Kids in Action: is engaging children as co-researchers key to promoting healthy physical activity and dietary behaviors?

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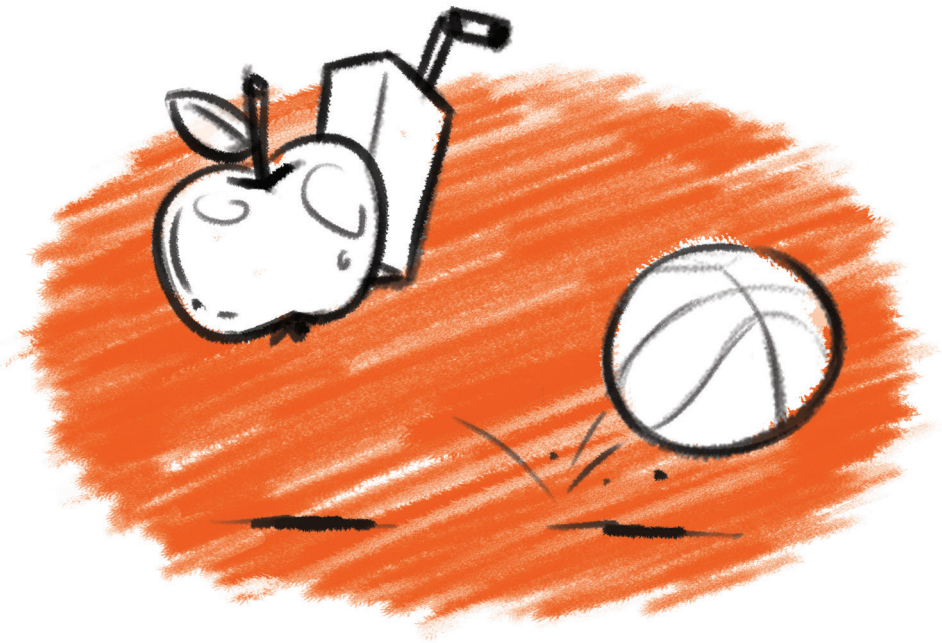
Chapter 7

Does co-creating actions with children improve energy balance-related behaviors, physical fitness and self-rated health?



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Abstract

Introduction Most actions targeting children's energy balance-related behaviors have limited involvement of children in the development, potentially contributing to disappointing effectiveness. Therefore, in the 3-year 'Kids in Action' study, 9-12-year old children from a low socioeconomic neighborhood were involved as co-researchers in the development, implementation and evaluation of actions targeting healthy physical activity and dietary behaviors. The current study describes the controlled trial that evaluated the effects on children's energy balance-related behaviors, physical fitness and self-rated health.

Materials and Methods Primary school children from the three highest grades of four intervention and four control schools participated in a controlled trial. Outcome measures were assessed at baseline, and at one and two year follow-up using fitness tests (N=656, N=485, N=608, resp.), accelerometers (N=223, N=149, N=164, resp.), and self-report (N=322, N=281, N=275, resp.). Mixed model analyses were performed, adjusting for clustering within schools and relevant confounders.

Results Significant beneficial intervention effects were found on self-reported consumption of energy/sports drinks (β=-1023.1mL, 95%CI=-1940.7;-105.5) at T2 versus T0, and on total time (β=9.5min/day, 95%CI=2.5;16.5) and ≥5-min bouts (β=2.0/day, 95%CI=0.0;3.9) of moderate-to-vigorous physical activity at T1 versus T0. Significant adverse effects were found on 'speed and agility' (β=0.5sec, 95%CI=0.0;1.0) and 'coordination and upper-limb speed' (β=0.5sec, 95%CI=0.1;0.9). No other significant effects were found.

Conclusions The current youth-led participatory action research is one of few using a controlled trial design. Unfortunately intervention effects were inconsistent which may be explained by the dynamic cohort and measures not matching the implemented actions due to the participatory design.

7.1. Background

In the Netherlands, a gradual decline can be seen in the number of children with overweight and obesity in the last decade[1], also in the city of Amsterdam[2]. Despite this promising development, the number of children with overweight or obesity with a low socioeconomic position (SEP) or from a non-Western background, remains high[2, 3]. These groups are disproportionally affected by unhealthy behaviors and related health effects. Previous intervention studies showed that these vulnerable groups are difficult to reach[4]. Moreover, reaching behavior change, especially in children from low SEP, remains a challenge for interventions[5]. Several reviews have shown that few interventions are effective in improving Energy Balance-Related Behaviors (EBRBs) in children from low SEP environments, and those that are effective show small effects[6-9]. One explanation could be that intervention strategies are insufficiently tailored to children from low socioeconomic positions. Therefore, interventions that are specifically designed for, or even together with, this vulnerable group may better fit their needs and interests and thereby may be more effective[10].

The 'Kids in Action' study combined Youth-led Participatory Action Research (YPAR) and Intervention Mapping, to structurally develop actions in collaboration with children from a low SEP neighborhood to improve their EBRBs[11]. YPAR is increasingly being used in public health research especially in hard-to-reach communities, as this bottom-up approach could lead to better tailored actions[12]. The process evaluation of the Kids in Action study showed that the implemented actions were well received, both by the children and other community members[10]. Children and community partners mentioned that empowerment improved of children who actively participated in the co-creation of actions. Moreover, these children developed skills such as critical awareness and self-confidence and learned about conducting research. Community partners indicated that awareness about EBRBs improved in children of the interventions schools, but they questioned whether the study also improved EBRBs of children. YPAR studies are rarely evaluated in a controlled trial design, while support for YPAR in the field of health promotion may increase if positive effects on

EBRBs could be demonstrated[13, 14]. Therefore, the current study evaluated the effects of the Kids in Action study on children's dietary behavior, physical activity, sedentary behavior and physical fitness, using a controlled design over the course of three years. We hypothesized that collaborating with children in the development and implementation of actions would lead to improvements in EBRBs.

7.2. Methods

7.2.1. Kids in Action

The Medical Ethics Committee of the VU Medical Center approved the study protocol (2016.366). Kids in Action was a 3-year YPAR study, taking place in a low SEP neighborhood in Amsterdam, The Netherlands. The neighborhood is characterized by high numbers of: childhood overweight, children growing up in a household defined as low-income, residents with a non-Western background, and feelings of unsafety[15, 16]. YPAR is mostly conducted in low SEP communities[12], as they can benefit most from such an approach by becoming empowered, learning new skills, and developing actions suitable to their needs[17]. In Kids in Action, children participated in the development, implementation and evaluation of actions, as explained in detail elsewhere[11, 18]. In the first two years a participatory group was installed in each of the four intervention schools. These Action Teams consisted of 6-8 children aged 9-12 years old who actively collaborated in the action development process. In the third year, one Action Team was established with representatives of three schools. In the first year of this study, the health needs of children were identified in a participatory needs assessment[19]. Based on this needs assessment is was decided that the Action Teams would develop, implement and evaluate actions specifically aimed to improve children's physical activity and dietary behavior. In the second year, most actions were developed by the Actions Teams. In the third year, developed actions of the previous year were ongoing and the Action Team worked on new actions to be implemented. Examples of actions that were implemented were extracurricular sports activities and cooking workshops[11].

7.2.2. Study design

All four primary schools in the intervention neighborhood were approached by the local government and invited to participate as intervention schools. Control schools were recruited from neighborhoods with inhabitants with similar socioeconomic characteristics, cultural background, and percentage of children with overweight and obesity. Schools in these neighborhoods were contacted (N=22) until four schools agreed to participate. The four control schools and four intervention schools participated in three measurement waves as part of the controlled trial. The first wave took place throughout the school year 2016-2017 and was considered the baseline (T0). In the school year 2017-2018 measurements were conducted in March-April 2018 (T1). The last measurement wave was conducted in February-April 2019 (T2). Each year all children in the three highest grades of the schools were invited to participate in the measurements. This resulted in a dynamic cohort, where some children were invited for two or three measurements, others only for one.

7.2.3. Procedures

The Motor Performance (MOPER) fitness test was included to evaluate neuromotor fitness, and a self-report questionnaire and accelerometers were included to measure physical activity, sedentary behavior and dietary behavior. The MOPER fitness test was part of the school curriculum for children in the three highest grades and data was collected anonymously. Parents received an information letter from the physical education teacher. Attached was a refusal form to be signed and returned if they did not approve of MOPER fitness test results to be anonymously shared with the Kids in Action researchers. For the accelerometer and self-report questionnaire, each year children of the three highest grades received an information letter with attached an informed consent form that at least one parent had to sign to approve participation in the measurements. Parents could contact the researchers by phone or email in case they had questions or wanted more information. Because of the different consent procedures, the number of consent varied between the MOPER, self-report questionnaire

and accelerometer, as depicted in Figure 1.

MOPER fitness test

The MOPER fitness test consists of eight test items: 10x5 meter run, leg-lifting while laying down, plate-tapping, bent-arm hang, sit-and-reach, arm-pull, standing high jump and a six minutes run test. The MOPER fitness test has shown acceptable validity and reliability for estimating neuromotor fitness in 9-12-year old children[20]. For practical reasons the hand-grip test was used instead of the arm-pull test and the six minute run test was omitted. Therefore seven test items were included measuring speed and agility, strength, flexibility, and coordination and upper-limb speed (see Table 1). The MOPER fitness test was administered during physical education by the physical education teacher with assistance of academic researchers or sports instructors. The class was divided in seven groups who completed all test items in the same order. Tests were conducted bare foot.

Questionnaire

The questionnaire was developed based on validated items from the ENERGY-child questionnaire[21], the DOiT questionnaire[22], and the EuroQol[23], that covered identified determinants of overweight in the needs assessment[19]. The developed questionnaire consisted of nine sections: (A) Demographic and Family characteristics; (B) Soft drinks consumption; (C) Energy- and sport drinks consumption; (D) Sweets consumption; (E) Snack consumption; (F) Playing outdoor; (G) Sports participation; (H) Screen viewing behavior; and (I) Perceived health[18]. Participants completed the questionnaire during school hours under the supervision of two trained researchers and the class teacher. Each section was explained by the researcher before that part of the questionnaire was collectively filled in. During the completion of the questionnaire children were free to ask questions or withdraw from participation at any time. Children needed approximately 45 minutes to complete the questionnaire.

If possible, categorical variables were recoded into continuous variables (see Additional File 1). For example the frequency of soda consumption

was multiplied with the sum of number of glasses, cans and bottles of soda consumed. Covariates were: gender, birth country of parents, having younger/older siblings, living with both parents or otherwise, and speaking mainly Dutch at home or not.

Table 1: Description of the MOPER fitness test items used in this study.

	Item	Characteristic	Description	Unit
1	**10x5 meter run**	Speed and agility	10 times running between 2 lines with a five meters distance as fast as possible, 2 attempts	s
2	**Plate tapping with one hand**	Coordination and upper limb speed	Tapping two plates alternately with the dominant hand 50 times as fast as possible, 2 attempts	s
3	**Bent-arm hang**	Upper body strength	Hanging from a horizontal bar with bended arms as long as possible, 1 attempt	s
4	**Hand-grip**	Hand-grip strength	Stand and hold a hand dynamometer in the dominant hand with a straight arm down. Pinch as hard as possible for two seconds.	kg
5	**Standing high jump**	Explosive leg strength	Jumping up from a standing position as high as possible, 2 attempts	cm
6	**Leg lifting while laying down**	Trunk and leg strength	Lifting outstretched legs 10 times while laying on back as fast as possible, 1 attempt	s
7	**Sit-and-reach**	Trunk and hamstrings flexibility	Reaching from sitting position with outstretched legs and arms as far as possible, 3 attempts	cm

Notes. cm=centimeters, kg=kilograms, s=seconds

Accelerometer

Time spent in physical activity and sedentary behavior was assessed using the Actigraph accelerometer. Children were asked to wear the accelerometer on their right hip for seven consecutive days during waking hours, with the exception of water activities and heavy contact sports. The Actigraph was set on a sample frequency of 100 Hz and data were analyzed in 15 second epochs between 07.00 a.m. and 10.00 p.m.[24]. Non-wear time was defined as a period of at least 60 consecutive minutes of zero counts[24]. For inclusion in the data analysis, each participant needed at least four days with a minimum of eight hours wear time per day, including at least one weekend day.

Raw accelerometer data were processed using a custom-made program developed in R. A cut point of ≤25 counts per 15 seconds (counts/15-sec) was selected for sedentary behavior[25, 26], 26-573 counts/15-sec for light physical activity and ≥574 counts/15-sec for moderate-to-vigorous-activity (MVPA)[27]. A sedentary bout was defined as a period of at least ten consecutive minutes <25 counts/15-sec. An MVPA bout was defined as a period of at least five consecutive minutes ≥574 counts/15-sec with 10% tolerance allowed below the threshold and an absolute tolerance of three consecutive minutes.

7.2.4. Analyses

Means (x) and standard deviations (SD) or medians (x) and interquartile ranges (IQR) (25th – 75th percentiles) were calculated for descriptive purposes. The residuals of linear regression analyses were used to check the assumptions of normality and homoscedasticity. Linear mixed model analyses with a four level structure (i.e. repeated measures were clustered within children, children were clustered within classes and classes were clustered within schools) were used to examine the difference in the outcome variables between the control and the intervention group for the questionnaire and accelerometer data. For the MOPER fitness data a three level structure was used because the data were collected anonymously. There was a substantial number of missing data by design because data was collected of children in grades 6/7/8 for three years, instead of following the same

group of children for three years. Linear mixed model analyses adequately deal with the missing data[28]. The linear mixed model analyses included time (represented by two dummy variables) and the interaction between group and time. The latter indicated the difference in outcome between the groups at the two follow-up moments[28].

The MOPER fitness test data were adjusted for gender and age. Analyses using the questionnaire and accelerometer data were adjusted for relevant confounders which were evaluated through a forward selection: ethnicity and living with both parents were selected as relevant confounders for most outcome measures and therefore included as covariates in the final analyses. Analyses using the accelerometer data were further adjusted for wear time. For all analyses, betas and 95% confidence intervals were calculated. The statistical analyses were conducted using IBM SPSS Statistics 24.0.

In case assumptions of normality and homoscedasticity were not met, log-transformations were conducted. The variables 'bent-arm hang' of the MOPER fitness test, 'consumption of sodas' and 'consumption of energy- and sports drinks' of the questionnaire, and 'MVPA accumulated in bouts ≥5 min' of the accelerometer, had a skewed distribution with an excess of zeros and were therefore analyzed using tobit mixed models analyses. Tobit mixed models analyses were performed in STATA (version 15).

7.3. Results

Figure 1 presents the flowchart of participants in the measurements.

Table 2 provides the characteristics of children participating in the MOPER fitness test. Participating children were equally divided across grades with a mean age of 10.6 years old. Tables 3 and 4 present the characteristics of the subgroup of children who completed the questionnaire and had valid accelerometer data, respectively. More girls than boys participated in these measurements (57%-71%). In this subgroup a substantial number of children had parents who were born in Morocco or Turkey (27%-41%), or in another country other than the Netherlands (29%-38%). Most children spoke Dutch at home (72%-91%), lived with both parents (67%-85%) and had siblings (84%-93%).

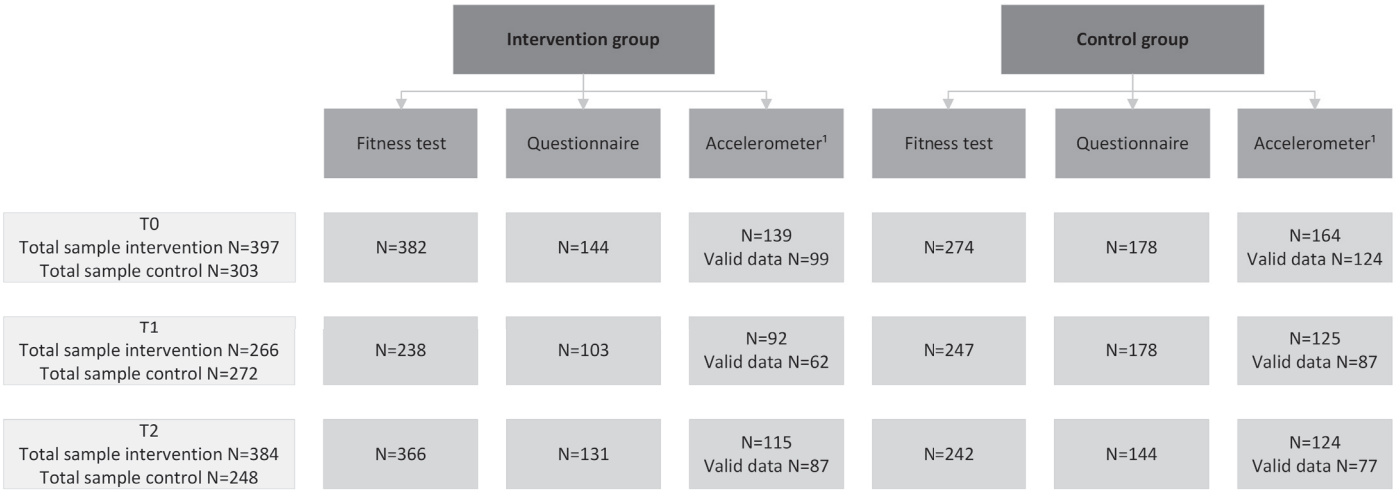

Figure 1: Flowchart of participants in the Kids in Action effect measurements
Notes. Each year, children of grades 6/7/8 participated in the measurements, resulting in a different sample at each time point.
[1] Participants needed a minimum of 8 hours of wear time per day on at least four days, including at least one weekend day, to be included in the analyses.

Table 2: Characteristics of children who completed the MOPER fitness test

	T0		T1		T2	
	Intervention N=382	**Control N=274**	**Intervention N=238**	**Control N=247**	**Intervention N=366**	**Control N=242**
Grade[1] (%)						
6	33.2	33.7	34.9	37.7	35.3	39.0
7	32.5	31.9	27.7	30.4	38.1	29.9
8	34.3	34.4	37.4	32.0	26.6	31.1
Females (%)	52.9	50.9	49.8	54.9	46.6	50.4
Mean age (years) (SD)	10.6 (1.0)	10.6 (1.1)	10.6 (1.1)	10.5 (1.1)	10.5 (1.0)	10.5 (1.1)
Bent-arm hang ↑ (s) $\tilde{x}$ (IQR)	2.0 (0.0-8.3)	3.0 (0.0-8.0)	3.0 (0.0-9.0)	2.0 (0.0-6.0)	3.0 (0.0-9.0)	4.0 (0.0-9.0)
10x5 meter run ↓ (s) $\bar{x}$ (SD)	21.0 (2.1)	21.3 (2.2)	21.6 (2.7)	21.7 (2.3)	21.6 (2.5)	21.4 (2.3)
Leg-lift ↓ (s) $\tilde{x}$ (IQR)	15.3 (13.5-17.4)	15.2 (13.4-17.3)	17.0 (14.4-21.5)	16.5 (14.3-20.0)	15.5 (13.4-18.8)	14.6 (12.9-17.5)
Plate-tapping ↓ (s) $\bar{x}$ (SD)	14.3 (1.9)	14.9 (2.0)	14.2 (2.2)	14.3 (2.1)	13.8 (1.9)	14.1 (2.3)
Sit-and-reach ↑ (cm) $\bar{x}$ (SD)	27.6 (7.6)	27.7(7.3)	28.1 (7.7)	27.5 (7.1)	28.9 (7.5)	28.0 (7.0)
Hand-grip (kg) ↑ $\bar{x}$ (SD)	21.6 (5.0)	21.3 (4.8)	21.8 (5.1)	21.0 (5.3)	21.2 (4.9)	21.2 (5.0)
High-jump (cm) $\bar{x}$ (SD) ↑	36.4 (7.4)	35.9 (7.1)	34.0 (6.2)	32.3 (6.2)	33.4 (6.7)	32.3 (6.4)

Notes. s=seconds, cm=centimeters, kg=kilograms, ↑ = a higher value indicates a better test score, ↓ = a lower value indicates a better test score

[1] Mixed grades (such as 6/7) are added to the lowest grades

Table 3: Characteristics of children with self-report data on physical activity, screen behavior, dietary behavior and self-rated health

	T0		**T1**		**T2**	
	Intervention N=144	**Control N=178**	**Intervention N=103**	**Control N=178**	**Intervention N=131**	**Control N=144**
Grade[1] %:						
6	35.9	34.3	36.9	32.4	35.1	27.8
7	33.8	34.9	29.1	32.4	35.9	32.6
8	30.3	30.9	34.0	35.2	29.0	39.6
Birth country parents %:						
Both NL	12.8	8.2	9.0	8.0	8.4	9.4
Both MR/TU	33.3	40.6	38.0	39.4	36.6	33.1
Both other	34	28.8	31.0	31.4	32.1	38.1
NL-MR/TU	9.9	11.2	8.0	14.3	9.2	15.8
NL-other	5.0	8.2	7.0	3.4	8.4	0.7
MR/TU-other	5.0	2.9	7.0	3.4	5.3	2.9
Lives with %:						
Both parents together	82.5	77.3	80.0	77.8	77.1	73.2
Parents separated	9.1	14.2	17.0	15.9	13.7	19.7
Parent + new partner	7.0	6.3	1.0	4.0	4.6	4.2
Other	1.4	2.3	2.0	2.3	4.6	2.8
Consumption soda (mL/ week) $\tilde{x}$ (IQR)	750.0 (250.0-2547.0)	580.0 (125.0-3240.0)	500.0 (155.0-1500.0)	580.0 (165.0-1830.0)	540.0 (155.0-1740.0)	540.0 (250.0-1740.0)

	T0		T1		T2	
	Intervention N=144	**Control N=178**	**Intervention N=103**	**Control N=178**	**Intervention N=131**	**Control N=144**
Consumption energy/sports drinks (mL/week) $\tilde{x}$ (IQR)	125.0 (0.0-250.0)	0.0 (0.0-250.0)	125.0 (0.0-250.0)	125.0 (0.0-281.3)	125.0 (0.0-250.0)	125.0 (0.0-375.0)
Consumption candy (portions/week) $\tilde{x}$ (IQR)	4.0 (2.0-8.0)	3.0 (1.5-6.0)	4.0 (2.0-7.0)	4.0 (2.0-7.0)	3.5 (1.5-7.1)	3.0 (1.5-7.0)
Consumption snacks (portions/week) $\tilde{x}$ (IQR)	5.0 (2.5-12.0)	4.0 (1.8-8.5)	9.0 (2.5-15.3)	6.8 (3.0-13.0)	5.0 (2.5-10.5)	5.0 (2.0-9.0)
Active transport to school (min) $\bar{x}$ (SD)	5.2 (4.7)	6.3 (5.1)	6.0 (4.7)	7.4 (5.6)	5.5 (5.2)	7.5 (5.6)
Outside play (min/day) $\bar{x}$ (SD)	108.0 (66.5)	84.0 (59.3)	115.0 (60.5)	92.8 (63.2)	105.8 (58.5)	92.9 (59.4)
Sports participation (min/day) $\tilde{x}$ (IQR)	47.1 (25.7-102.9)	34.3 (17.1-79.3)	42.9 (21.4-85.7)	38.6 (17.1-73.9)	47.1 (24.6-78.2)	38.6 (25.7-76.1)
Watching TV/movies (min/day) $\bar{x}$ (SD)	87.5 (63.6)	88.6 (71.8)	114.3 (92.5)	108.7 (90.1)	93.4 (72.7)	97.9 (78.6)
Gaming (min/day) $\bar{x}$ (SD)	72.2 (73.0)	90.5 (93.3)	110.3 (87.2)	95.0 (99.5)	99.2 (91.0)	105.9 (88.9)
Self-rated health (scale 0-100) $\bar{x}$ (SD)	82.9 (18.7)	80.8 (21.2)	82.1 (18.3)	78.8 (21.3)	78.2 (19.1)	79.2 (20.9)

Notes. mL=milliliter, min=minutes, MR=Morocco, NL=the Netherlands, TU=Turkey.
[1] Mixed grades (such as 6/7) are added to the lowest grades

Table 4: Characteristics of children with valid accelerometer data

	T0		T1		T2	
	Intervention N=99	**Control N=124**	**Intervention N=62**	**Control N=87**	**Intervention N=87**	**Control N=77**
Grade[1] (%):						
6	31.6	32.0	43.5	22.1	42.5	32.5
7	35.7	36.1	29.0	41.9	37.9	42.9
8	32.7	32.0	27.4	36.0	19.5	24.7
Birth country parents (%):						
Both NL	15.5	7.5	9.8	6.9	10.6	11.0
Both MR/TU	34.0	40.0	37.7	41.4	41.2	27.4
Both other	30.9	29.2	24.6	37.9	25.9	41.1
NL-MR/TU	11.3	10.8	4.9	6.9	9.4	16.4
NL-other	5.2	9.2	14.8	3.4	10.6	1.4
MR/TU-other	3.1	3.3	8.2	3.4	2.4	2.7
Lives with (%):						
Both parents together	80.8	77.2	85.2	80.5	81.2	66.7
Parents separate	10.1	13.8	8.2	11.5	9.4	28.0
Parent + new partner	8.1	6.5	3.3	4.6	5.9	5.3
Other	1.0	2.4	3.3	3.4	3.5	0.0
Wear time (min/day) $\bar{x}$ (SD)	759.8 (56.9)	776.1 (42.5)	766.9 (50.5)	756.2 (58.0)	773.4 (52.1)	770.4 (51.3)
Time spent sedentary (min/day) $\bar{x}$ (SD)	440.0 (59.0)	461.2 (57.0)	433.3 (68.4)	434.1 (67.6)	447.7 (56.2)	433.0 (60.8)
Time spent in LPA (min/day) $\bar{x}$ (SD)	261.8 (46.4)	268.3 (64.2)	263.9 (51.1)	260.9 (51.8)	265.5 (39.7)	271.4 (42.5)

	T0		T1		T2	
	Intervention N=99	**Control N=124**	**Intervention N=62**	**Control N=87**	**Intervention N=87**	**Control N=77**
Time spent in MVPA (min/day) $\bar{x}$ (SD)	58.2 (21.0)	50.7 (18.0)	69.7 (31.3)	60.9 (23.9)	61.8 (23.0)	66.0 (29.0)
MVPA accumulated in bouts of ≥5 min (nr/day) $\tilde{x}$ (IQR)	2.0 (0.0-3.9)	2.4 (0.8-5.9)	4.8 (1.4-8.1)	2.7 (0.8-6.8)	3.1 (1.9-6.6)	4.2 (1.5-6.8)
Sedentary time accumulated in bouts of ≥10 min (nr/day) $\bar{x}$ (SD)	99.4 (48.0)	108.7 (49.2)	101.6 (56.8)	112.5 (54.1)	101.6 (43.1)	100.3 (43.3)

Notes. LPA=light physical activity, min=minutes, MR=Morocco, MVPA=moderate-to-vigorous physical activity, NL=the Netherlands, nr=number, TU=Turkey.
Only data is presented from outcome variables or relevant covariates.
[1] Mixed grades (such as 6/7) are added to the lowest grades

Table 5 provides the results of the mixed model analyses. The intervention had significant adverse effects on the '10x5 meter run' (β=0.5 sec, 95% CI=0.0; 1.0) at T2 versus T0 and 'plate-tapping' (β=0.5 sec, 95% CI=0.1; 0.9) at T1 versus T0, the latter due to improved scores of the control group. We found a significant beneficial intervention effect on consumption of energy/sports drinks at T2 versus T0 (β=-1023.1 mL, 95% CI=-1940.7; -105.5) due to an increase in the control group. Based on the accelerometer data, the intervention had significant beneficial effects at T1 versus T0 on total MVPA (β=9.5 min, 95% CI=2.5; 16.5) and MVPA in bouts (β=2.0 per day, 95% CI=0.0; 3.9). These effects were not present at T2 versus T0, due to an improvement in MVPA in the control group and a decline in the intervention group. No other significant effects were found.

Table 5: Effects (β(95% CI)) of Kids in Action on neuromotor fitness, dietary behavior, physical activity, sedentary behavior, and self-rated health

	T1 vs T0	**T2 vs T0**
MOPER[1]		
Bent-arm hang[2] (s) ↑[3]	1.5 (-0.7; 3.7)	-0.7 (-2.7; 1.2)
10x5 meter run (s) ↓[4]	-0.4 (-0.9; 0.2)	0.5 (0.0; 1.0)*
Leg-lift[5] (s) ↓	1.0 (1.0; 1.0)	1.0 (1.0; 1.0)
Plate-tapping (s) ↓	0.5 (0.1; 0.9)*	0.2 (-0.2; 0.6)
Sit-and-reach (cm) ↑	0.6 (-0.7; 2.0)	1.1 (-0.1; 2.3)
Hand-grip strength (kg) ↑	0.2 (-1.0; 1.3)	0.1 (-0.7; 1.0)
High-jump (cm) ↑	0.9 (-0.6; 2.3)	0.6 (-0.8; 1.9)
Self-report[6]		
Consumption soda[2] (mL/week)	-578.1 (-1798.0; 641.8)	-736.4 (-1910.9; 438.1)
Consumption energy/sports drinks[2] (mL/week)	-192.4 (-1156.7; 771.8)	-1023.1 (-1940.7; -105.5)*
Consumption candy[5] (portions/week)	1.0 (0.9; 1.1)	1.0 (0.9; 1.1)
Consumption snacks[5] (portions/week)	0.9 (0.8; 1.1)	1.0 (0.9; 1.1)
Active transport to school (min)	-1.0 (-2.4; 0.5)	-1.5 (-3.0; 0.0)
Outside play (min/day)	3.6 (-15.0; 22.2)	-3.6 (-22.3; 15.1)
Sports participation[5] (min/day)	1.0 (0.9; 1.1)	1.0 (0.9; 1.1)
Watching TV/movies (min/day)	6.1 (-15.4; 27.7)	-0.7 (-21.6; 20.3)
Gaming (min/day)	19.8 (-6.1; 45.8)	-0.9(-26.1; 24.3)
Self-rated health (scale 0-100)	4.2 (-1.6; 9.9)	-1.4 (-6.9; 4.1)

Accelerometer[7]		
Time spent sedentary (min/day)	-0.3 (-18.8; 18.2)	18.4 (-0.2; 37.1)
Time spent in LPA (min/day)	-6.2 (-24.2; 11.7)	-5.3 (-22.4; 11.7)
Time spent in MVPA (min/day)	9.5 (2.5; 16.5)**	-6.4 (-13.3; 0.5)
MVPA accumulated in bouts ≥5 min[2] (nr/day)	2.0 (0.0; 3.9)*	-1.0 (-2.9; 0.9)
Sedentary time accumulated in bouts ≥10 min (nr/day)	-1.0 (-18.1; 16.2)	3.5 (-12.7; 19.8)

Notes. Control group is coded as 0. cm=centimeters, kg=kilograms, LPA=light physical activity, min=minutes, mL=milliliter, MVPA=moderate-to-vigorous physical activity, nr=number, s=seconds.

* p<0.05. ** p<0.01

[1] Adjusted for *age* and *gender*
[2] Tobit mixed models analysis performed
[3] A higher value indicates a better test score
[4] A lower value indicates a better test score
[5] Data log-transformed, β has to be interpreted as a ratio
[6] Adjusted for *ethnicity* and *living with both parents*
[7] Adjusted for *ethnicity*, *living with both parents* and *wear time*

7.4. Discussion

This paper presents the effects of the intervention Kids in Action on children's dietary behavior, physical activity, sedentary behavior, and neuromotor fitness. Inconsistent results were found, with significant favorable effects on total MVPA and MVPA in bouts at T1 and on the consumption of energy/sports drinks at T2. On the MOPER fitness test adverse effects were found on '10x5 meter run' at T2 and 'plate-tapping' at T1.

Most of the actions that focused on stimulating sports and play were implemented in the first year, which could explain the favorable effects on total MVPA and MVPA in bouts[11]. The favorable intervention effects on the consumption of energy/sports drinks at T2 versus T0 derives from an increase in the consumption of energy/sports drinks of children in the control group. Promotion of drinking water was implemented as part of 'usual care' by community organizations and local government in both intervention and control neighborhoods and in most schools. Additionally, Kids in Action promoted drinking water and raised awareness on sugar-sweetened beverages. These child-initiated actions within Kids in Action at intervention

schools could have contributed to the stabilization of consumption of energy/sports drinks in the intervention group, versus an increase in the control group. This is supported by the process evaluation, which showed that Kids in Action stimulated organizations in the intervention neighborhood to prioritize healthy lifestyle policies[10]. The adverse effects on fitness items are difficult to explain, but since no actions were developed that specifically targeted neuromotor fitness, these could be chance findings.

The lack of consistent, favorable intervention effects can be explained in several ways. Most importantly, as the focus of our study was on children in the three highest grades of primary school, the measured sample differed each year. For example children who were in the highest grade at T0, had left the school at T1. Secondly, an intricate and inevitable challenge of PAR evaluations is that beforehand it is unknown what behaviors will specifically be targeted by the developed actions[29, 30]. Subsequently, it is unknown what specific outcomes should be measured at baseline and follow-up. For example, in the present study a water policy was successfully implemented at one school, but water consumption was not measured. Future YPAR studies might add delayed baseline measurements to include measures of outcomes that were unknown at baseline. Additionally, process evaluations are of utmost importance to provide insight into the targeted health behaviors[31]. Thirdly, in Kids in Action the focus was on the collaboration with children[11, 18]. This process was optimized by closely collaborating with schools, community organizations and the local government. By developing and implementing actions with them, Kids in Action hoped to also reach changes in the system and in local/organizational policies. However, not all partners were engaged in all phases of the project and most actions focused on the school and neighborhood environment and less on the home environment and parents[10]. Ecological models describe that when aiming to improve EBRBs in children, the system surrounding the child also has to be targeted[32, 33]. We recommend future YPAR studies to obtain a systems science approach, involving important stakeholders on all system levels and thereby develop synergistic actions, and also evaluate their impact on different levels and with all involved stakeholders[34, 35]. A fourth reason for the lack of consistent, favorable intervention effects, is

that children mainly developed actions related to sports and play. Children were free to decide what kind of behaviors they wanted to target, and they were less interested in developing actions to improve their dietary behavior. In YPAR children decide to work on a topic that is relevant to them and that they want to address[17, 36]. For children this may mean that they do not wish to participate in all topics related to a healthy lifestyle and perhaps even decline some power. We recommend future studies to discuss with children their desired level of power-sharing on each of the research topics, to make sure all topics are covered and children participate on the level of their choosing[37, 38]. Lastly, the relatively short duration of Kids in Action and the low number of children that actively participated in the study could have contributed to the lack of consistent, favorable intervention effects. In Kids in Action, we closely collaborated with 13-18 children per year, over the course of three years, and the majority of actions were developed and implemented in the second year[10, 11]. Our process evaluation indicated that community partners put healthy behaviors and child participation higher on their agenda, that professionals from different organizations worked more closely together, that children's awareness about healthy behaviors improved, as well as children's empowerment[10]. But, it may take more time – and participation of more children, parents and other stakeholders – for these improvements to result in effects on EBRBs[10, 39, 40].

It is difficult to compare the current study to previous studies as to the best of our knowledge there are no other YPAR studies aimed at improving children's EBRBs with a similar level of child participation throughout the development, implementation and evaluation of actions, and including a controlled trial design. Looking more generally to previous YPAR studies aiming to improve EBRBs, they do also show small or inconsistent effects[34, 41-43], similar to interventions which did not include participatory methods[5, 7, 8, 44-46]. YPAR does show promising results in creating actions that adhere to children's needs and interests, in community engagement, improving children's awareness of unhealthy behavior, and in developing several valuable life skills[10, 12, 29]. Therefore we hope that future studies aiming to improve children's EBRBs apply the lessons learned from YPAR studies such as ours, and further examine how YPAR-based interventions can improve their effects on children's EBRBs.

The current study has several strengths and limitations. A limitation of this study is the low participation rate in the self-report questionnaire and accelerometer data, limiting the representativeness of our study. Another limitation is that no valid and reliable questionnaires on the consumption of sugar-sweetened beverages and unhealthy snacks, and sports and outdoor play participation were available. So even though our questionnaire consisted of the most valid and reliable items from existing questionnaires, the questionnaire may have been inadequate in measuring subtle changes in EBRBs. Lastly, a limitation is the dynamic cohort, making it impossible to draw strong conclusions about the intervention effect on an individual level. This is further impeded by the choice of one intervention school to not participate in the second year.

An important strength of this study is that it included a community approach, in which all primary schools in the community participated, as well as the local government and relevant stakeholders. A second strength is that this study included a controlled design which rarely occurs in YPAR studies[13, 14]. Furthermore, intervention and control schools were similar regarding childhood overweight, ethnicity and socio-economic status. Future studies could consider a three-arm study adding a treatment arm where actions are developed and implemented top-down without child participation to examine the added effect of child participation.

7.5. Conclusions

In the Kids in Action study, 9-12 year old children co-created actions to stimulate physical activity and healthy dietary behaviors in peers using a YPAR approach. Despite positive findings on children's empowerment and awareness of healthy behaviors observed in the process evaluation[10], the current effect evaluation showed no consistent beneficial effects on children's physical activity, sedentary behavior, dietary behavior and neuromotor fitness. To obtain larger effects we advise future YPAR studies to collaborate with more children and more intensively with school staff, families and local organizations, trying to improve the larger system surrounding the child. Additionally, we advocate for the value of process evaluations in YPAR,

obtaining stakeholders' experiences as well as including relevant effect measures from the stakeholder perspective.

Additional File 1: Outcome variables used in the analysis and the categorical questionnaire constructs they are based on.

Outcome variable	Constructs used from questionnaire
Consumption soda (mL/week)	How many days a week do you drink sugar-sweetened beverages? On a day you drink sugar-sweetened beverages, how many glasses/small bottles (250mL), cans (330mL) or big bottles (500mL) do you drink?
Consumption energy/ sports drinks (mL/ week)	How many days a week do you drink energy drinks or sports drinks? On a day you drink energy drinks or sports drinks, how many small cans/bottles (250mL) or big cans/bottles (500mL) do you drink?
Consumption candy (portions/week)	How many school days per week do you eat sweets? When you eat candy on a school day, how much sweets do you eat? How many days in the weekend (Saturday/Sunday) do you eat sweets? When you eat sweets on a day in the weekend, how much candy do you eat?
Consumption snacks (portions/week)	How many schooldays per week do you eat snacks? When you eat snacks on a school day, how many small and large snacks do you eat? How many days in the weekend (Saturday/Sunday) do you eat snacks? When you eat snacks in the weekend (Saturday/Sunday), how many small and large snacks do you eat?
Active transport to school (min)	How do you usually travel to school? How long does it take you to get from home to school?
Outside play (min/day)	When you play outside after school, how long do you play? (fill in the number of hours per day in table)
Sports participation (min/day)	Do you participate in sports in your free time? How many times per week do you do this sport? How many hours per day do you do this sport?
Watching TV/movies (min/day)	About how many hours a day do you usually watch television/ DVDs/movies on the tablet or iPad in your free time?
Gaming (min/day)	About how many hours a day do you usually play games on your game computer, iPad, smartphone or surfing on the internet in your free time?
Self-rated health (scale 0-100)	How do you rate your health today?

Notes. min=minutes mL=milliliter

7.7. References

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