph accelerometers are unable to accurately measure PA associated with non-ambulatory activities like cycling [288], and we did not measure PA during activities involving water (e.g., swimming). Finally, results on SB and PA were limited to children with at least 2 days of valid data recording during school days as adherence to the wear protocol was low during weekend days. Yet, the content of the intervention was mostly designed to influence SB and PA during school days rather than weekends, lowering the impact of this limitation.

Other methodological limitations of our study are the use of self-reporting instruments for children's nutrition behavior. These reporting instruments might lead to socially desirable answers [289] and, although the child questionnaire had a high response rate, the parent questionnaire was subject to a lower response rate (± 62%) and a selective sample (parents who had filled in the questionnaire were more likely to be of Western origin, $\chi 2$ (1, N = 520) = 41.60, p <.001).

A strength related to the study objectives is the link between intervention comprehensiveness and intervention effectiveness. There are limited school-based intervention studies, including studies that adopted a comprehensive school health approach, that link the level of implementation at a school level to outcomes [282]. We encourage researchers to include this objective when studying intervention effects.

Conclusions

The KEIGAAF intervention, a mutual adaptation PA and nutrition intervention, is effective in improving children's BMI z-score and MVPA. Larger effects were found on BMI z-score and PA levels when schools implemented a comprehensive PA-promoting approach. Schools with the most vulnerable population and in need for improvement in SB and PA behavior succeeded in implementing such an approach. We emphasize the importance of implementing a long-term, locally appropriate, comprehensive approach to promote a healthy weight status, to stimulate children's PA levels, and to prevent them spending excessive time in sedentary behaviors.

Appendices Chapter 7

Additional file 7.1

Table 7.5. Schools' physical activity promotion at the end of the intervention period.

	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8
(1) Physical education								
Weekly physical education (PE) (provided by PE-teacher and school teacher)	60 minutes (PE-teacher)	2x 45 minutes	2x 45 minutes	60 + 45 minutes	2x 45 minutes	50 + 45 minutes	2x 45 minutes	2x 45 minutes
Sports clinics during PE° (e.g., boxing clinic)		√	√	√		√	√	√
(2) Physical activity (PA) during school								
PA activities during recess° (e.g., sports activity, such as basketball, organized by local social work organization)	Three times a week	Once a week	Once a week	Once a week		Once a week	Four times a week	Once a week
PA equipment during recess (e.g., balls, hockey sticks, cones)	√	√	√	√	√	√	√	√
Active curriculum (e.g., learning mathematics while being active)	√	√	√	√		√	√	√
Standing learning (e.g., standing desk for the children)						√	√	
Activity breaks (i.e., short bouts of activities in between lessons)	√	√	√	√	√	√		
Sports day once a year° (e.g., school day full of sports and play at nearby soccer field)	√	√	√	√	√	√	√	√
PA and healthy nutrition week once a year (e.g., a whole school week full of extra PA and healthy nutrition-related activities)				√				
One mile run once a week (e.g., children run one mile around the school building in between lessons)				√				

	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8
(3) PA before and after school								
After-school PA (i.e., after school activities, such as tag, dodgeball, soccer, organized by PE-teacher for interested children/ children of a specific age group)	Once a month	Once a week°	Once a month	Once a month		Once a month	Once a week°	Once a month
Active transport activity once a month (e.g., children come to school with a bicycle, step, or roller skates and are allowed to use these during recess.)	√		√					
National sports week once a year° (i.e., local sport clubs provide introduction lessons free of charge. Schools promote this week under school hours.)		√	√	√			√	
National outdoor play day once a year (i.e., schools promote that children play outside after school time during this day)		√						
Active transport week once a year (e.g., children travel to school actively. School stimulate active transport by providing activities like traffic lessons.)	√					√		
Local ice-skating event once a year° (i.e., interested children participate in an ice-skating competition under guidance of schoolteachers and parents)		√	√	√		√		√
Local marathon once a year° (i.e., interested children participate in the mini marathon or kids runs under guidance of schoolteachers and parents)		√	√	√	√	√	√	√
School soccer tournament once a year (e.g., schools organize a soccer tournament after school hours for interested children)						√		
Three-day neighborhood walk once a year° (e.g., interested children participate in a neighborhood walk after school hours for three days in a row under guidance of parents)							√	√

	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8
(4) PA policy								
PA policy	Written policy	Unwritten policy	Unwritten policy	Written policy	Written policy	No policy	Unwritten policy	Unwritten policy
Support of PA policy by school staff	High	Very high	Very high	Very high	High	NA	High	Very high
(5) Staff involvement in school PA policy/activities, degree of …								
… stimulation of PA activities during recess	High	Moderate	High	Moderate	Moderate	Moderate	High	Low
… active transport stimulation	High	Moderate	High	Very high	High	Moderate	Moderate	Low
… implementation of school PA policy	High	Moderate	High	Moderate	Moderate	NA	High	Moderate
(6) Parental engagement in school PA activities, parental engagement in …								
… activities during recess								
… implementing sports day	√	√	√	√	√	√	√	√
… active transport stimulation	√		√	√				
… after school PA						√		
Level of PA comprehensiveness*								
Comprehensiveness	LOW	HIGH	LOW	HIGH	LOW	HIGH	HIGH	LOW

Note. Activities and actions in green were implemented or enhanced/improved during the intervention period (activities and actions in black were already present at the start of the intervention). The provided examples may differ per school and are merely provided to give an idea of the implemented activities. *Comparison of comprehensiveness of PA promotion between schools: low versus high. Level of comprehensiveness was based on activities implemented in all categories (presented in the Table), coherence between practice and policies and a consistent spread of the message via different channels in and outside the school environment. °Activity was organized by an external organization, e.g., local sports club, municipal sports support organization, or event organizers.

Table 7.6. Schools' healthy nutrition promotion at the end of the intervention period.

	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8
(1) Nutrition education								
Educational program "Nice and Fit"° (i.e., education on nutrition, PA and making healthy choices for all grades consisting of 10 educational hours)	√		√	√	√		√	√
"Taste lessons" / "Taste Mission"° (i.e., education on nutrition for all grades. In five lessons (of 60 minutes each) children experiment with nutrition.)	√	√	√	√		√		
"I eat it better" lessons° (i.e., education on nutrition for the higher grades (children aged 9 to 12 years) consisting of two hours)		√	√	√		√		
EU school fruit lessons° (i.e., education on fruit and vegetables for all grades consisting of five to eight lessons (of 50-60 minutes each)	√	√		√	√	√	√	√
National tap water day once a year° (i.e., schools educate children on the importance of consuming tap water)					√	√		
National Breakfast event lessons° (i.e., animation movies and one lesson educating on the importance of a healthy breakfast for all grades)						√		
(2) Healthy nutrition during school								
EU school fruit for 20 weeks° (i.e., 3 pieces of fruit per child per week)	√	√		√	√	√	√	√
Vegetable garden (e.g., children take care of the vegetable garden)					√		√	
Water bottles/water jugs (daily) (e.g., each child has a water bottle at school which has to be filled with water)	√	√	√			√		√

	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8
Healthy breakfast week once a year (e.g., children consume a healthy breakfast at school during a whole week)	√							
National breakfast activity° (e.g., children consume a healthy breakfast at school)	Twice a year	Twice a year	Once a year	Twice a year	Three times a year	Twice a year		Twice a year
Healthy nutrition week once a year (e.g., attention is paid to healthy nutrition during a whole week by having healthy lunch competitions, and reminding the children and parents of the nutrition rules)	√			√				
National healthy snack week once a year° (i.e., schools pay attention to healthy snacks by showing movies, providing healthy snacks and challenging children to perform certain healthy snack related tasks)		√	√	√		√		
Water promotion week once a year (e.g., children are requested and challenged to only drink water for a whole week)				√				
Fruit promotion month once a year (e.g., children are challenged to consume fruit instead of unhealthy snacks during recess by participating in a fruit competition)						√		
Healthy birthday treats session once year° (e.g., the local municipal health service provides a workshop for all schoolchildren on making healthy birthday treats)						√		
Cooking workshop once a year (e.g., interested children attend a workshop on cooking)							√	
(3) Healthy nutrition before and after school								
Cooking workshop (10 lessons) twice a year° (e.g., interested children participate in a workshop on cooking organized by a social organization)	√							

	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8
Healthy nutrition and birthday treats at out-of-school care center (continuous)° (e.g., birthday children make their own healthy birthday treats at the out-of-school care center)				√				
Water tap at nearby playground° (e.g., a water tap is placed at a public playground by the municipality)					√			
(4) Nutrition policy								
Nutrition policy	Written nutrition policy	Written nutrition policy	Written nutrition policy	Written nutrition policy	Unwritten nutrition policy	Written nutrition policy	Written nutrition policy	Written nutrition policy
Nutrition policy concerning…								
… healthy lunch	√	√	√	√	√	√	√	
… healthy drinks (i.e., water)	√	√	√	√	√	√	√	√
… healthy birthday treats	√		√	√		√	√	√
… healthy snacks (i.e., fruit and vegetables)	√	√	√	√		√	√	√
… modeling healthy nutrition behavior by teachers	√	√	√	√		√		√
Support of nutrition policy by school staff	High	Moderate	High	High	Moderate	High	High	High
(5) Staff involvement in school nutrition policy/activities, degree of …								
Degree of implementation of school nutrition policies	High	Moderate	High	High	Moderate	High	High	High
(6) Parental engagement in school nutrition activities, parental engagement in …								
… school nutrition education	√			√	√			
… nutrition policy	√	√		√		√		√
… nutrition activities	√			√			√	

Note. Activities and actions in green were implemented or enhanced/improved during the intervention period (activities and actions in black were already present at the start of the intervention). The provided examples may differ per school and are merely provided to give an idea of the implemented activities. °Activity was developed and/or organized by an external organization, e.g., the Dutch Nutrition Centre, local social work organization, local cooking organization.

Table 7.7. One- and two-year observed changes in BMI z-score for (1) the comprehensive PA intervention group, (2) the less comprehensive PA intervention group and (3) the control group (Model 1) and intervention effects after one and two years comparing (1), (2) and (3) (Model 2).

		(1) (N = 141)		(2) (N = 278)		(3) (N = 104)		(1) vs (3)			(2) vs (3)			(1) vs (2)		
		N	Mean (SD)[a]	N	Mean (SD)[a]	N	Mean (SD)[a]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]
BMI z-score	T0	133	0.38 (1.08)	270	0.15 (1.09)	98	0.22 (0.97)	Ref1			Ref1			Ref2		
	T1	130	0.39 (1.03)	253	0.23 (1.13)	91	0.38 (1.03)	**-0.17 (-0.29; -0.05)**	**0.01**	**-0.07**	**-0.08 (-0.19; 0.03)**	**0.00**	**-0.14**	-0.09 (-0.19; 0.00)	0.06	-0.01
	T2	117	0.24 (1.01)	240	0.15 (1.07)	83	0.38 (1.06)	**-0.35 (-0.50; -0.19)**	**0.00**	**-0.06**	-0.20 (-0.34; -0.07)	0.16	-0.10	**-0.15 (-0.27; -0.02)**	**0.02**	**-0.21**

Note. Analyses were conducted with repeated measures linear mixed model analysis with adjustment for clustering of data within persons. Predictor variable is time*condition (Ref1 = baseline measurement*control, Ref2 = baseline measurement*less comprehensive PA promoting approach). Analyses were adjusted for ethnicity (Western vs. non-Western), and the residential socioeconomic status score . (1) comprehensive PA promoting approach, (2) less comprehensive PA promoting approach, (3) control group, BMI = Body Mass Index, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, SD = standard deviation, B = unstandardized beta coefficient, CI = confidence interval, p = p-value, ES = effect size, Ref = reference. Bold numbers are significant at $p < 0.05$. [a]Mean is the observed BMI z-score of participants with data. [b]Unstandardized beta coefficient of linear mixed models. [c]Cohen's d effect size, calculated with estimated means of linear mixed models.

Table 7.8. One- and two-year observed changes in sedentary and physical activity (PA) behavior for (1) the comprehensive PA intervention group, (2) the less comprehensive PA intervention group and (3) the control group (Model 1) and intervention effects after one and two years comparing (1), (2) and (3) (Model 2)

		(1) (N = 141)		(2) (N = 278)		(3) (N = 104)		(1) vs (3)			(2) vs (3)			(1) vs (2)		
		N	Mean (SD)[a]	N	Mean (SD)[a]	N	Mean (SD)[a]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]
SB (%)	T0	118	63.28 (6.23)*	261	60.46 (6.56)	84	60.03 (7.11)	Ref1			Ref1			Ref2		
	T1	99	65.83 (5.57)	227	63.86 (6.64)	75	62.66 (6.95)	-0.18 (-1.96; 1.61)	0.85	-0.02	0.10 (-1.50; 1.71)	0.90	0.01	-0.28 (-1.85; 1.30)	0.73	-0.02
	T2	89	65.48 (7.12)	176	67.25 (5.94)	67	66.39 (6.83)	**-2.89 (-5.05; -0.74)**	**0.01**	**-0.31**	0.44 (-1.30; 2.19)	0.62	0.04	**-3.34 (-4.98; 1.70)**	**0.00**	**-0.23**
LPA (%)	T0	118	29.44 (5.08)*	261	31.52 (4.94)	84	31.34 (5.36)	Ref1			Ref1			Ref2		
	T1	99	27.37 (4.64)	227	28.85 (4.97)	75	29.11 (5.13)	0.05 (-1.35; 1.45)	0.95	0.01	0.11 (-1.15; 1.38)	0.86	0.01	-0.07 (-1.30; 1.16)	0.91	-0.01
	T2	89	27.20 (5.45)	176	26.18 (4.37)	67	27.01 (5.27)	0.96 (-0.70; 2.61)	0.26	0.14	-1.14 (-2.49; 0.22)	0.10	-0.14	**2.09 (0.83; 3.36)**	**0.00**	**0.19**
MVPA (%)	T0	118	7.27 (2.83)†	261	8.02 (2.89)	84	8.63 (3.78)	Ref1			Ref1			Ref2		
	T1	99	6.80 (2.31)	227	7.29 (2.69)	75	8.23 (3.18)	0.03 (-0.79; 0.86)	0.94	0.00	-0.20 (-0.95; 0.54)	0.59	-0.04	0.24 (-0.49; 0.96)	0.52	0.04
	T2	89	7.32 (3.28)	176	6.57 (2.52)	67	6.60 (2.34)	**1.84 (0.82; 2.85)**	**0.00**	**0.44**	0.65 (-0.18; 1.48)	0.13	0.13	**1.19 (0.42; 1.96)**	**0.00**	**0.18**

		(1) (N = 141)		(2) (N = 278)		(3) (N = 104)		(1) vs (3)			(2) vs (3)			(1) vs (2)		
		N	Mean (SD)[a]	N	Mean (SD)[a]	N	Mean (SD)[a]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]
CPM	T0	118	1085.00 (270.36)*	261	1185.04 (291.89)	84	1270.87 (489.96)	Ref1			Ref1			Ref2		
	T1	99	1000.75 (238.79)	227	1058.15 (266.52)	75	1131.00 (323.44)	56.38 (-33.74; 146.49)	0.22	0.12	16.13 (-65.19; 97.44)	0.70	0.03	40.25 (-38.31; 118.82)	0.32	0.05
	T2	89	1013.55 (298.68)	176	951.11 (273.80)	67	926.21 (227.56)	**225.52 (118.02; 333.02)**	**0.00**	**0.48**	**97.48 (8.82; 186.13)**	**0.03**	**0.18**	**128.04 (45.54; 210.54)**	**0.00**	**0.17**

Note. Analyses were conducted with repeated measures linear mixed model analysis with adjustment for clustering of data within persons and adjustment of clustering of data at school level. Predictor variable is time*condition (Ref1 = baseline measurement*control, Ref2 = baseline measurement*less comprehensive PA promoting approach). Analyses were adjusted for children's age at baseline, BMI z-score at baseline, gender, ethnicity (Western vs. non-Western), the residential socioeconomic status score and weather conditions (i.e., sunshine, temperature and precipitation). (1) comprehensive PA promoting approach, (2) less comprehensive PA promoting approach, (3) control group, SB = Sedentary behavior, LPA = Light physical activity behavior, MVPA = moderate-to-vigorous physical activity behavior, CPM = counts per minute, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, SD = standard deviation, B = unstandardized beta coefficient, CI = confidence interval, p = p-value, ES = effect size, Ref = reference. Bold numbers are significant at $p < 0.05$. *Significantly different from the baseline levels of the children of the less comprehensive PA intervention group and the children of the control group (Welch's test and Games-Howell post-hoc analysis). †Significantly different from the baseline levels of the children of the control group, but not compared to the children of the less comprehensive PA intervention group (Welch's test and Games-Howell post-hoc analysis). [a]Mean is the observed SB, LPA, MVPA and CPM of participants with data. [b]Unstandardized beta coefficient of linear mixed models. [c]Cohen's d effect size, calculated with estimated means of linear mixed models.

Table 7.9. One- and two-year observed changes in (child-reported) nutrition behavior at school for (1) the comprehensive physical activity (PA) intervention group, (2) the less comprehensive PA intervention group and (3) the control group (Model 1) and intervention effects after one and two years comparing (1), (2) and (3) (Model 2).

		(1) (N = 141)		(2) (N = 278)		(3) (N = 104)		(1) vs (3)		(2) vs (3)		(1) vs (2)	
		N	Obs %[a]	N	Obs %[a]	N	Obs %[a]	OR (95% CI)[b]	p	OR (95%CI)[b]	p	OR (95%CI)[b]	p
Breakfast	T0	141	91.5	272	93.8	101	87.1	Ref1		Ref1		Ref2	
(%yes)	T1	126	88.9	250	90.8	90	76.7	1.85 (0.64; 5.38)	0.26	1.34 (0.52; 3.52)	0.55	1.38 (0.52; 3.68)	0.52
	T2	117	88.0	236	89.4	81	75.3	1.99 (0.68; 5.83)	0.21	1.99 (0.68; 5.83)	0.41	1.33 (0.50; 3.55)	0.57
Fruit or	T0	141	88.7†	271	89.7	101	75.2	Ref1		Ref1		Ref2	
vegetables	T1	126	92.1	249	88.8	90	75.6	2.16 (0.82; 5.68)	0.19	1.22 (0.54; 2.72)	0.63	1.78 (0.72; 4.38)	0.21
(%yes)	T2	116	90.5	236	91.1	81	74.1	2.01 (0.75; 5.37)	0.17	1.55 (0.67; 3.59)	0.31	1.30 (0.51; 3.28)	0.58
Candy, cookies	T0	141	41.1	271	44.3	101	42.6	Ref1		Ref1		Ref2	
or snacks	T1	126	30.2	250	48.0	90	35.6	0.80 (0.39; 1.67)	0.56	1.60 (0.85; 3.02)	0.15	**0.50 (0.28; 0.89)**	**0.02**
(%yes)	T2	116	28.4	237	41.4	81	38.3	0.64 (0.30; 1.35)	0.24	1.03 (0.54; 1.96)	0.94	0.62 (0.34; 1.13)	0.12
Sugar-	T0	141	61.0*	271	50.6	101	47.5	Ref1		Ref1		Ref2	
sweetened	T1	126	47.6	250	51.2	90	13.3	**3.35 (1.54; 7.252)**	**0.00**	**5.85 (2.88; 11.90)**	**0.00**	**0.57 (0.34; 0.97)**	**0.04**
beverages (%yes)	T2	116	45.7	236	34.3	81	7.4	**5.94 (2.31; 15.27)**	**0.00**	**5.51 (2.26; 13.45)**	**0.00**	1.08 (0.63; 1.86)	0.79
Water (%yes)	T0	141	52.5	267	60.3	101	59.4	Ref1		Ref1		Ref2	
	T1	126	61.9	250	63.6	90	95.6	**0.09 (0.03; 0.25)**	**0.00**	**0.08 (0.03; 0.21)**	**0.00**	1.14 (0.67; 1.92)	0.63
	T2	116	66.4	236	74.2	81	86.4	**0.37 (0.17; 0.83)**	**0.02**	**0.39 (0.19; 0.83)**	**0.02**	0.95 (0.54; 1.66)	0.86

Note. Analyses were conducted with generalized estimating equations analysis with adjustment for clustering of data within persons. Predictor variable is time*condition (Ref1 = baseline measurement*control, Ref2 = baseline measurement*less comprehensive PA promoting approach). Analyses were adjusted for children's age at baseline, BMI z-score at baseline, gender, ethnicity (Western vs. non-Western), and the residential socioeconomic status score. (1) comprehensive PA promoting approach, (2) less comprehensive PA promoting approach, (3) control group, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, Obs % = observed percentage, OR = odds ratio, CI = confidence interval, p = p-value, ES = effect size, Ref = reference. Bold numbers are significant at $p < 0.05$. *Significantly different from the baseline levels of the children of the less comprehensive PA intervention group and the children of the control group (Pearson Chi-Square test). †Significantly different from the baseline levels of the children of the control group, but not compared to the children of the less comprehensive PA intervention group (Pearson Chi-Square test). [a]Mean is the observed percentage of children consuming the food/drink. [b]Odds ratio of GEE model adjusted for child age, gender, ethnicity and BMI z-score at baseline and residential socioeconomic status score at baseline.

Table 7.10. One- and two-year observed changes in (parent-reported) daily nutrition behavior for (1) the comprehensive physical activity (PA) intervention group, (2) the less comprehensive PA intervention group and (3) the control group (Model 1) and intervention effects after one and two years comparing (1), (2) and (3) (Model 2).

		(1) (N = 141)		(2) (N = 278)		(3) (N = 104)		(1) vs (3)		(2) vs (3)		(1) vs (2)	
		N	Obs %[a]	N	Obs %[a]	N	Obs %[a]	OR (95% CI)[b]	p	OR (95%CI)[b]	p	OR (95%CI)[b]	p
Adherence fruit	T0	87	32.2	176	41.5	48	27.1	Ref1		Ref1		Ref2	
recommendation	T1	77	44.2	165	41.8	57	22.8	1.78 (0.67; 4.77)	0.25	1.17 (0.48; 2.85)	0.73	1.52 (0.77; 3.02)	0.23
(%yes)	T2	81	38.3	171	33.9	58	20.7	1.98 (0.72; 5.41)	0.19	0.97 (0.39; 2.42)	0.95	2.04 (1.02; 4.10)	0.05
Adherence vegetable	T0	79	24.1	171	26.9	52	23.1	Ref1		Ref1		Ref2	
recommendation	T1	72	16.7	161	25.5	58	12.1	1.49 (0.42; 5.30)	0.54	1.95 (0.64; 5.97)	0.24	0.76 (0.31; 1.89)	0.56
(%yes)	T2	78	10.3	161	20.5	54	3.7	2.62 (0.49; 14.11)	0.26	5.42 (1.18; 24.98)	0.03	0.48 (0.18; 1.32)	0.16
Daily consumption	T0	87	37.9†	187	50.8	52	50.0	Ref1		Ref1		Ref2	
of snacks (%yes)	T1	82	22.0	173	35.3	61	44.3	0.56 (0.25; 1.27)	0.17	0.61 (0.31; 1.22)	0.17	0.92 (0.48; 1.75)	0.80
	T2	86	29.1	178	37.1	63	28.6	1.70 (0.75; 3.84)	0.20	1.54 (0.75; 3.16)	0.24	1.11 (0.60; 2.04)	0.75
Daily consumption	T0	87	66.7†	183	50.8	51	52.9	Ref1		Ref1		Ref2	
of sugar-sweetened	T1	80	53.8	169	39.1	62	59.7	0.42 (0.18; 0.98)	0.04	0.46 (0.22; 0.98)	0.04	0.90 (0.46; 1.76)	0.77
beverages (%yes)	T2	85	41.2	180	35.6	63	42.9	0.46 (0.20; 1.09)	0.08	0.81 (0.38; 1.73)	0.58	0.57 (0.29; 1.11)	0.10
Daily consumption of	T0	85	62.4	188	69.7	52	61.5	Ref1		Ref1		Ref2	
Water (%yes)	T1	79	69.6	172	70.9	62	72.6	0.77 (0.33; 1.79)	0.54	0.56 (0.27; 1.19)	0.13	1.37 (0.71; 2.62)	0.35
	T2	86	70.9	181	71.3	62	71.0	0.90 (0.39; 2.10)	0.81	0.64 (0.30; 1.36)	0.24	1.41 (0.74; 2.69)	0.29

Note. Analyses were conducted with generalized estimating equations analysis with adjustment for clustering of data within persons. Predictor variable is time*condition (Ref1 = baseline measurement*control, Ref2 = baseline measurement*less comprehensive PA promoting approach). Analyses were adjusted for children's age at baseline, BMI z-score at baseline, gender, ethnicity (Western vs. non-Western), and the residential socioeconomic status score. (1) comprehensive PA promoting approach, (2) less comprehensive PA promoting approach, (3) control group, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, Obs % = observed percentage, OR = odds ratio, CI = confidence interval, p = p-value, ES = effect size, Ref = reference. Bold numbers are significant at $p < 0.05$. †Significantly different from the baseline levels of the children of the control group, but not compared to the children of the less comprehensive PA intervention group (Pearson Chi-Square test). [a]Mean is the observed percentage of children consuming the food/drink. [b]Odds ratio of GEE model adjusted for child age, gender, ethnicity and BMI z-score at baseline and residential socioeconomic status score at baseline.

Additional file 7.3

#	Item	Where located	
		Primary paper (page or appendix number)	Other (details)
Brief name			
1.	Provide the name or a phrase that describes the intervention.	155	
Why			
2.	Describe any rationale, theory, or goal of the elements essential to the intervention.	155-157	
What			
3.	Materials: Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers. Provide information on where the materials can be accessed (e.g. online appendix, URL).	179-185 Additional file 7.1 : Table 7.5 and 7.6	[179]
4.	Procedures: Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities.	156-157	[179]
Who provided			
5.	For each category of intervention provider (e.g. psychologist, nursing assistant), describe their expertise, background and any specific training given.	156-157	[265]
How			
6.	Describe the modes of delivery (e.g. face-to-face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group.	156-157 & Additional file 7.1: Table 7.5 and 7.6	
Where			
7.	Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features.	156 & Additional file 7.1: Table 7.5 and 7.6	
When and how much			
8.	Describe the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity or dose.	156-157 & Additional file 7.1: Table 7.5 and 7.6	[265]
Tailoring			
9.	If the intervention was planned to be personalised, titrated or adapted, then describe what, why, when, and how.	156-157	[265]
Modifications			
10.	If the intervention was modified during the course of the study, describe the changes (what, why, when, and how).	N/A	

How well			
11.	Planned: If intervention adherence or fidelity was assessed, describe how and by whom, and if any strategies were used to maintain or improve fidelity, describe them.	N/A	
12.	Actual: If intervention adherence or fidelity was assessed, describe the extent to which the intervention was delivered as planned.	N/A	

Note. N/A = not applicable.

Figure 7.5. The TIDIeR (Template for Intervention Description and Replication) Checklist.

Chapter 8

General discussion

Main findings

In this chapter, the main findings of the studies included in this dissertation are summarized. The results are discussed and, methodological considerations are described. Further, the lessons learned from implementing and evaluating the intervention and the subsequent recommended improvements, as well as recommendations for practice are outlined. Finally, a general conclusion is drawn. This dissertation had three aims: the first aim was to conduct a systematic review, the second aim was to develop the KEIGAAF intervention and the evaluation study and the third aim was to evaluate the intervention. The latter aim was divided into the evaluation of the implementation process of the intervention and the evaluation of the effectiveness of the intervention. The results of the studies belonging to these aims are described below.

Aim 1: Systematic review

To explore the effectiveness of school-based interventions that also targeted the home setting on children's BMI z-score and their energy balance-related behaviors, 24 school-based physical activity (PA) and/or nutrition interventions with direct parental involvement were systematically reviewed (Chapter 2). Parental involvement was considered to be direct when parents were invited to attend energy balance-related education sessions or when parents were asked to attend or participate in family behavior counseling or parent training sessions. This systematic review showed that school-based interventions with direct parental involvement have the potential to improve children's Body Mass Index (BMI) or BMI z-score (BMI adjusted for age- and gender), children's PA levels and their sedentary behavior. However, school-based PA and nutrition interventions with direct parental involvement were not effective in changing children's nutrition behavior. Important components of school-based interventions with direct parental involvement were the focus on multiple energy balance-related behaviors simultaneously, changing different types of environments within the school and home environments, in particular the social (e.g., support of teachers in performing PA during recess, modeling behavior of parents) and physical environments (e.g., school playground, availability of play material at home). Additionally, effective interventions were the interventions which lasted at least one year.

Aim 2: Intervention design

The KEIGAAF intervention was developed based on previous experiences and the systematic literature review. This PA and nutrition intervention consisted of a combined top-down and bottom-up approach which was applied previously in the Active Living study [22, 40, 290]. In this approach, local working groups were responsible for the development and implementation of their own activity plans aimed at improving children's energy balance-related behaviors. The working groups were supported by a Health Promotion (HP) advisor and guided by a steering committee. We hypothesized this approach to be effective and sustainable in improving children's BMI z-score and

energy balance-related behaviors due to the contextual fit of the intervention. The KEIGAAF intervention targeted both the child's school and home environments and was aimed at primary school children aged 7 to 12 years. The effects of the intervention on children's BMI z-score, their waist circumference, their PA behavior, sedentary behavior, physical fitness, and their nutrition behavior were studied in a quasi-experimental controlled study (Chapter 3). Eight intervention schools were compared to three control schools and child and parental data were collected using different data collection tools at baseline in March and April 2017, after one year and after two years. Additionally, various methods, such as participatory observations and interviews, were used to evaluate the implementation of the KEIGAAF intervention.

The baseline data of the KEIGAAF study were used to gain deeper understanding of the influence of the home environment on children's behavior (Chapter 4). A cross-sectional study was conducted in which the associations between the Family Nutrition Climate and children's nutrition behavior were analyzed. The study showed that the climate within a family concerning healthy nutrition is a predictor of the child's nutrition behavior, especially the consumption of healthy foods. However, associations between the Family Nutrition Climate and children's nutrition behavior were weak.

Aim 3: Evaluation of the KEIGAAF intervention

Implementation of the KEIGAAF intervention

The KEIGAAF intervention was implemented from April 2016 until June 2019 in eight primary schools located in low socioeconomic neighborhoods in Eindhoven. This period consisted of a preparatory phase of about one year and an implementation period of two years. The KEIGAAF working groups consisted of teachers, parents, and local professionals and were responsible for the development and implementation of activities that stimulated and promoted PA and healthy nutrition among the children. The steering committee consisted of local stakeholders who designed general intervention principles. A qualitative process evaluation revealed that implementation differed per working group, as did the pace of implementation and the intervention output (i.e., the activities implemented) (Chapter 5). Differences in implementation were the result of various contextual and intervention factors influencing implementation in differing degrees. Contextual factors influencing implementation were categorized into the concepts of the Consolidated Framework for Implementation Research of Damschroder et al., [209]: outer setting, inner setting and characteristics of the implementers. Contextual factors facilitating implementation were: national Health Promoting School trends (i.e., the Healthy School program), top-down influence of the school boards (outer setting), support of school staff and principals, employee turnover, the presence of intervention champions (inner setting), the practice-oriented way of thinking of working group members and positive dynamics within the working groups (characteristics of the implementers). Contextual factors hindering implementation were a lack of potential local partners for the working groups (outer setting), the perception of low parental involvement and support (inner setting), and misinterpretation of the intervention approach (characteristics of the implementers). The starting situation (inner setting)

either facilitated or hindered implementation, depending on its state. Intervention factors facilitating implementation were the practical support of the HP advisor and the financial support provided for the intervention. The feedback loops (generated by working group evaluation and reporting back of study results) in the intervention either hindered or facilitated implementation, depending on the appropriateness of these feedback loops for the context. Mutual adaptation was an essential element of the intervention. Mutual adaptation was adaptation of top-down intervention principles to local practice and adaptation of bottom-up practices to top-down support. Local adaptation of activities facilitated implementation and enhanced feelings of ownership.

The working groups mainly implemented activities in and around school. To reach the children's home environment, a family-based intervention was implemented (based on Triple P Lifestyle [41, 132]). In this intervention, parents were invited to participate in group sessions in which they were coached by a professional on positive parenting, and parenting practices in relation to children's PA and nutrition behavior. Given the low participation rates (described in more detail further on in this chapter), an alternative intervention was implemented in four intervention schools in January and February 2019. The intervention aimed to involve parents in the performance of energy balance-related activities performed by their children. Parents were involved indirectly, but actively, via the child. Children were requested to perform as many as possible energy balance-related challenges, some of which had to be performed together with their parents (referred to as child-only activities and parental involvement activities). In an exploratory cross-sectional study, the engagement in the intervention was investigated, as well as the type of children and families participating in the intervention based on the child and family characteristics (Chapter 6). Many children and parents (93%) were engaged in the intervention. In general, the children performed more PA challenges than nutrition challenges. The intervention was not selective in engagement of children with a lower or higher BMI z-score, children with a higher or lower preference concerning physical activity and healthy nutrition, nor were challenges selectively performed by boys or girls. Also, the family health climate concerning PA and nutrition did not play a role. However, PA challenges were performed more often by children who were already a member of a sports club and younger children. Children from a Western background performed more PA parental involvement challenges compared to children from a non-Western background, but this relation was mediated by sports membership. Western children were more likely to be a member of a sports club compared to non-Western children. Children of larger families performed more PA parental involvement challenges, whereas children living in higher SES neighborhoods performed more PA child-only challenges compared to children living in lower SES neighborhoods. Finally, children of families with a mixed educational level performed more nutrition child-only challenges compared to children of low educated parents (but not compared to high educated parents).

Effectiveness of the KEIGAAF intervention

Finally, to evaluate the effects of the KEIGAAF intervention on children's BMI z-score, their PA behavior, sedentary behavior, and their nutrition behavior, a quasi-experimental controlled study was conducted (Chapter 7). In the study, it was analyzed whether children's BMI z-score and energy balance-related behaviors improved after one and two years compared to a control group that was not exposed to the KEIGAAF intervention. In total, 523 children with a mean age of 8.5 years participated in the study. After one year, children's increase in BMI z-score was smaller for the intervention group compared to the control group. No effects were visible on children's PA levels, while favorable intervention effects were seen on children's daily sugar-sweetened beverage consumption, and negative intervention effects were found on children's water and sugar-sweetened beverage consumption at school (a smaller increase in water consumption and a smaller decrease in soda consumption compared to the control group). After two years, the intervention effectively reduced children's BMI z-score and prevented an age-related decline in children's moderate-to-vigorous PA (MVPA). The negative intervention effects on children's sugar-sweetened beverages consumption at school persisted after two years. The positive intervention effect on daily sugar-sweetened beverage intake was not present after two years. In general, the intervention schools that implemented a comprehensive PA approach (an approach in which PA was stimulated during the entire day inside and outside of school by all actors involved, e.g., teachers, other school staff, parents, and local organizations) showed beneficial results on children's BMI z-score and MVPA compared to intervention schools that implemented a less comprehensive PA approach and control schools. Schools with the most vulnerable population, and in need of behavioral improvement, implemented such approach.

Intervention effects on waist circumference and physical fitness

We aimed to not only analyze intervention effects on children's BMI z-score, PA levels, and nutrition behavior, but also on their waist circumference and physical fitness (Chapter 3). Nevertheless, only intervention effects on BMI z-score, PA levels, and nutrition behavior were incorporated in the evaluation study (Chapter 7). The reason for this was the unreliability of the data regarding children's waist circumference and physical fitness. When designing the evaluation study, it was chosen to not only measure BMI z-score, but also conduct a sensitivity analysis by measuring intervention effects on children's waist circumference. This measure is inexpensive and quick, and it measures fat distribution rather than amount of overall adiposity [156]. However, it is not very reliable [156]. We also noticed that, in practice, even though research assistants were well-trained, the interrater reliability was low. Children's waist circumference was measured at baseline, after one year, and after two years, but eventually it was decided not to include the intervention effects on this outcome measure in the effect paper. However, the analyses have been executed. Linear mixed model analyses showed similar intervention effects on waist circumference as on BMI z-score. The increase in waist circumference was less for the intervention group compared to the control group (Additional file 8.1: Table 8.1). The intervention effect for waist circumference was only significant after two years (B = -1.31, 95% CI -2.43; -0.19, p =.02, ES -0.14), whereas a significant positive intervention

effect was found at both one and two years for BMI z-score. When stratifying outcomes for comprehensive PA schools and less comprehensive PA schools, favorable significant intervention effects on waist circumference were found in children of comprehensive PA schools compared to control schools (one year: B = -1.33, 95% CI -2.42; -0.25, p =.02, ES -0.14; two years: B = -1.70, 95% CI -3.02; -0.38, p =.01, ES -0.18), but not in children of less comprehensive PA schools (Additional file 8.1: Table 8.2). Similar to the effects for BMI z-score, effect sizes for waist circumference were small.

Besides assessing changes in children's PA levels, we also wanted to know whether children's aerobic fitness levels improved. Aerobic fitness is one of the measures of physical fitness which is considered an important health marker [291]. We indirectly assessed change in children's aerobic fitness level by conducting the PACER 15-meter fitness test during a physical education lesson [141]. Unfortunately, a large amount of the data (85 children, 16% of the total sample) of the two-year follow-up measurement was unreliable. Therefore, the data of those children had to be removed from the dataset, making the two-year results unrepresentative for the whole sample. Nonetheless, analyses were performed with the available data. Linear mixed model analyses showed that the intervention was not effective in improving physical fitness after one year. Both the intervention children and the control children scored higher on the PACER test after one year (B = 1.91, 95% CI 0.41; 4.24, p =.11, ES 0.16). However, after two years, the intervention was effective in improving children's physical fitness level (B = 5.86, 95% CI 3.02; 8.71, p <.01, ES 0.49) (Additional file 8.2: Table 8.3). These results are in line with the results found on children's MVPA, which can be explained by the association between aerobic fitness and MVPA [292]. Children at comprehensive PA schools did not perform better compared to children at less comprehensive PA schools and control schools (Additional file 8.2: Table 8.4).

Discussion of the main findings

The results of the studies concerning the implementation and the effectiveness of the intervention described in this dissertation have to be interpreted in light of some considerations. These considerations are related to the latter two aims of this dissertation: (2) intervention design and (3) evaluation of the KEIGAAF intervention.

From direct parental involvement to indirect parental involvement

KEIGAAF is a Dutch acronym for 'Chances in Eindhoven for a family-based approach by Fontys' ('Kansen in Eindhoven voor GezinsAAnpak met Fontys'). This name was chosen because it represented in a familiar local term one of the main aims of the KEIGAAF intervention: targeting the home environment. The aim to target both the school environment and the home environment originated from theories and studies emphasizing the importance of parental involvement in school-based interventions [32, 36, 50, 53] and the advice to focus on the whole child system and thus go beyond the school environment [293]. Although the few studies comparing school-only interventions with school- and-family-based interventions showed inconclusive results concerning

the added value of a family component on the intervention effectiveness [54], targeting parents directly and involving them intensely in obesity prevention interventions (e.g., targeting parents via educational sessions for a longer time period) is more likely to result in positive outcomes than indirect strategies [53, 294]. Looking merely at the effectiveness of school-based interventions with direct parental involvement, it was found that these interventions were effective in improving children's BMI z-score and PA levels (Chapter 2).

In the KEIGAAF intervention, the family-based component of the intervention was aimed at improving children's energy balance-related behaviors by targeting the energy balance-related practices of parents. Focusing on parenting practices in a family-based intervention shows great promise given the association between parenting practices and children's energy balance-related behaviors [89]. The family-based intervention was based on an existing intervention, Lifestyle Triple P [41, 132], which was proven effective in changing overweight children's energy balance-related behaviors and parents' parenting practices [41]. In this intervention, parents are coached by a trained professional on positive parenting, parenting and, practices in relation to children's PA and nutrition behavior. In the KEIGAAF intervention, the intervention was initially an indicated prevention intervention targeting overweight children (Chapter 3). When implementing the KEIGAAF intervention, it was decided to prepare the school-based part of the intervention first and move on to the family-based intervention when the foundation for the school-based intervention was laid, i.e., working groups were created and prepared to start implementation. After preparing this school-based part of the intervention, which lasted at least a year, more attention was given to the family-based intervention. The initial plan was reviewed and it was decided to change the indicated prevention intervention into a selective prevention intervention, aiming to involve all parents of intervention children aged 7 to 12 years of the low SES schools, to prevent stigmatization. A local organization employing professionals who were trained in the Triple P Lifestyle intervention was contacted. Based on the experiences of this organization, it was decided to reduce the number of fourteen group sessions to eight, with an option to extend the number of group sessions to reduce the burden of participation for parents. Since it was assumed that the presence of children at home after school would hinder parents from attending the sessions, fun active childcare was arranged for their children parallel to the parent sessions. After making these adjustments to the initial plan, the recruitment for the family-based intervention was started in one intervention school during the first year of implementation. Parents were invited via school media and face-to-face by the Triple P coach, a researcher, and the youth health care physician to participate in the group sessions. However, in practice, recruitment turned out to be very challenging: most parents were not present on school when children went home and parents that were approached to participate in the intervention were not interested. Eventually, only three parents decided to participate, while the group of children joining the active sessions increased weekly (also children whose parents did not participate in the sessions participated). After that, the intervention was to be repeated in another intervention school. The recruitment strategies were repeated and intensified: more parents were contacted face-to-face and by the use of a recruitment video. Nevertheless, the recruitment rate was too low (N=1). Therefore, the steering committee decided to develop and implement a new

intervention to engage parents in the intervention: Challenge Me. This pilot intervention was relatively easy to execute. It was implemented by the intervention schools, but schools functioned as a messenger for the intervention, because the children and parents performed the intervention mainly at home. The intervention differed highly in the way parents were involved in the intervention compared to the initial family-based intervention, i.e., parents were stimulated to perform certain activities together with their child. Thus, instead of being involved directly, they were involved indirectly. In this intervention, children were challenged to be physically active and to be exposed to healthy nutrition with and without the help of their parents. The intervention was implemented in four of the eight intervention schools (Chapter 6). Additionally, in the entire KEIGAAF intervention, parents were mainly involved indirectly (instead of directly) in the activities implemented by the working groups. Parents received information about the activities and/or were asked to support or participate in the activity via the school newsletter, the website, and/or the school-app. Thus, overall, direct parental involvement was limited to those parents that participated as a member in the working groups and those that helped in implementing activities.

The importance of mutual adaptation

Many contextual factors played a role in the implementation of the KEIGAAF intervention. Mutual adaptation was considered one of the key elements of the intervention. In a mutual adaptation intervention, the contextual factors important for, and influencing implementation are taken into account. Mutual adaptation is a process showing adaptation simultaneously at top-down and bottom-up levels [119, 130]. Project stakeholders adapt project goals and methods to suit local needs and possibilities (adaptation at the top-down level) and local staff change practices to meet project requirements (adaptation at the bottom-up level). In a mutual adaptation approach, top-down and bottom-up forces meet and are combined, resulting in an approach in which local context and ownership is honored while larger-scale principles and broader system influences are acknowledged (Figure 8.1) [119, 130].

The amount of adaptation at both levels and the capacity of working groups to implement change differed per school, which is explained by the unique characteristics of each school [120, 295]. No prepackaged programs were used, but general intervention principles guided the working groups. Though best practices and evidence-based activities were proposed by the HP advisor, these activities were adapted by the working groups. These adaptations enhanced the local fit of the activities and the sustainability of the changes. The importance of mutual adaptation was already acknowledged in the 1970s by a large-scale study (the Rand Change Agent study) on programs that aimed to spread innovative practices in public schools to achieve educational change [296]. Evaluating these programs, McLaughlin and Berman [297] found that mutual adaptation was the implementation process that lead to the most significant changes and had the highest chance of sustaining these changes [296]. They also mentioned that mutual adaptation was not a straightforward process and seldom occurred smoothly and without problems – which is in line with our findings. For an activity to be implemented in the local context, organizational practices had to be changed. This sometimes led

to reluctance or even resistance from colleagues of the working group members or parents.

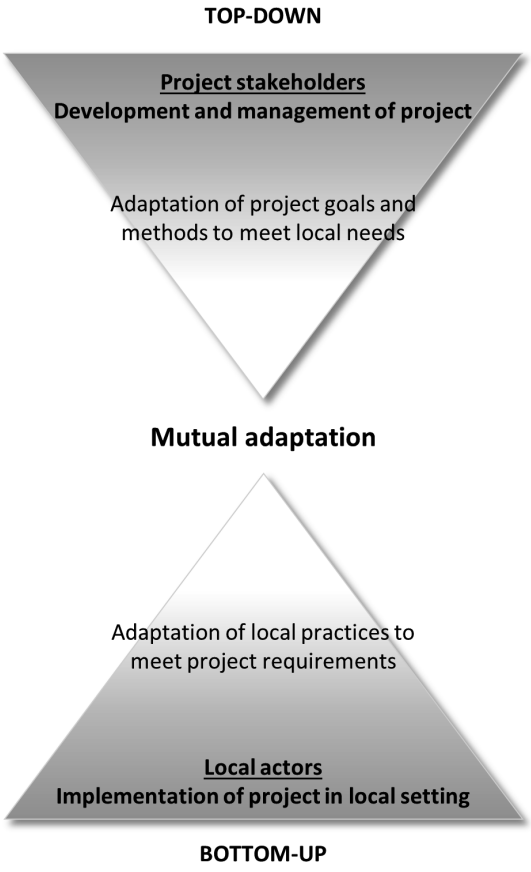


Figure 8.1. Mutual adaptation.

The Rand Change Agent Study and the KEIGAAF intervention are exceptions to many traditional implementation studies. For years, researchers aimed for consistency in implementation, used intervention protocols and did not allow deviations from these protocols, through a fear of compromising intervention integrity [204]. However, adaptation is normal practice when implementing interventions in the real world [129] and researchers are increasingly embracing adaptation [205]. In the KEIGAAF intervention, we allowed and even encouraged adaptation of activities to fit the local context. That did not mean that every school could do whatever they wanted: standardization of the KEIGAAF intervention was achieved by implementing the same intervention principles, using the combined top-down and bottom-up approach in all schools, by being advised by health promotors on PA and nutrition-related interventions, and by ensuring adherence to the intervention's functions [204].

KEIGAAF and the Healthy School program

As in many interventions implemented in real life, the intervention was implemented alongside other new and existing initiatives aimed at improving children's health and health behaviors. In the Netherlands, school health promotion is not mandatory [215], and therefore often not a priority for schools. HP in schools is coordinated by the national Healthy School committee, a collaboration of governmental agencies [213]. Regional public health services are responsible for the implementation of the Healthy School model in primary and secondary schools and serve as the linking pin between the educational sector (e.g., the schools), public service stakeholders, and health authorities (e.g., the municipality) [298]. Each regional municipal health service has one or more Healthy School advisors who support schools in the systematic implementation of the Healthy School model. The model consists of three phases: preparation, execution, and evaluation. It encourages schools to consider their existing situation concerning school health promotion in relation to one or more health-promoting themes (e.g., PA and sports, smoking and alcohol, nutrition, or wellbeing) and advises them to enhance the activities that work well by combining them into a comprehensive health-promoting approach. Schools are required to assign one staff member the task of Healthy School coordinator, who collaborates with a regional Healthy School advisor in the implementation of the Healthy School model. An online database of Healthy School activities is used to ensure that activities are being implemented that are evaluated by independent professionals as having a good chance of being effective [299]. Schools that follow the method of the Healthy School model and promote one of the themes of the Healthy School model can apply for a certificate [213]. The Healthy School certificate is granted by the national Healthy School committee and is valid for three years. The Healthy School model differs from the KEIGAAF intervention in terms of the approach. First, the KEIGAAF intervention encourages schools to adapt interventions to the local context, while the Healthy School model merely advises implementing interventions as intended (fidelity) [299]. Second, in implementing the Healthy School model, a Healthy School coordinator of the school collaborates with the Healthy School advisor, while the KEIGAAF intervention is developed and implemented by multiple stakeholders working in different sectors (school, sports, health care). Finally, schools have to adhere to general requirements to be certified to become a Healthy School, while the KEIGAAF schools looked specifically toward their own situation and made locally appropriate changes according to their needs and possibilities.

Various schools in the intervention region participated in the Healthy School program and/or were advised on this program by the regional public health service. At the start of the intervention, seven intervention schools were asked to become a Healthy School by their school board within two years. This demand of the school board, the guidelines of the national Healthy School committee, and local Healthy School advisors supported and accelerated implementation of the KEIGAAF intervention and functioned as a breeding ground. The seven intervention schools belonging to this school board aimed to comply with the demand of the school board and most of the seven intervention schools used KEIGAAF as a means to become a Healthy School and perceived the KEIGAAF intervention as strengthening the Healthy School program. However, during implementation, some schools saw the KEIGAAF intervention (at first) as a competitor of the Healthy School program and were less successful in implementing the KEIGAAF

intervention. Interestingly, these schools were also less successful in obtaining the Healthy School certificates. For KEIGAAF to be implemented successfully, it had to be seen as an umbrella intervention (i.e., an approach): where needed, new activities were implemented, but the main focus had to be on strengthening existing activities, combining activities, and making use of local resources. It was not a rival of existing programs, but it rather embraced existing programs and trajectories in becoming a Healthy School.

Intervention effects on PA are limited to the school day

The analyses of the intervention effectiveness on children's PA were limited to children's PA levels on school days. Additional analyses were conducted to see whether the intervention also led to effects on sedentary behavior and PA behavior during the weekend. We included children with at least one valid 'wear day' during the weekend (a wear day was valid when the child wore the accelerometer at least 480 minutes between 06.00 AM and 11.00 PM). Mixed model analysis revealed that there were no significant intervention effects on sedentary behavior, light PA, and MVPA during the weekend between the intervention group and the control group after one and two years (Additional file 8.3: Table 8.5) However, when comparing the comprehensive PA schools and the less comprehensive PA schools with the control group, we found that the children attending the comprehensive PA schools showed a larger reduction in light PA compared to the control group after one year (B = -3.03, 95% CI -6.01; -0.05, p =.05, ES -0.38). This negative intervention effect decreased after two years (Additional file 8.3: Table 8.6). These results suggest that there was no intervention effect on PA behavior in the weekend and that the intervention effectiveness on PA was limited to the school days. However, it should be noted that these results should be interpreted with caution. The sample used for the statistical analysis on intervention effects on PA in the weekend was smaller compared to the sample used for intervention effects on PA on an average school day. Only 71.5%, 64.8%, and 64.5% of the children had valid data on a weekend day at baseline, after one year and after two years, respectively, compared to 88.5%, 84.1%, and 74.6% of the children with valid data on school days. This lack of intervention effectiveness on PA in the weekend is probably due to the focus of the intervention (i.e., school-based) and the limited involvement of parents in the intervention. Another explanation for these results can be that the data recording by the accelerometers in the weekends was less reliable compared to the school days, because children had to remove the accelerometer when taking part in sports (competitions) and swimming. Activities like these are mostly performed in the weekend. This was visible in the average wear time of the accelerometer. Children with valid data recordings wore the accelerometer on average M = 710.70, SD = 115.76 minutes in the weekend, while they wore it longer on school days (M = 781.96, SD = 80.01 minutes).

Methodological considerations

Below are some methodological considerations regarding the evaluation of the implementation and effectiveness of the KEIGAAF intervention provided.

Context evaluation

Given the importance of context in the KEIGAAF intervention, we aimed to gain insight into this context by conducting a school scan, an environmental scan, observations, participating in the meetings of the working groups and the steering committee, and by conducting timeline evaluations. Context is an extremely broad concept and there is no agreed definition [300]. When we referred to context, we meant all circumstances or factors that might play a role in the implementation of an intervention, including the setting (i.e., the physical and social school environments) [209]. Besides physical characteristics like school size, examples of contextual factors and circumstances in a school context are staff connectedness, the role of children in school decision-making, existing collaborations of schools and other sectors, or the interactions between school and parents [300]. These contextual influences are intangible and interact with each other, complicating perception and understanding of a specific context and making context very subjective [300]. Therefore, our evaluation of context is exploratory and imperfect [301], and important contextual information could have been missed due to a too narrow focus, because changes or factors were difficult to detect or because we decomposed a dynamic and systemic context into single factors.

External validity

The KEIGAAF intervention was implemented in a particular context. Eindhoven has a history of industrial and population growth. It is a city of middle-to-large size, with 234,401 inhabitants in 2020. Due to historical events, Eindhoven today has a mix of inhabitants of different nationalities, including Western and non-Western. This mix is different compared to the mix of nationalities in the control region [227]. Besides influencing immigration, historical events also influenced the growth of the intervention region over the years and the current municipality consists of annexed municipalities. The annexed municipalities can still be found in the current city districts and are colloquially referred to as large villages by their inhabitants. The primary schools participating in the intervention were located in four of the seven city districts of Eindhoven, which differed in characteristics, e.g., size, housing, and organizations operating there. The schools were also different in characteristics. All schools were considered low SES schools, based on the residential status score of the school's location as defined by the Netherlands Institute for Social Research, but residential status scores of the schools ranged between -1.56 to 0.13 in 2017 (the average status score in the Netherlands at that time was 0.02) [302]. The schools varied in size (range 118 to 387 children in 2017) and had a differing mix of children of Western and non-Western ethnicity (range 30 to 80 percent children with a migration background in 2017). Besides the many factors

mentioned in Chapter 5, these differences in contextual factors at school and regional level explain to some degree the differences in implementation of the intervention in the schools. However, there were many more factors, like the limited amount of money available for the regional public health service to coordinate school health promotion, or national concerns about implementation of water policies at schools at that time that played a role in the implementation of the KEIGAAF intervention. All these contextual factors interacted with each other and influenced implementation, making implementation and the resulting intervention effects time- and context-specific, possibly impacting the transferability of the results to other contexts [303]. However, the summary of the contextual insights provided in Chapter 5, although not exhaustive, might help researchers in judging the relevance of these findings for another context by comparing the other context with this context [304].

Sampling

Instead of randomizing schools to an intervention or a control group, we used a convenience sample of intervention schools and compared these to schools located in another region. For many years now, a randomized controlled trial has been the gold standard. However, in randomized controlled trials, it is not the implementation context that is used to explain differences between the intervention group and control group, but the absence of the intervention in the control region [35]. Yet, given that the KEIGAAF intervention was implemented in a natural setting and the interaction of the intervention with its context was important, randomization was considered inappropriate and impractical [305-307]. We included a convenience sample of low SES schools that were willing to actively participate in the KEIGAAF intervention, which is common in co-creation interventions [308]. To interpret intervention effects, we compared effects on intervention children's BMI z-score and energy balance-related behaviors with changes in BMI z-score and energy balance-related behaviors of children of control schools. However, we could only include three control schools, which is a low number compared to the eight intervention schools. Besides, although the control schools did not implement the KEIGAAF intervention, they were subjected to other health-promoting initiatives (including the Healthy School program). The control region implemented the Dutch EPODE approach named JOGG (a Dutch acronym for 'Jongeren Op Gezond Gewicht'). The JOGG approach is an intersectoral community approach aimed at reducing childhood obesity by promoting a healthy lifestyle in children [43, 279]. The approach has a strong focus on promoting the consumption of water among children [281]. Observations during the measurement periods, the results of the school scan, and information from the JOGG coordinator showed us that the control schools actively participated in this approach. Having this insight into the JOGG approach implemented in the control region enabled us to interpret the negative intervention effects on children's consumption of water and sugar-sweetened beverages at school. It also taught us that it is valuable to gain contextual insights in control regions when conducting real life controlled intervention studies.

Measurement instruments

To measure intervention effects, we evaluated changes in children's BMI z-score and energy balance-related behaviors. We aimed to conduct the measurements in as reliable a manner as possible in a practical setting. We objectively assessed BMI z-score and PA levels during schooldays. However, objective assessments of PA are subject to some limitations that deserve additional attention in this paragraph. The data were limited to children who had valid data recording on school days for at least two days. Given the nature of the intervention, we focused on intervention effects on PA levels during schooldays. At baseline, 463 children of the 523 children (86%) had valid data recordings during school days. Wear time was affected by the prohibition of wearing the accelerometer during water-related activities, including swimming. Additionally, wear time was limited by other factors, like sports coaches requesting children to remove the accelerometer when performing sports (competitions) like judo or boxing. Given the limitations of accelerometers, intervention effects on other outcomes like well-being should be measured, to generate a fuller picture of how children's lives and health are impacted by the intervention [162].

Another limitation of the data collection tools was the use of questionnaires to assess children's nutrition behavior. Since it was impractical to objectively measure children's nutrition behavior (e.g., through observational evaluation measurements), we used questionnaires. By using child questionnaires, we ensured that we collected data of almost all study participants, because children filled in this questionnaire at school. However, this questionnaire was limited to nutrition behavior at school and did not provide very detailed information because it was simplified for child use (the youngest children were aged 7 years old). Nevertheless, all children, even the youngest ones, were able to fill in the questionnaire. Because of the limitations of the child questionnaire , we also used a parent questionnaire. Although, the parent questionnaire provided more detailed information on children's daily nutrition behavior, there were also some limitations related to this measurement instrument. The response rate of the questionnaire was ± 62%. The majority (67.8%) of this subsample consisted of parents of a child of Western origin (based on the birth countries of both parents), while the total sample of children consisted of 57.1% Western children and 42.9% non-Western children. This means that the results are slightly less representative for the whole sample. Reasons for the lower response rate among non-Western parents are purely speculative. A second limitation of the questionnaire is that it is impossible to measure nutrition behavior perfectly via a questionnaire, due to the complexity of the behavior. Although most children probably have an average consumption pattern, children's consumption patterns evolve over time (acquiring new preferences or dislikes) and exceptions to these patterns (e.g., occasional consumption of candies) make it difficult for parents to report children's average nutrition behavior in a questionnaire. In addition, parents of children in this age range do not always know what children consume when they are outside the home, i.e., at school or at a friend's place. The final limitation is related to the nutrition data. The distribution of the nutrition data was skewed (which is often seen with nutrition data [309]). Therefore, it was decided to transform the continuous nutrition data into binary data, rendering the information less rich.

Lessons learned

Several lessons were learned while implementing and evaluating the KEIGAAF intervention. Based on these lessons learned and theoretical recommendations provided in the literature concerning comprehensive school health promotion, parts of the KEIGAAF intervention can or even should be improved when implementing the intervention in the future.

Implementing a family-based intervention to improve the home environment

Important lessons were learned from the implementation of the family-based intervention: implementing a family-based intervention requires time and insight into parental needs, interests, and successful recruitment strategies. However, an indirect parental involvement intervention in which parents and children participate together has the potential to reach many parents. First, in comparison to the time and energy used to set up the school-based intervention, too little time and energy were used to develop and implement the family-based intervention. Other family-based interventions used a preparatory phase in which qualitative research was conducted to assess parental needs, barriers to participation, and/or effective recruitment strategies before developing the intervention (e.g., [310-312]). We used only a limited amount of time for the family-based intervention and did not study parental needs and potential effective recruitment strategies for our target population. Second, the family-based intervention was not in line with the action-oriented approach applied in the school-based intervention in which working groups developed and implemented the intervention according to their needs and possibilities (Chapter 3 and Chapter 5). Instead, the family-based intervention was developed and implemented top-down; assumptions were based on theoretical insights and experiences of professionals, but not on the target population's needs. By involving the parents in intervention development and implementation, the intervention could have been effectively tailored to the target population, thereby increasing adherence [308]. Third, we learned that the indirect alternative to parental involvement turned out to be a promising strategy in engaging parents (Chapter 6). It is likely that the intervention was successful in reaching many parents, because parents executed the activities together with their children, which parents prefer when participating in interventions, and because they could perform the activities at a convenient moment at home [312]. However, it remains unknown whether this indirect parental involvement intervention was effective in changing the home environment (e.g., paying more attention to healthy nutrition and PA by parents, promoting parent-child play, or supporting the consumption of healthy nutrition and PA at home) [237].

School as a setting to promote healthy nutrition behavior

In contrast to the favorable intervention effects on children's BMI z-score and MVPA level, negative intervention effects on children's nutrition behavior were found when compared to the control group. Although intervention children's water consumption increased and intake of sugar-sweetened beverages decreased at school, the effects were smaller compared to the control group. In addition, consumption of water and sugar-sweetened beverages on a daily basis and the intake of other foods (i.e., fruit, vegetables and snacks) did not improve significantly (Chapter 7). These results were not surprising, in view of the results of our (Chapter 2) and other reviews (e.g., [53, 237]), which show that school-based interventions with parental involvement, even direct parental involvement, showed inconclusive results concerning intervention effectiveness on children's dietary intakes. The involvement of parents in these interventions, even if parents are directly involved, is probably inadequate to change children's nutrition behavior [37]. The role of parents regarding children's nutrition behavior is larger than the role of schools [114] and children's nutrition behavior is seen as parents' main responsibility by parents and by schools [118, 312]. In the Netherlands, parents influence not only children's breakfast consumption and nutrition intake during dinner, but also determine what is consumed during lunch [278]. Therefore, it is important that schools and parents align their views on children's nutrition behavior and work together in the promotion of children's nutrition behavior [118]. Changing children's nutrition behavior in the school setting likely requires a more rigorous approach, like offering a healthy lunch at school. However, such an approach requires major financial support and schools that are willing to implement a disruptive intervention [313-315]. Additionally, it is then still up to the parents to maintain these healthy school practices in the home environment [316]. To support parents in this, interventions are then needed that reach the home environment [238], e.g., online or via home visits [317]. Implementing these home-based interventions is not an easy task: it takes time and a lot of effort to recruit parents [318]. Besides, parents experience many barriers to participating in these interventions, like time or participation concerns [318]. However, once parents decide to take part in the intervention, attrition rates are low and the intervention can lead to promising changes in children's nutrition behavior [317].

Child involvement

The intervention was a co-creation intervention, in which actors from the intervention setting (e.g., teachers, parents, local professionals), non-academic stakeholders (e.g., a school board, a social work organization, the municipality, the Municipal Health Service, a sports support organization), and academic researchers collaborated. When implementing an intervention in the school setting aimed at increasing children's PA and promote healthy nutrition behaviors, it is advised to also include the children in the intervention and even have them involved as change agents [122, 220, 223]. As in many interventions, the children were minimally involved in the development of the activity plans by the working groups [319]. In three schools, children were to a certain degree involved in the intervention design: in the form of a child council, semi-structured interviews conducted with children about requirements and needs concerning recess

activities [320], and a photo-voice study to map the child's environment regarding PA and healthy nutrition [321]. However, most working groups did not use an aforementioned form, but discussed their ideas with the children and/or modified activities based on children's reactions to the activity. Thus, in most schools, working groups developed the activities based on their perspectives and experiences, and they voiced the needs of the children. However, by involving the end-users, implementers can ensure that an intervention truly fits local needs [319]. Children between the ages of 9 and 12 years are well able to voice their ideas, and they enjoy and appreciate being part of the development process of activities [260]. Activities that are developed by or with children suit children's interests much more than activities developed without their participation. However, the process of genuinely involving children in intervention development should not be underestimated. It takes time, money, and staff resources to build trust between adults and children, to involve children, and train children to participate [322]. Besides, adults have to be trained as well in how to involve children in intervention development [260]. Children need the help of adults to voice and execute their ideas, suggesting that a strong collaboration between adults and children is required when involving children in intervention development [260]. Perhaps the requirement of time, money and staff resources was also the limitation for working groups to involve children more in their intervention design. Additionally, although two working groups were supported in conducting semi-structured interviews with children and conducting a photo-voice study by external staff, most working groups were not advised to build structures of child involvement in the intervention design, nor supported to do this. However, it is possible that the KEIGAAF intervention could have benefited from more involvement of the children in the development of activities that fit the needs of children [322]. Furthermore, research shows that children may also benefit from their involvement in intervention development and research: children's social-emotional and cognitive development, and their skills as agents of change are found to improve, as does their knowledge about the topic of intervention [322].

Intersectoral collaboration

Although the outputs of working groups may differ, it is important that the activities (existing and new ones) form a comprehensive whole. In a comprehensive PA promotion approach, PA is promoted during physical education, during school hours (e.g., during recess and during educational hours, for example, in the form of energizers), and before and after school (e.g., after school sports and active transportation to school). Staff are involved in this approach as well as the community and parents [14]. Implementing such an approach requires intersectoral collaboration and a focus beyond the school premises [286]. Intersectoral collaborations are critical for the implementation of a comprehensive approach, given the fact that most partners operate outside of schools and can have a leading role in implementing activities or changes beyond the school premises. Inside and outside of the working groups, teachers collaborated with partners in designing and implementing their action plans, and partners came and went depending on the action plans. However, creating successful intersectoral collaborations was one of the biggest challenges for teachers in the working groups, and in reality,

intersectoral collaborations were limited (Chapter 5). Partnerships were not strong and although schools and potential partners might have had the same intentions, they struggled to join forces to achieve common goals. Generally, schools look upon partners from a limited and school-oriented point of view. Partners are viewed as someone who can help the schools to meet their aims, for example, by providing the schools with something (e.g., implementing activities, delivering materials). However, partnerships should be mutually supportive, and partners should have a mutual commitment toward common goals [223]. To create successful intersectoral collaboration, stakeholders should be capable of collaborating with partners from different sectors and they should be motivated and have the opportunity to do so [323]. If these determinants are not present or are suboptimal, intervention is needed (e.g., educating, enabling, persuading) [323]. Although the HP advisors tried to connect schools with potential partners, discussed the issues of intersectoral collaboration with the steering committee, and brought the chairs of the working groups together to share ideas and discuss with which partners they collaborated to learn from each other, intervention strategies were too limited to stimulate intersectoral collaboration. The HP advisor and steering committee could have assisted working groups more in obtaining intersectoral collaboration by training working group members and school staff in intersectoral collaboration. Working group members tended to stick to common practice, while it is important in intersectoral collaboration that partners do not only focus on their own area of interest and expertise, but also move out of their 'comfort zone' [323]. Aiming to implement a comprehensive approach with partners can lead to the development of certain activities that are not so easy to implement and that entail excellent communication, task division, and thus extra efforts. Because of this, it is easy to discard these ideas and focus on the easy-to-implement activities [286] and the own setting. The HP advisor should ensure that activities are implemented together with partners that make school health promotion comprehensive, while keeping the working group members motivated and interested in implementing those activities that are relatively difficult, less fun to implement, or too innovative. In this case, top-down support is very important. Managers should show their trust in the plans, support in building relationships with potential partners and convince colleagues of the working group members in case of doubt or resistance. The HP advisor can assist in gaining this managerial support.

Recommendations for practice

The KEIGAAF intervention is a process of changes in a particular context [131]. The results of the intervention are time- and context-specific. However, the intervention can be disseminated to other contexts and may lead to similar results when implementers adhere to the key functions of the intervention – creating a healthy environment in the school and home setting (and preferably the broader community setting), ensuring contextual fit, and creating long-term, sustainable changes [205]. By transferring the key elements of the intervention – local intersectoral working groups that are responsible for the development and implementation of activity plans, an HP advisor or advisors to guide the working groups, and a steering committee that provides the basic principles

for the intervention and support in implementation – other contexts can adhere to these key functions. It is advised to use a cascade model for the dissemination of locally-generated outputs – locally developed and implemented successful activities in the KEIGAAF intervention can serve as inspiration for others, but can be adapted to fit local needs [308]. For the HP advisor involved in the implementation of the KEIGAAF intervention, practical recommendations were provided in Chapter 5. Below we outline additional recommendations for practice when implementing interventions like the KEIGAAF intervention in other school contexts, based on the results of the studies included in this dissertation. Given the intertwined nature of research and practice, recommendations for both implementation and evaluation are provided. In some cases, recommendations apply to both.

Flexibility, flexibility, flexibility

It is important to have a flexible attitude when implementing the KEIGAAF intervention. Schools' reactions to external interventions are unpredictable and non-linear [120, 295]. This is because schools consist of many actors, interacting with each other and changing over time. These dynamics influence intervention implementation and require flexibility on the part of health promotors and other stakeholders (like a steering committee) when guiding schools in the implementation of the intervention. A one-size-fits-all guiding approach is inappropriate. Instead, health promotors have to decide for each school which guidance is required and which step has to be taken next. Additionally, a flexible and receptive approach is required in the evaluation of the process by researchers [324]. It might turn out that certain measurement instruments are inappropriate and have to be replaced by other measurement tools. For example, the high turnover of employees and working groups members (which was not anticipated beforehand) did not allow data collection on team climate, so another measurement instrument (timeline sessions) was chosen. Which even seemed to provide more valuable data on the process.

Choose your outcome measures wisely

Formal evaluation of intervention effectiveness shows whether the intervention actually resulted in positive changes in the targeted problem. Formal evaluation is in most cases focused on health outcomes at the individual level. However, such outcomes do not tell us all we need to know to be able to evaluate implementation success [296]. For example, they do not provide insight into organizational changes [35]. Besides, health behavior change is difficult to achieve through school-based interventions alone [35]. We need to understand the intervention process and the changes occurring within the implementation context to evaluate an intervention's (potential) effectiveness [35, 296]. Therefore, it is recommended that effects are evaluated on intermediate individual

level outcomes, like knowledge, attitudes, motivation, behavioral intentions, and personal skills, and that changes in social action (e.g., participation of children, school staff, parents, and the formation of collaborations) be studied as well as changes in and influences of the broader context (e.g., policies, healthy environments, supportive economic conditions, and positive school culture towards HP) [35]. This requires other types of research designs than the randomized controlled trials to study intervention effectiveness and the traditional 'fidelity to form' evaluations in which researchers attempt to quantify implementation [35, 204, 205]. The implementation evaluation should focus on the interaction of the context with the intervention, which does not consist of a linear cause-effect relationship [324]. Insights in intervention effectiveness, the implementation context, and the interaction of the intervention with the context should be obtained by using mixed methods [324], such as conducting quantitative effectiveness trials in addition to qualitative process research (e.g., individual interviews, (participatory) observations, informal conversations with stakeholders, and evaluations with the implementers and end-users). To collect these data, a researcher should be part of the intervention setting. Useful insights are gained when 'reading between the lines' and further exploring potentially interesting observations or comments made, even when they might seem futile at first. To be able to do this, the researcher should become a familiar face within the intervention setting. While collecting these data, the researcher should take a step back regularly, analyze the data at a more abstract level, and interpret the findings. Then, these findings should be reported to the stakeholders for verification and to improve the intervention process, before continuing data collection [324]. Tactical decisions should be made on how these data are reported to ensure that the stakeholders benefit the most from the data and that the trust relationship is maintained. Stakeholders in school-based interventions place more value on outcomes like learning abilities and achievements, behaviors affecting health, and physical and psycho-social environments, whereas the health sector tends to evaluate outcomes related to children's health status [325]. Therefore, to ensure relevance of data for stakeholders, outcome measures should be chosen in collaboration with stakeholders and they should be involved in the evaluation process [325].

Professionalization of the HP advisor

The HP advisor played a key role in the implementation of the KEIGAAF intervention. The HP advisor has to have a set of diverse skills to support the working groups. The advisor advises on PA and nutrition-related interventions, assists a group of professionals with differing organizational goals, and advises working groups regarding the changes needed to implement a comprehensive approach. In addition, he/she combines top-down forces with bottom-up influences. To perform these tasks, it is important that there is a relationship of trust between the HP advisor and intervention stakeholders [215]. Performing these tasks requires specific skills, such as leadership, management, planning, and evaluation [215, 286]. Furthermore, the advisor should apply these skills in a particular context and be knowledgeable about this context. Although some skills can be acquired through training, it requires special personal characteristics, like flexibility, enthusiasm, and perseverance, to be able to perform the role of HP advisor [326].

Find your champions

In a flexible and open intervention like the KEIGAAF intervention it is important that all actors involved – academic and non-academic – understand and agree on the aim of the intervention [122]. The intervention is a process; it is not a prepackaged program to be implemented. At the beginning of the intervention, it may be difficult to see the end-result. Where does the process lead to? What's in it for me? And what's expected of me? These questions should be addressed during the preparatory phase of the intervention. It is important that the functions of the intervention are made clear to everybody involved [301]. Misunderstandings might lead to ineffective implementation [122]. Therefore, this process of explaining the intervention was repeated many times. However, sometimes it appeared as if the intervention was misunderstood by working groups, while in reality there was no readiness to change. Readiness to change and actively participate in the intervention was one of the main preconditions of the KEIGAAF intervention. Sometimes, it appeared that the wrong persons participated in the working groups and that implementation flourished when there was a turnover in participants. Teachers became involved who were willing to change, were enthusiastic about the intervention and able to involve others in the implementation. These persons acted as champions. It is possible that a champion or multiple champions are not present in the initial stages of implementation, but that their role evolves over time. Therefore, it is recommended to take the time to create relationships with the working groups and other stakeholders and find the champions who should be involved in the intervention [122].

Long-term investment

It takes time to implement an intervention like the KEIGAAF intervention; at least three years were needed for preparation and implementation. Most of the time and effort were needed to invest in relationships, to become familiar with the context, to build networks, to create readiness among other school staff, to identify needs and discuss actions to address those needs. These steps are all part of the preparing and planning phase [223]. It is a process that not only takes place before implementation, but one that continues during implementation. This process is of utmost importance and should not be underestimated nor rushed. At least one year of preparation was needed before implementation could be started by the first working groups. It should be acknowledged that some working groups even needed more time before implementation could take place. Therefore, it is highly recommended to take at least three years to actively support schools in preparation and implementation. During this phase, it is important to focus on the sustainability of the actions from the start: activities should be implemented continuously (instead of sporadically), they should be included in school policies and become embedded in organizational practices. Furthermore, school leadership in HP should be created [220]. To facilitate the sustainability of actions, performance should be monitored and progress should be evaluated [220].

Conclusion

The KEIGAAF intervention is a PA and nutrition intervention implemented mainly in the primary school environment. Because the intervention was context-based, the implementation and outputs of the intervention differed highly between working groups. Mutual adaptation, in which adaptation of top-down support to bottom-up development of activities occurred simultaneously with adaptation of bottom-up activity to top-down intervention principles, was a key element of the intervention. The HP advisors played a key role in obtaining mutual adaptation in intervention development and implementation in the intervention schools. This process was complex; it took a long time and intervention effects were mainly visible after one year of preparation and two years of implementation, underlining the importance of long-term, sustained interventions. After two years of implementation, the intervention resulted in an improvement in children's BMI z-score and prevented an age-related decline in moderate-to-vigorous PA, especially of vulnerable children. These effects were mainly present in schools that implemented a comprehensive PA approach.

Although the home environment is an important environment influencing children's energy balance-related behavior, the challenges regarding recruiting parents for an energy balance-related parenting intervention made us operationalize the family-based component of the intervention differently: parents were mainly involved indirectly in the intervention by supporting the implemented activities at school and by performing energy balance-related activities together with their child. This latter part of the KEIGAAF intervention ensured engagement of many children and parents. This flexible approach to intervention development, implementation, and evaluation was inherent to the KEIGAAF intervention.

Appendices Chapter 8

Additional file 8.1. Intervention effects on waist circumference

Table 8.1. Change in waist circumference of intervention group and control group after one and two years (Model 1) and one- and two-year intervention effects (Model 2).

		Model 1							Model 2		
		Intervention group (N = 419)			Control group (N = 104)			Intervention group vs. control group		
		N	Mean (SD)[a]	B (95% CI)[b]	p	N	Mean (SD)[a]	B (95% CI)[b]	p	B (95% CI)[b]	p	ES[c]
Waist cir-	T0	401	62.73 (8.49)			99	63.21 (8.38)					
cumference	T1	384	65.45 (9.43)	**2.51 (2.08; 2.93)**	**0.00**	91	66.50 (9.10)	**3.25 (2.57; 3.93)**	**0.00**	-0.77 (-1.70; 0.15)	0.10	-0.08
(cm)	T2	357	68.49 (9.96)	**5.73 (5.23; 6.23)**	**0.00**	83	69.54 (9.01)	**7.01 (6.08; 7.95)**	**0.00**	**-1.31 (-2.43; -0.19)**	**0.02**	-0.14

Note. Model 1: predictor variable is time (reference group = baseline measurement) / Model 2: predictor variable is time*condition (reference group = baseline measurement*control group). Analyses were conducted with repeated measures linear mixed model analysis adjusting for child age, gender, ethnicity, and residential socioeconomic status score at baseline. T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, SD = standard deviation, B = unstandardized beta coefficient, CI = confidence interval, p = p-value, ES = effect size. Bold numbers are significant at p <.05. [a]Mean is the observed waist circumference of participants with data. [b]Unstandardized beta coefficient of linear mixed models. [c]Cohen's d effect size, calculated with estimated means of linear mixed models.

Table 8.2. Observed waist circumference for: (1) the comprehensive PA intervention group; (2) the less comprehensive PA intervention group; and (3) the control group, and intervention effects after one and two years comparing (1), (2) and (3).

		(1) (N = 141)		(2) (N = 278)		(3) (N = 104)		(1) vs (3)			(2) vs (3)			(1) vs (2)		
		N	Mean (SD)[a]	N	Mean (SD)[a]	N	Mean (SD)[a]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]
Waist circumference	T0	133	63.95 (9.24)	268	62.13 (8.05)	99	63.21 (8.38)	Ref1			Ref1			Ref2		
(cm)	T1	130	66.08 (9.45)	254	65.13 (9.42)	91	66.50 (9.10)	**-1.33 (-2.41; -0.25)**	**0.02**	**-0.13**	-0.47 (-1.43; 0.50)	0.34	-0.05	-0.86 (-1.72; 0.00)	0.05	-0.07
	T2	117	69.16 (10.11)	240	68.17 (9.90)	83	69.54 (9.01)	**-1.70 (-3.02; -0.38)**	**0.01**	**-0.17**	-1.09 (-2.27; 0.08)	0.07	-0.11	-0.61 (-1.65; 0.44)	0.25	-0.05

Note. Analyses were conducted with repeated measures linear mixed model analysis. Predictor variable is time*condition (Ref1 = baseline measurement*control, Ref2 baseline measurement*less comprehensive PA promoting approach). Analyses were adjusted for child age, gender, ethnicity, BMI z-score at baseline, and residential socioeconomic status score at baseline. (1) comprehensive PA promoting approach, (2) less comprehensive PA promoting approach, (3) control group, BMI = Body Mass Index, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, SD = standard deviation, B = unstandardized beta coefficient, CI = confidence interval, p = p-value, ES = effect size, Ref = reference. Bold numbers are significant at p <.05. [a]Mean is the observed waist circumference of participants with data. [b]Unstandardized beta coefficient of linear mixed models. [c]Cohen's d effect size, calculated with estimated means of linear mixed models.

Table 8.3. Change in physical fitness level (PACER 15M) of intervention group and control group after one and two years (Model 1) and one- and two-year intervention effects (Model 2).

		Model 1								Model 2		
		Intervention group (N = 419)				Control group (N = 104)				Intervention group vs. control group		
		N	Mean (SD)[a]	B (95% CI)[b]	p	N	Mean (SD)[a]	B (95% CI)[b]	p	B (95% CI)[b]	p	ES[c]
PACER 15 M	T0	400	21.50 (10.73)			98	22.91 (11.02)					
(laps)	T1	343	26.71 (13.34)	**5.35 (4.29; 6.41)**	**0.00**	87	26.84 (14.29)	**3.41 (1.50; 5.33)**	**0.00**	1.91 (-0.41; 4.24)	0.11	0.16
	T2	241	31.94 (15.25)	**9.52 (8.45; 10.89)**	**0.00**	77	27.73 (13.89)	**3.74 (1.28; 6.21)**	**0.00**	**5.86 (3.01; 8.71)**	**0.00**	0.49

Note. Model 1: predictor variable is time (reference group = baseline measurement) / Model 2: predictor variable is time*condition (reference group = baseline measurement*control group). Analyses were conducted with repeated measures linear mixed model analysis adjusting for child age, gender, ethnicity, BMI z-score at baseline, and residential socioeconomic status score at baseline. PACER = Progressive Aerobic Cardiovascular Endurance Run, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, SD = standard deviation, B = unstandardized beta coefficient, CI = confidence interval, p = p-value, ES = effect size.Bold numbers are significant at p <.05. [a]Mean is the observed PACER 15 M score of participants with data. [b]Unstandardized beta coefficient of linear mixed models. [c]Cohen's d effect size, calculated with estimated means of linear mixed models.

Table 8.4. Observed physical fitness level (PACER 15M) for: (1) the comprehensive PA intervention group; (2) the less comprehensive PA intervention group; and (3) the control group, and intervention effects after one and two years comparing (1), (2) and (3).

		(1) (N = 141)		(2) (N = 278)		(3) (N = 104)		(1) vs (3)			(2) vs (3)			(1) vs (2)		
		N	Mean (SD)[a]	N	Mean (SD)[a]	N	Mean (SD)[a]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]
PACER 15M (laps)	T0	133	23.36 (11.45)	267	20.57 (10.24)	98	22.91 (11.02)	Ref1			Ref1			Ref2		
	T1	119	27.51 (14.31)	224	26.29 (12.81)	87	26.84 (14.29)	0.65 (-2.08; 3.38)	0.64	0.05	**2.57 (0.14; 5.01)**	**0.04**	**0.22**	-1.92 (-4.11; 0.26)	0.09	-0.14
	T2	109	32.02 (15.83)	132	31.88 (14.82)	77	27.73 (13.89)	**5.07 (1.78; 8.35)**	**0.00**	**0.42**	**6.18 (3.10; 9.26)**	**0.00**	**0.52**	-1.11 (-3.89; 1.67)	0.43	-0.08

Note. Analyses were conducted with repeated measures linear mixed model analysis. Predictor variable is time*condition (Ref1 = baseline measurement*control, Ref2 = baseline measurement*less comprehensive PA promoting approach). Analyses were adjusted for child age, gender, ethnicity, BMI z-score at baseline, and residential socioeconomic status score at baseline. (1) comprehensive PA promoting approach, (2) less comprehensive PA promoting approach, (3) control group, PACER = Progressive Aerobic Cardiovascular Endurance Run, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, SD = standard deviation, B = unstandardized beta coefficient, CI = confidence interval, p = p-value, ES = effect size, Ref = reference. Bold numbers are significant at p <.05. [a]Mean is the observed PACER 15 M score of participants with data. [b]Unstandardized beta coefficient of linear mixed models. [c]Cohen's d effect size, calculated with estimated means of linear mixed models.

Additional file 8.3. Intervention effects on PA behavior during weekend

Table 8.5. Change in sedentary and PA behavior of intervention group and control group after one and two years (Model 1) and one- and two-year intervention effects (Model 2).

		Model 1								Model 2		
		Intervention group (N = 419)				Control group (N = 104)				Intervention group vs. control group		
		N	Mean (SD)[a]	B (95% CI)[b]	p	N	Mean (SD)[a]	B (95% CI)[b]	p	B (95% CI)[b]	p	ES[c]
%SB	T0	306	60.39 (9.67)			68	62.28 (10.73)					
	T1	255	62.60 (10.70)	**2.92 (1.41; 4.45)**	**0.00**	54	60.18 (10.24)	1.64 (-2.47; 5.75)	0.43	1.17 (-2.10; 4.45)	0.48	0.06
	T2	242	65.56 (10.01)	**7.76 (6.04; 9.48)**	**0.00**	45	65.31 (11.06)	**6.56 (1.35; 11.76)**	**0.01**	1.59 (-2.04; 5.22)	0.39	0.08
%LPA	T0	306	31.75 (7.13)			68	30.70 (8.03)					
	T1	255	29.79 (7.13)	**-2.50 (-3.63; -1.36)**	**0.00**	54	31.62 (8.11)	-1.12 (-4.11; 1.88)	0.46	-1.34 (-3.77; 1.10)	0.28	-0.09
	T2	242	26.92 (6.82)	**-6.64 (-7.87; -5.40)**	**0.00**	45	28.07 (8.70)	**-4.45 (-8.46; -0.43)**	**0.03**	-2.32 (-4.94; 0.29)	0.08	-0.16
%MVPA	T0	306	7.86 (4.23)			68	8.01 (4.37)					
	T1	255	7.61 (4.78)	-0.43 (-1.07; 0.22)	0.19	54	8.19 (3.84)	-0.45 (-2.15; 1.24)	0.60	0.18 (-1.20; 1.57)	0.79	0.02
	T2	242	7.53 (4.86)	**-1.12 (-1.90; -0.33)**	**0.01**	45	6.62 (3.59)	-1.65 (-3.49; 0.19)	0.08	0.69 (-0.92; 2.30)	0.40	0.08
CPM	T0	306	1211.34 (471.03)			68	1174.07 (417.60)					
	T1	255	1130.75 (526.47)	**-107.74 (-181.74; -33.74)**	**0.00**	54	1215.49 (409.16)	-33.69 (-211.41; 144.04)	0.71	-41.78 (-198.54; 114.99)	0.60	0.07
	T2	242	1047.42 (475.07)	**-275.33 (-357.95; -192.70)**	**0.00**	45	987.75 (378.35)	**-226.89 (-420.84; -32.94)**	**0.02**	-24.63 (-190.60; 141.35)	0.77	-0.03

Note. Model 1: predictor variable is time (reference group = baseline measurement) / Model 2: predictor variable is time*condition (reference group = baseline measurement*control group). Analyses were conducted with repeated measures linear mixed model analysis adjusting for child age, gender, ethnicity, BMI z-score at baseline, residential socioeconomic status score at baseline, and weather conditions (i.e., sunshine, temperature and precipitation). SB = Sedentary behavior, LPA = light physical activity, MVPA = moderate-to-vigorous physical activity, CPM = counts per minute, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, SD = standard deviation, B = unstandardized beta coefficient, CI = confidence interval, p = p-value, ES = effect size. Bold numbers are significant at p <.05. [a]Mean is the observed PA levels of participants with data. [b]Unstandardized beta coefficient of linear mixed models. [c]Cohen's d effect size, calculated with estimated means of linear mixed models.

Table 8.6. Observed sedentary and PA behavior for: (1) the comprehensive PA intervention group; (2) the less comprehensive PA intervention group; and (3) the control group, and intervention effects after one and two years comparing (1), (2) and (3).

		(1) (N = 141)		(2) (N = 278)		(3) (N = 104)		(1) vs (3)			(2) vs (3)			(1) vs (2)		
		N	Mean (SD)[a]	N	Mean (SD)[a]	N	Mean (SD)[a]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]
SB (%)	T0	89	58.40 (8.92)	217	61.21 (9.86)	68	61.28 (10.73)									
	T1	81	63.68 (9.65)	174	62.10 (11.14)	54	60.18 (10.24)	3.37 (-0.66; 7.40)	0.10	0.32	0.19 (-3.26; 3.63)	0.92	0.02	3.18 (-0.24;6.61)	0.07	0.20
	T2	76	64.72 (11.13)	166	65.94 (9.46)	45	65.31 (11.06)	2.60 (-1.62; 6.82)	0.23	0.25	1.40 (-2.43; 5.23)	0.47	0.13	1.20 (-2.16; 4.55)	0.48	0.08
LPA (%)	T0	89	33.32 (6.99)	217	31.11 (7.11)	68	30.70 (8.03)									
	T1	81	28.67 (6.87)	174	30.31 (7.77)	54	31.63 (8.11)	-3.03 (-6.01; -0.05)	0.05	-0.38	-0.58 (-3.13; 1.99)	0.66	-0.07	-2.46 (-4.99; 0.06)	0.06	-0.21
	T2	76	27.44 (7.26)	166	26.68 (6.61)	45	28.07 (8.70)	-3.04 (-6.09; 0.00)	0.05	-0.38	-2.21 (-4.98; 0.55)	0.12	-0.25	-0.83 (-3.27; 1.60)	0.50	-0.07
MVPA (%)	T0	89	8.28 (4.00)	217	7.68 (4.32)	68	8.01 (4.37)									
	T1	81	7.66 (4.85)	174	7.59 (4.76)	54	8.19 (3.84)	-0.24 (-1.95; 1.47)	0.78	-0.05	0.39 (-1.07; 1.85)	0.60	0.08	-0.63 (-2.09; 0.82)	0.39	-0.09
	T2	76	7.84 (5.59)	166	7.38 (4.50)	45	6.62 (3.59)	0.38 (-1.49; 2.24)	0.69	0.08	0.80 (-0.89; 2.50)	0.35	0.16	-0.73 (-1.90; 1.05)	0.57	-0.06

		(1) (N = 141)		(2) (N = 278)		(3) (N = 104)		(1) vs (3)			(2) vs (3)			(1) vs (2)		
		N	Mean (SD)[a]	N	Mean (SD)[a]	N	Mean (SD)[a]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]	B (95% CI)[b]	p	ES[c]
CPM	T0	89	1265.03 (397.46)	217	1189.32 (497.24)	68	1174.07 (417.60)	Ref1			Ref1			Ref2		
	T1	81	1113.02 (501.33)	174	1139.00 (538.99)	54	1215.49 (409.17)	-114.86 (-307.94; 78.21)	0.24	-0.23	-8.35 (-173.72; 157.03)	0.92	-0.01	-106.52 (-270.38; 57.34)	0.20	-0.14
	T2	76	1070.23 (492.76)	166	1036.97 (467.90)	45	987.75 (378.35)	-56.71 (-249.66; 136.25)	0.56	-0.11	-19.96 (-195.29; 155.36)	0.82	-0.04	-36.75 (-190.73; 117.24)	0.64	-0.05

Note. Analyses were conducted with repeated measures linear mixed model analysis. . Predictor variable is time*condition (Ref1 = baseline measurement*control, Ref2 = baseline measurement*less comprehensive PA promoting approach). Analyses were adjusted for child age, gender, ethnicity, BMI z-score at baseline, and residential socioeconomic status score at baseline, and weather conditions (i.e., sunshine, temperature and precipitation). (1) comprehensive PA promoting approach, (2) less comprehensive PA promoting approach, (3) control group, BMI = Body Mass Index, T0 = baseline measurement, T1 = measurement at year one, T2 = measurement at year two, SD = standard deviation, B = unstandardized beta coefficient, CI = confidence interval, p = p-value, ES = effect size, Ref = reference. Bold numbers are significant at p <.05. [a]Mean is the observed PA levels of participants with data. [b]Unstandardized beta coefficient of linear mixed models. [c]Cohen's d effect size, calculated with estimated means of linear mixed models

Impact paragraph

Conclusions of this dissertation

The main goal of this dissertation was the implementation and evaluation of KEIGAAF. The KEIGAAF intervention was a flexible and context-based physical activity and nutrition intervention implemented in primary schools located in low socio-economic neighborhoods in Eindhoven, the Netherlands.

An essential element of this intervention was mutual adaptation in intervention development and implementation. During mutual adaptation, top-down and bottom-up forces meet and are combined. The navigation between top-down and bottom-up influences was not an easy process, given the myriad of factors influencing the implementation of a flexible and context-based intervention. This mutual adaptation resulted in a tailored intervention on the promotion of physical activity behavior and healthy nutrition in primary schools. Implementing such an intervention consists of a long-term process (taking up at least one year of preparation and two years of implementation), the involvement of multiple stakeholders and, skilled advisors to support the implementation.

The KEIGAAF intervention led to improvements in children's BMI z-score and moderate-to-vigorous physical activity (PA) behavior after two years, especially children of vulnerable populations. The most favorable results concerning children's BMI z-score and PA behavior were seen when working groups implemented a comprehensive PA approach. In a comprehensive PA promotion approach, PA is promoted during physical education, during school hours (e.g., during recess and during educational hours, for example, in the form of energizers), and before and after school (e.g., after school sports and active transportation to school). Staff are involved in this approach as well as the community and parents [14]. Not all schools were able to implement a comprehensive approach. The ones that had the most vulnerable population (in terms of ethnicity and educational level of the parent) and in need for improvement in sedentary and PA behavior succeeded in implementing such approach.

The studies described in this dissertation have generated knowledge for science and for practice on the implementation and evaluation of school health promotion. In addition, the implementation of the KEIGAAF intervention has led and will lead to social changes. Firstly, the implementation and evaluation of the KEIGAAF intervention has provided new insights for (school) health promotion, which will hopefully lead to improvements within this field. Secondly, the implementation of the intervention resulted in changes within the participating schools. The scientific and social impact of this dissertation are described in this paragraph.

Scientific impact of this dissertation

The results presented in this dissertation are published in scientific journals and presented at (inter)national conferences. The results are valuable for scientific researchers in the field of school health promotion and practitioners working at organizations that develop and/or implement school-based interventions, such as the National Institute for Public Health and the Environment, Municipal Health Services, JOGG and, (municipal) sports organizations. The researchers and practitioners working in the field of school health promotion are moving from traditional top-down theory-based interventions towards more bottom-up context-based interventions. In a top-down intervention, health professionals implement an intervention package and require implementation according to the intervention protocol. Whereas, in a more bottom-up intervention, school staff, parents, local professionals and children are involved in the development and implementation of the intervention. For many years, the theory-driven, top-down intervention was considered to be the golden standard in school health promotion, given the fact that it leads to optimal use of expert knowledge and the implementation of evidence-based interventions. However, in recent years, research on school-based health promotion has shown that a specific intervention package does not fit all school environments and that more flexibility is required in school-based interventions to ensure that the intervention fits school' needs and opportunities. The studies on the implementation and effectiveness of the KEIGAAF intervention confirm the importance of bottom-up involvement and emphasize the added value of context-based school health promotion. The results support researchers and practitioners in moving from top-down interventions to more bottom-up interventions that interact with the local context. In addition, the studies presented in this dissertation might challenge the view of researchers on appropriate research designs to evaluate these context-based interventions.

The implementation of the KEIGAAF intervention provides a practical example of school health promotion in line with the School Health Promotion framework of the World Health Organization. It shows how to implement the theoretical principles of the framework: (1) health education at school; (2) changes to the physical and social school environment; and (3) involvement of parents and the wider community in the promotion of children's health behaviors [37]. The insights into the implementation of KEIGAAF also shows the time, effort and preconditions needed to implement these principles. Besides, it shows the difficulties with implementing some of these theoretical principles, such as the involvement of the whole school environment and the implementation of healthy policies in an environment that has educational goals as main responsibility.

Social impact of this dissertation

The implementation of the KEIGAAF intervention has led to changes within the school environments of the intervention schools. Most changes were small and easy to incorporate in current practices, while some required more effort to implement. In the end, they all contributed to changes within children's BMI z-score and PA behaviors. Six schools were able to continue these changes within the second year of implementation and guaranteed to continue these in the upcoming years. These schools are currently being supported in the implementation of KEIGAAF by school health promoters of the Municipal Health Service of Brabant Zuidoost. The activities implemented in the intervention schools are being transferred to other schools via the school board of the intervention schools and other stakeholders of the intervention, such as the Municipal Health Service of Brabant Zuidoost, the municipality and the local sports support organization.

The results of the KEIGAAF intervention are being disseminated via symposia, like the Day of Sports Research (in Dutch: 'Dag van het Sportonderzoek') and the end symposium of the Healthy Primary School of the Future. People that are interested in the KEIGAAF intervention, including schools, can obtain more information on the intervention or contact the project leader via the website www.eenlevenlangbewegen.nu of the lectorate of Move to Be of Fontys University of Applied Sciences, School of Sports Studies. On this website, the KEIGAAF intervention is shown as best practice. An animation video is presented in which the mutual adaptation approach is explained. The KEIGAAF intervention acts as inspiration for multiple (research)projects and partners of Fontys University of Applied Sciences, School of Sports Studies.

Additionally, the mutual adaptation approach is embedded in the bachelor programs Sport Studies and Physical Education, and the master program Sports and Physical Education of Fontys University of Applies Sciences, School of Sport Studies. By implementing the approach in these programs, future and current physical education teachers and sports professionals are educated on a combined top-down and bottom-up approach, the importance of mutual adaptation, and obtain practical and scientific skills concerning the implementation and evaluation of this approach. In the future, this will lead to community-involved (school) health promotion in which these current students will play an important role as advisors and/or researchers.

Concluding, the studies presented in this dissertation contribute to the development and implementation of effective context-based primary school interventions aimed at the improvement of energy balance-related behaviors of children.

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Summary

Globally, too many children suffer from overweight and obesity. Childhood overweight and obesity are associated with negative health outcomes in adulthood. Overweight is the result of an imbalance in energy intake and energy expenditure. Children spend too less time physically active, too much time sedentary and consume too much foods low in nutrients and high in fat and sugar. These unhealthy energy balance-related behaviors are more prominent in children from low socio-economic neighborhoods. Interventions aimed at this target population are necessary. The main goal of this dissertation was the implementation and evaluation of a physical activity and nutrition intervention implemented in primary schools located in low socio-economic neighborhoods in a municipality in the Netherlands.

In **Chapter 1**, the influence of the environment on children's energy balance-related behaviors is introduced. Important environments influencing children's behaviors are the school and the home environment. Given the large reach of schools and the significant amount of time children spend at schools, schools are ideal settings to intervene. The KEIGAAF intervention was a school-based intervention with a family-based intervention component, aimed at promoting healthy energy balance-related behaviors among children aged 7 to 12 years. The intervention consisted of a combined top-down and bottom-up approach. Local working groups developed and implemented activities to promote healthy nutrition and stimulate physical activity among the children (bottom-up). A steering committee provided the basic intervention principles and supported the working groups (top-down). The family-based intervention component aimed to improve parents' energy balance-related parenting practices. The three aims of this dissertation were to conduct a systematic review, design the intervention and evaluate the intervention.

Chapter 2 presents the results of a systematic literature review on the effectiveness of primary school-based physical activity (PA), sedentary behavior and nutrition interventions with direct parental involvement on children's Body Mass Index (BMI) or BMI z-score, PA, sedentary behavior, and nutrition behavior. Four electronic databases were searched for effectiveness studies on these type of interventions. School-based interventions directly involved parents when parents were requested to attend energy balance-related education sessions or family behavior counseling or parent training sessions. Twenty-five studies were included. Most studies found favorable results on children's BMI or BMI z-score, PA and sedentary behavior. The results regarding nutrition behavior were inconclusive. No consistent pattern was found between the type of environment (physical, social, political and economic) targeted within the school and the family environment and intervention effectiveness. The same applied for a potential pattern between the child's targeted socio-cognitive determinants targeted within the intervention and intervention effectiveness. However, it was found that interventions of at least one year duration were more likely to be effective. In addition, it is assumed that interventions targeting both the physical and social environment within both the school and the family environment are more likely to be effective.

The design of the KEIGAAF intervention is described in **Chapter 3**. The KEIGAAF intervention was implemented in Eindhoven, the Netherlands. The overall aim of the intervention was to improve the energy balance-related behaviors of children living in low socio-economic neighborhoods by creating an environment that stimulated healthy energy balance-related behaviors and discouraged unhealthy energy balance-related

behaviors. Eight intervention schools participated in the intervention. They were located in low socio-economic neighborhoods and willing to participate actively in KEIGAAF in collaboration with parents and local professionals in working groups. In a mutual adaptation approach, the local working groups implemented the KEIGAAF intervention principles as developed by the steering committee, consisting of researchers and local stakeholders. These principles stated that each school formed an interdisciplinary working group which developed and implemented the intervention activities to stimulate children's PA, and healthy nutrition intake and decrease sedentariness in accordance with local needs and possibilities. Health promotors supported the working groups. The groups received a small budget to initiate activities. In addition to this school-centered intervention, parents were invited to participate in a family-based parenting program. The program was mainly aimed at parents of overweight or obese children. Parents were invited to participate in group sessions in which they were coached on positive parenting and, nutrition and PA-related parenting practices.

In a quasi-experimental controlled study, the intervention effectiveness on children's BMI z-score, waist circumference, PA, sedentary behavior, physical fitness, and nutrition behavior were evaluated. Three control schools of a different municipality were recruited. Children aged 7 to 10 years participated in the study. Outcome measures were assessed at baseline, after one year and after two years by using a child questionnaire, accelerometers, anthropometry, a shuttle run test, and a parent questionnaire. A mixed-methods process evaluation was conducted to study the implementation of the KEIGAAF intervention.

Chapter 4 reports the results of a cross-sectional study on the association between the family nutrition climate and children's nutrition behavior. The family nutrition climate is the families' view on the consumption of healthy nutrition, operating on a relatively distal level within the family system. The family nutrition climate was measured with the validated Family Nutrition Climate-scale. This scale consists of four concepts: value, communication, cohesion and consensus. Parents of children aged 7 to 10 years filled in the scale. They also reported their children's average consumption of fruit, vegetable, water, candy, savory snack and soda during a normal week. The family nutrition climate was related to children's consumption of fruit, vegetable and soda. Although the associations were weak, it is important to consider this family-level influence when aiming to improve children's nutrition behavior.

Chapter 5 describes the implementation of the KEIGAAF intervention in the eight intervention schools. In a qualitative, multiple-case study, the implementation and contextual factors affecting implementation were evaluated. Implementation started in April 2016 and consisted of a preparation period of one year and an implementation period of two years. All schools composed a working group. The working groups defined local needs, based on a brainstorm and/or the results of a school scan and environmental scan on the PA and nutrition promotion of the school and its surrounding environment. They developed an activity plan, and implemented PA and healthy nutrition-promoting activities. The pace of implementation differed per school. In general, physical activities took less time to implement than nutrition activities. The degree and intensity of the implemented PA and nutrition activities differed per working group. Implementation was characterized by many feedback loops: working groups went back and forth in the development and implementation of activity plans and modified plans and activities

based on evaluations and reactions of the target population, the advice of the health promotion advisor and the research results. Six schools guaranteed sustainability of the implemented activities.

The practical support of the health promotion advisor, the intervention budget and the feedback loops in the intervention facilitated implementation. The focus on nutrition delayed implementation given the support from multiple actors that was needed for this intervention topic. Contextual factors facilitating implementation were the participation of the schools in the national Healthy School program, the top-down demand from the school board to become a healthy school, the support from other school staff and the principal in the intervention, and the turnover in employees (school staff were replaced by more motivated employees and employees that were unfamiliar with the old practices). The presence of an intervention champion aided implementation. The positive dynamics within the working groups, and the practice-oriented way of thinking of the working groups facilitated implementation, whereas misunderstanding of the intervention approach by the working groups hindered implementation. The lack of potential community partners or the mismatch between potential partners and school's working methods, and low parental support for intervention activities also impeded implementation. A good starting situation for implementation was a situation in which the working group considered that the current situation had to change. When the working group considered that their school was already making much effort regarding PA and healthy nutrition promotion, implementation was hindered.

The implementation of the KEIGAAF intervention was the result of an interplay between top-down influences and bottom-up development and implementation, which led to adaptation of the intervention to the local context. This mutual adaptation was a considered a key element of the intervention and health promotion advisors played a crucial role in this. Although this process was time-consuming, it was feasible.

The study discussed in **Chapter 6** focused on the feasibility of the Challenge Me intervention to engage children and parents, especially those of vulnerable populations, in a school-based intervention. The Challenge Me intervention was an alternative to the initial family-based intervention. It challenged children to perform PA and nutrition related challenges alone and together with their parent(s) or guardian(s). The intervention was implemented in four of the eight intervention schools. Children of grade five to eight participated in the intervention (aged 8 to 12 years). Of the study children, 100% performed at least one challenge, and 93% performed at least one parental involvement challenge. Younger children, children who were member of a sports club, children living in higher socioeconomic status neighborhoods, children of Western ethnicity and children from larger families performed more PA challenges. Regarding nutrition challenges involving parents, younger children performed more challenges. There was no difference in intervention engagement concerning children's gender, weight status, PA preference, healthy nutrition preference, or the Family PA and Family Nutrition Climate. Challenge Me has potential in involving parents in a school-based intervention. However, certain child and parent characteristics were associated with higher involvement.

Chapter 7 presents the results of the quasi-experimental study on the one- and two-year effects of the KEIGAAF intervention on the BMI z-score, sedentary behavior, PA and nutrition behavior of children aged seven to ten years. Baseline measurements

were conducted in March and April 2017 and repeated after one and two years. The eight intervention schools were compared to the three control schools. In total, 523 children participated in the study. Children were on average 8.5 years old and 54% were girls. Favorable intervention effects were found on children's BMI z-score after one and two years and on moderate-to-vigorous PA during school days after two years. After two years, intervention children had a lower BMI z-score, while BMI z-score increased for the control children. A decline in moderate-to-vigorous PA during school days was prevented in the intervention group compared to the control group. After one year, significant favorable intervention effects were seen on children's daily consumption of sugar-sweetened beverages, while negative intervention effects were found on children's consumption of sugar-sweetened beverages and water at school (a smaller decrease and a smaller increase compared to the control group, respectively). After two years, the negative intervention effects on children's consumption of sugar-sweetened beverages and water at school persisted, while the favorable intervention effects on children's daily consumption of sugar-sweetened beverages diminished.

The favorable two-year intervention effects on BMI z-score and PA behavior mainly occurred in the schools that implemented a comprehensive PA promoting approach. The intervention schools with the most vulnerable population, in terms of ethnicity and parental educational level, and in need of behavioral improvement succeeded in implementing a comprehensive approach. Children attending comprehensive PA schools showed an increase in MVPA of approximately 30 minutes per week from year one to year two. Additionally, these comprehensive PA schools showed favorable intervention effects on children's sedentary behavior and light PA behavior. Schools were considered comprehensive when physical activities were implemented during school, before and after school, and when staff and parents were involved. Based on these results, it is advised to implement a long-term, locally appropriate, comprehensive approach to promote a healthy weight status, to stimulate children's PA levels, and to prevent them from spending excessive time in sedentary behaviors.

The main findings of the studies in this dissertation are discussed in **Chapter 8**. Additionally, intervention effects on children's waist circumference and physical fitness are presented. There are some methodological considerations that should be taken into account when interpreting the results. Important lessons were learned from implementing and evaluating the KEIGAAF intervention. The KEIGAAF intervention was flexible in design and the main intervention components changed during implementation: an alternative approach to the family-based intervention was implemented. This entailed that parents were not involved directly in the intervention, but indirectly via the child. An advantage of the alternative approach was that many children and parents were engaged. Although parents were mainly involved indirectly in the intervention, the KEIGAAF intervention was effective in improving children's weight status and PA behavior. In contrast, the ineffectiveness of the intervention concerning children's nutrition behavior in comparison to the control group could have been the result of inadequate involvement of the parents in the intervention.

The results of the KEIGAAF intervention were context- and time-specific, however, these results have the potential to be transferred to other contexts. When disseminating the intervention to other contexts, it is recommended that implementers adhere to the key functions and key elements of the intervention while ensuring that the intervention

is locally appropriate. To do this, implementers and researchers should be flexible, they should not only focus on intervention effectiveness on individual level health outcomes, but also investigate the intervention process and evaluate effects on intermediate individual level outcomes, such as knowledge, attitudes, personal skills. Additionally, the importance of a professional health promotion advisor with the right set of skills and characteristics should not be underestimated. Intervention champions aid the implementation process and the intervention only has the potential to be effective when long-term investments are done.

Overall, it is concluded that the KEIGAAF intervention is a promising intervention in the promotion of a healthy weight status and moderate-to-vigorous PA behavior among primary school-aged children, especially those of vulnerable populations. This dissertation shows the importance of a context-based, long-term, mutual adaptation approach in the implementation of PA and nutrition activities in the primary school and home environment.

Samenvatting

Wereldwijd hebben te veel kinderen overgewicht of obesitas. Overgewicht en obesitas in de kindertijd zijn gerelateerd aan negatieve gezondheidsuitkomsten tijdens volwassenheid. Overgewicht is het resultaat van een disbalans in energie-inname en energieafgifte. Gedurende de dag zijn kinderen te weinig fysiek actief. Ze brengen veel tijd zittend door en consumeren voeding met een laag nutriëntengehalte en veel vet en suikers. Deze ongezonde energiebalans-gerelateerde gedragingen komen met name voor bij kinderen uit wijken met een lage sociaaleconomische status. Het is belangrijk om te interventies te ontwikkelen die zich richten op deze kinderen. Het hoofddoel van dit proefschrift was het implementeren en evalueren van een beweeg- en voedingsinterventie. De interventie is geïmplementeerd in basisscholen gelegen in kansarme wijken in een Nederlandse gemeente.

In **Hoofdstuk 1** wordt de invloed van de omgeving op energiebalans-gerelateerde gedragingen van kinderen geïntroduceerd. Belangrijke omgevingen die het gedrag van kinderen beïnvloeden zijn de school- en de thuisomgeving. Door het grote bereik van scholen en de grote hoeveelheid tijd die kinderen er doorbrengen, is de school een ideale setting om in te interveniëren. De KEIGAAF interventie was een school- en familie-interventie met als doel om energiebalans-gerelateerde gedragingen van kinderen in de leeftijd van 7 tot 12 jaar te bevorderen. De interventie bestond uit een gecombineerde top-down en bottom-up aanpak. Lokale werkgroepen ontwikkelden en implementeerden activiteiten om de inname van gezonde voeding en fysieke activiteit door de kinderen te bevorderen (bottom-up). Een stuurgroep voorzag de werkgroepen van basis interventieprincipes en ondersteunde hen bij de implementatie (top-down). De familie-interventie had als doel om energiebalans-gerelateerde opvoedpraktijken van ouders te verbeteren. De drie doelen van dit proefschrift waren het uitvoeren van een systematische review, het ontwikkelen van de interventie en het evalueren van de interventie.

Hoofdstuk 2 presenteert de resultaten van een systematisch literatuuronderzoek naar basisschoolinterventies met directe ouderbetrokkenheid én als onderwerp beweging, zitgedrag en/of voeding. In vier elektronische databanken werd op systematische wijze gezocht naar studies die de effecten van dit type interventie op de body mass index (BMI) of de BMI z-score, het beweeggedrag, zitgedrag en voedingsgedrag van kinderen onderzochten. Er was sprake van directe ouderbetrokkenheid binnen de schoolinterventies wanneer de ouders verzocht werden om deel te nemen aan energiebalans-gerelateerde educatiesessies, gezinsgedragstherapie of oudertrainingssessies. Vijfentwintig studies werden opgenomen in de systematische review. De meeste studies vonden gunstige resultaten op de BMI of de BMI z-score, het beweeggedrag en het zitgedrag van kinderen. De resultaten ten opzichte van voedingsgedrag waren niet eenduidig. Er was geen consistent patroon zichtbaar tussen het type omgeving (sociaal, fysiek, politiek of economisch) waarop de interventie gericht was in de school en de thuisomgeving en de effectiviteit van de interventie. Hetzelfde gold voor de socio-cognitieve determinanten van het kind waarop de interventie gericht was en de effectiviteit van de interventie. Uit de resultaten bleek wel dat voornamelijk interventies met tenminste een duur van één jaar effectief waren. Daarnaast wordt verwacht dat interventies die zich richten op zowel de fysieke als de sociale omgeving binnen de schoolomgeving én de thuisomgeving een grotere kans op effectiviteit hebben.

Het ontwerp van de KEIGAAF interventie is beschreven in **Hoofdstuk 3**. De KEIGAAF

interventie is geïmplementeerd in Eindhoven, Nederland. Het algemene doel van de interventie was het bevorderen van de energiebalans-gerelateerde gedragingen van kinderen woonachtig in kansarme wijken door een omgeving te creëren die aanzet tot gezonde energiebalans-gerelateerde gedragingen en die ongezonde gedragingen ontmoedigd. Acht interventiescholen namen deel aan de interventie. De scholen waren gelegen in wijken met een lage sociaaleconomische status en bereid om actief deel te nemen aan KEIGAAF in werkgroepen samen met ouders en lokale professionals. In een wederzijdse adaptieve aanpak, implementeerden de lokale werkgroepen de KEIGAAF interventieprincipes zoals ze ontwikkeld waren door de stuurgroep. De stuurgroep bestond uit onderzoekers en lokale belanghebbenden. De principes bestonden uit het volgende: elke school vormde een interdisciplinaire werkgroep welke interventie-activiteiten ontwikkelende en implementeerde die het beweeggedrag van kinderen stimuleren, gezond voedingsgedrag bevorderen en zitgedrag ontmoedigen in lijn met lokale behoeften en mogelijkheden. Gezondheidsbevorderaars ondersteunden de werkgroepen. De groepen kregen een klein budget om activiteiten te initiëren. Naast deze schoolgerichte aanpak werden ouders uitgenodigd voor deelname aan een familiegerichte opvoedingsinterventie. Het programma was voornamelijk gericht op ouders van kinderen met overgewicht of obesitas. Ouders werden uitgenodigd om deel te nemen aan groepssessies waarin zij gecoacht werden op het gebied van positief opvoeden en voeding- en beweging-gerelateerde opvoedpraktijken.

In een quasi-experimenteel gecontroleerde studie werd de effectiviteit van de interventie op de BMI z-score, het beweeggedrag, het zitgedrag, de fysieke fitheid, en het voedingsgedrag van kinderen geëvalueerd. Drie controlescholen van een andere gemeente werden geworven. Kinderen, in de leeftijd van 7 tot 10 jaar namen deel aan de studie. De uitkomstmaten werden gemeten bij aanvang van de interventie, na één jaar en na twee jaar door middel van een kindervragenlijst, beweegmeters, antropometrie, een shuttle run test, en een oudervragenlijst. Een 'mixed-methods' procesevaluatie werd uitgevoerd om de implementatie van de KEIGAAF interventie te bestuderen.

Hoofdstuk 4 geeft de resultaten weer van een cross-sectionele studie naar de verbanden tussen het familie voedingsklimaat en het eetgedrag van kinderen. Het familie voedingsklimaat is de visie van de familie op de inname van gezonde voeding en opereert op een relatief distaal niveau binnen het familiesysteem. Het familie voedingsklimaat werd gemeten met de gevalideerde 'Family Nutrition Climate'-schaal. Deze schaal bestaat uit vier concepten: waarde, communicatie, cohesie en consensus. De ouders van kinderen tussen de 7 en 10 jaar oud vulden de schaal in. Zij gaven ook aan hoeveel fruit, groenten, water, snoep, hartige snacks en frisdrank hun kind gemiddeld genomen consumeerde tijdens een normale week. Het familie voedingsklimaat was gerelateerd aan de inname van fruit, groenten en frisdrank. Hoewel de associaties zwak waren, is het belangrijk om de invloed op familie-niveau mee te nemen wanneer men probeert om het voedingsgedrag van kinderen te verbeteren.

Hoofdstuk 5 beschrijft de implementatie van de KEIGAAF interventie in de acht interventiescholen. In een kwalitatieve studie werden, gebruikmakend van meerdere casussen, de implementatie en contextuele factoren die de implementatie beïnvloedden geëvalueerd. De implementatie startte in april 2016 en bestond uit één jaar voorbereiding en twee jaar implementatie. Alle scholen vormden een werkgroep. De werkgroepen bepaalden lokale behoeften, gebaseerd op een brainstorm en/of de

resultaten van een schoolscan en een omgevingsscan naar de status van de school en haar omgeving met betrekking tot het stimuleren van beweging en gezonde voeding. De werkgroepen ontwikkelden een activiteitenplan en implementeerden beweeg- en voeding-bevorderende activiteiten. Het tempo van implementatie verschilde per school. Over het algemeen nam de implementatie van de beweegactiviteiten minder tijd in beslag dan de implementatie van voedingsactiviteiten. De omvang en de intensiteit van de geïmplementeerde beweeg- en voedingsactiviteiten verschilden per werkgroep. Implementatie werd gekarakteriseerd door vele terugkoppelingen: werkgroepen gingen heen en weer tussen ontwikkeling en implementatie van activiteitenplannen en pasten plannen en activiteiten aan op basis van evaluaties en reacties van de doelgroep, het advies van de adviseur en de onderzoeksresultaten. Zes scholen slaagden in het borgen van de geïmplementeerde activiteiten.

De praktische ondersteuning van de adviseur, het interventiebudget en de terugkoppelingen in de interventie faciliteerden implementatie. De focus op voeding vertraagde implementatie, omdat steun van verschillende betrokkenen nodig was voor dit onderwerp. Contextuele factoren die de implementatie bevorderden waren de deelname van de scholen aan het nationale Gezonde School programma, de top-down verplichting van de scholenstichting om een gezonde school te worden, de steun van ander schoolpersoneel en de directeur tijdens de interventie, en de wisseling in personeel (schoolpersoneel werd vervangen door gemotiveerdere medewerkers en medewerkers die onbekend waren met de oude schoolpraktijken). De aanwezigheid van een groot voorstander van de interventie had een gunstig effect op de implementatie ervan. De positieve dynamiek binnen de werkgroepen en de praktijkgerichte manier van denken van de werkgroepen faciliteerden implementatie, terwijl de onduidelijkheid over de interventieaanpak binnen sommige werkgroepen implementatie hinderde. De afwezigheid van potentiële wijkpartners of het idee dat sommige partners niet pasten bij de werkmethodes van de school, en de lage ouderbetrokkenheid voor de interventieactiviteiten waren ook beperkende factoren voor de implementatie. Een goede startsituatie voor de implementatie was een situatie waarbij de werkgroep het nodig achtte om de huidige situatie te veranderen. Daarentegen kwam het implementatie niet ten goede, wanneer de werkgroep vond dat hun school al genoeg deed op het gebied van het bevorderen van beweging en gezonde voeding.

De implementatie van de KEIGAAF interventie was het resultaat van een wisselwerking tussen top-down en bottom-up ontwikkeling en implementatie, welke leidde tot aanpassing van de interventie aan de lokale context. Deze wederzijdse adaptatie werd beschouwd als een essentieel onderdeel van de interventie en de adviseurs speelden een cruciale rol hierin. Hoewel het proces tijdrovend was, was het haalbaar.

De studie die in **Hoofdstuk 6** wordt beschreven richt zich op de haalbaarheid van de Challenge Me interventie om kinderen en ouders, en voornamelijk degenen van een kwetsbare populatie, te betrekken. De Challenge Me interventie was een alternatief voor de initiële familie-interventie. In de interventie werden kinderen uitgedaagd om beweeg- en voedingsopdrachten uit te voeren, alleen of samen met hun ouder(s) of verzorger(s). De interventie werd geïmplementeerd in vier van de acht interventiescholen. Kinderen van groep 5 tot en met 8 (in de leeftijd van 8 tot 12 jaar) namen deel aan de interventie. 100% van de studiedeelnemers voerde ten minste één opdracht uit en 93% voerde een

opdracht uit waarbij ouderbetrokkenheid vereist was. Jongere kinderen, kinderen die lid waren van een sportvereniging, kinderen die woonachtig waren in wijken met een hogere sociaaleconomische status, kinderen met een Westerse etniciteit en kinderen van grotere gezinnen voerden relatief meer beweegopdrachten uit. Voornamelijk jongere kinderen voerden meer voedingsopdrachten uit waarbij ouderbetrokkenheid vereist was. Er was geen verschil in de betrokkenheid in de interventie als er gekeken werd naar het geslacht van het kind, de gewichtsstatus, de voorkeur voor beweging, de voorkeur voor gezonde voeding of het Familie Bewegings- en Familie Voedingsklimaat. Challenge Me is in staat om ouders te betrekken in een schoolinterventie. Echter, sommige kind- en ouderkenmerken zijn geassocieerd met een hogere betrokkenheid.

Hoofdstuk 7 presenteert de resultaten van een quasi-experimentele studie naar effecten van de KEIGAAF interventie na één jaar en na twee jaar op de BMI z-score, zitgedrag, beweeggedrag en voedingsgedrag van kinderen tussen de zeven en tien jaar. De acht interventiescholen werden vergeleken met drie controlescholen. In totaal namen 523 kinderen deel aan de studie. De kinderen waren gemiddeld 8,5 jaar oud en 54% was een meisje. Gunstige interventie effecten werden gevonden op de BMI z-score na één en na twee jaar en op matig-tot-intensieve fysieke activiteit tijdens schooldagen na twee jaar. Na twee jaar hebben de interventiekinderen een lagere BMI z-score, terwijl de BMI z-score van de controlekinderen toeneemt. Een daling in matig-tot-intensieve fysieke activiteit tijdens schooldagen werd voorkomen in de interventiegroep vergeleken met de controlegroep. Na één jaar zijn er significante gunstige interventie effecten zichtbaar op de dagelijkse consumptie van suikerhoudende dranken, terwijl er negatieve interventie effecten te zien waren op de inname van suikerhoudende dranken en water op school (een kleinere daling en een kleinere toename vergeleken met de controlegroep, respectievelijk). Na twee jaar houden de negatieve interventie effecten op de consumptie van suikerhoudende dranken en water op school aan, terwijl de gunstige effecten op de dagelijkse consumptie van suikerhoudende dranken verdwijnen.

De gunstige twee-jaar effecten op BMI z-score en beweeggedrag kwamen voornamelijk voor in de scholen die een alomvattende beweegaanpak implementeerden. De interventiescholen met de meest kwetsbare populatie in termen van etniciteit en educatieniveau van de ouders, en waar gedragsverandering nodig was, waren in staat om dergelijke aanpak te implementeren. Kinderen van scholen met een alomvattende beweegaanpak toonden een toename in matig-tot-intensieve fysieke activiteit van ongeveer 30 minuten per week van jaar één naar jaar twee. Bovendien, toonden de scholen met een alomvattende beweegaanpak gunstige effecten op het zitgedrag en lichte intensiteit beweging van de kinderen. Scholen waren alomvattend met betrekking tot beweging als ze beweegactiviteiten implementeerden voor, tijdens en na schooltijd en wanneer schoolpersoneel en ouders erbij betrokken waren. Gebaseerd op deze resultaten wordt geadviseerd om een langdurige, lokaal geschikte, alomvattende aanpak te implementeren om een gezonde gewichtsstatus en beweeggedrag te bevorderen en te voorkomen dat kinderen een grote hoeveelheid tijd zittend doorbrengen.

De hoofdbevindingen van de studies in dit proefschrift worden bediscussieerd in **Hoofdstuk 8**. Ook worden de interventie effecten op de middelomtrek en de fysieke fitheid van de kinderen gepresenteerd. Er zijn enkele methodologische overwegingen die gemaakt moeten worden tijdens het interpreteren van de resultaten. Belangrijke lessen zijn geleerd van de implementatie en de evaluatie van de KEIGAAF interventie.

Het design van de KEIGAAF interventie was flexibel en de belangrijkste onderdelen van de interventie veranderden tijdens de implementatie; zo werd er een alternatieve aanpak voor de familie-interventie geïmplementeerd. Dit hield in dat de ouders niet meer direct bij de interventie werden betrokken, maar indirect via het kind. Een voordeel van deze alternatieve aanpak was het grote bereik van kinderen en ouders. Hoewel ouders voornamelijk indirect betrokken werden bij de interventie, was de KEIGAAF interventie effectief in het verbeteren van de gewichtsstatus en het beweeggedrag van de kinderen. De ineffectiviteit van de interventie met betrekking tot het voedingsgedrag van de kinderen in vergelijking met de controlegroep kan daarentegen het resultaat zijn van onvoldoende betrokkenheid van de ouders in de interventie.

De resultaten van de KEIGAAF interventie waren context- en tijd-specifiek, maar de resultaten kunnen wel overgebracht worden naar andere contexten. Uitvoerders worden geadviseerd om vast te houden aan de essentiële functies en elementen van de interventie terwijl ze ervoor zorgen dat de interventie geschikt is voor de lokale omgeving wanneer de interventie naar andere contexten wordt verspreid. Om dit te kunnen doen moeten uitvoerders en onderzoekers flexibel zijn en niet alleen gericht zijn op de effectiviteit van de interventie op uitkomstmaten op individueel niveau, maar moeten ze ook het interventieproces bestuderen alsmede effecten op intermediair individueel niveau evalueren, zoals kennis, attitudes en persoonlijke vaardigheden. Daarnaast moet het belang van een professionele adviseur met de juiste set aan vaardigheden en kenmerken niet onderschat worden. Interventie voorstanders ondersteunen het implementatieproces en de interventie heeft alleen kans van slagen wanneer een langdurige investering wordt gedaan.

Concluderend, de KEIGAAF interventie is een veelbelovende aanpak in de bevordering van een gezonde gewichtsstatus en matig-tot-intensieve fysieke activiteit van basisschoolkinderen, met name kinderen afkomstig uit kwetsbare populaties. Dit proefschrift toont het belang van een context-interventie, die langdurig is en waarin een wederzijdse adaptieve aanpak van beweeg- en voeding-activiteiten wordt geïmplementeerd in de basisschoolomgeving en de thuisomgeving.

Curriculum Vitae

Sacha Renérus Barbara Janssen was born on March 2nd 1990 in Geleen, the Netherlands. She went to primary school in Susteren and attended VWO, gymnasium at Trevianum in Sittard. From 2008 to 2011, she studied at Wageningen University. There, she obtained her Bachelor of Science-diploma Nutrition and Health there in 2011. After that, she studied at Maastricht University where she graduated cum laude for the Master of Science Sports and Physical Activity Interventions in 2012.

After her graduation, she started working as a project member at the Dutch Nutrition Centre. There, she developed practical tools for community sports coaches (in Dutch: buurtsportcoaches) to incorporate healthy nutrition in their work. Additionally, she was involved in developing guidelines for a healthy nutrition policy for childcare organizations. In 2014, she worked as a JOGG (Youngsters on a Healthy Weight) manager in the municipality Alphen aan den Rijn. She developed the local JOGG-implementation plan and explored existing initiatives aimed at the promotion of healthy energy balance-related behaviors of children living in Alphen aan den Rijn. In the beginning of 2015, she and her husband decided to leave the Netherlands behind and went to Eastern Africa to explore the opportunity to live and work there . Eventually, they decided to return to the Netherlands.

In March 2016, Sacha started working as a PhD candidate at the department of Health Promotion of Maastricht University. She was responsible for the implementation and the evaluation of the KEIGAAF intervention in Eindhoven. In collaboration with her colleagues, she advised local working groups in the implementation of energy balance-related promoting activities. She collected numerous qualitative and quantitative data to evaluate the intervention's implementation process and its effectiveness. She presented her work at (inter)national conferences. During her PhD-trajectory, she performed several teaching activities at Maastricht University. She left Maastricht University in July 2020.

Currently, Sacha is working at Ecsplore, a local sports foundation located in Sittard-Geleen. She is the project leader of healthyLIFE, a multidisciplinary approach and lifestyle intervention aimed at overweight and obese adults.

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