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Positive Effects of Promoting Physical Activity and Balanced Diets in a Primary School Setting with a High Proportion of Migrant School Children

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ABSTRACT

Background Children with migration background are at particular risk for overweight. We assessed the effects of a primary school-based initiative targeted at enhancing physical activity and dietary education among children with a high proportion of migration background.

Methods Four 3rd and 4th grade classes (n = 70 children, 77 % with migration background) participated in a 10-months intervention comprising 2 additional exercise lessons weekly and 10 nutrition lessons per school year. 6 school classes (n = 125 children, 65 % with migration background) served as control. Before and after the intervention, an assessment of physical fitness and motor skills and questionnaires on dietary behavior and knowledge were conducted. In a subgroup (n = 37), after 6 months of the intervention, daily physical activity was assessed by accelerometer-based monitoring. Differences in changes between the groups were assessed using linear regression analyses.

Results Changes between the 2 time points for fitness and motor skill tests (differences in standard deviation scores) were larger in the intervention than in the control group for the total mean test value ($\beta = 0.38$, $p < 0.001$), driven by higher improvements in 5 of the 8 test items, i.e., obstacle race (speed) ($\beta = 0.22$, $p = 0.049$), standing long jump (strength) ($\beta = 0.35$, $p < 0.001$), sit-ups (strength) ($\beta = 0.33$, $p = 0.002$), stand and reach (mobility) ($\beta = 0.22$, $p = 0.042$), and 6 min run (endurance) ($\beta = 0.40$, $p < 0.001$), independently of confounders. Changes in dietary knowledge and consumption frequencies did not differ between groups.

Conclusions Promoting guided physical activity in a primary school setting with a high proportion of children with migration background positively affected parameters of fitness and motor skills.

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Abbreviations

BMI body mass index
FPQ food propensity questionnaire
KiGGS Studie zur Gesundheit von Kindern und Jugendlichen in Deutschland [German National Health Interview and Examination Survey for Children and Adolescents]
SDS_{LMS} standard deviation score with the footnote LMS indicating that the SDS values were derived according to a specific equation
TEW-K Test zum Ernährungswissen für Kinder und Jugendliche [test on the dietary knowledge of children and adolescents]

Introduction

In Germany, the prevalence of overweight and obesity doubles during primary school years [1]. According to a health survey in Germany, children with migration background have a markedly increased risk of overweight and obesity compared to their German counterparts [1]. This increased risk is only partially explainable by socio-economic factors [2]. Migration background might influence dietary behavior and physical activity. In fact, children with migration background, especially young females, were more likely to be physically inactive when compared to children without migration background [3]. Also, children with migration background had a less favorable dietary behavior with a higher consumption of sugar sweetened beverages, white bread, fried potatoes, chocolate, and salty snacks in comparison to children without migration background [4].

This emphasizes the need for programs focusing on the prevention of obesity by means of increased physical activity and favorable dietary behavior, particularly in children with migration background [5]. However, only few programs exist for this target group [6, 7] and evidence about their effectiveness is inconclusive [7–10]. The primary school is particularly suitable, as behaviors are getting formed at these ages [11]. As a setting, schools have numerous advantages, i.e., children spend a considerable part of their time there, programs can be mandatory as part of the school curricula, and hard-to-reach target groups are more easily accessible [10, 12].

The aim of the present study was to evaluate the effects of a school-based intervention offering additional hours of supervised physical activity and dietary education for 3rd and 4th graders in primary schools with a large proportion of children with migration background. We hypothesized that this intervention improves physical fitness and motor skills and dietary behavior and knowledge in the primary school children participating in the intervention in comparison to children from classes with a comparable percentage of migration background, not receiving the intervention.

Materials and Methods

The initiative 'SMS. Sei schlau. Mach mit. Sei fit.' ['Be smart. Join in. Be fit.'] (http://www.sms-mach-mit.de/) was evaluated within a controlled, non-randomized intervention trial in a primary school-based setting aiming to assess the efficacy of a regular exercise program and nutrition lessons on anthropometric parameters, physical fitness, motor skills, and dietary behavior (German Clinical Trials Register: DRKS00005119). The evaluation was performed according to the Declaration of Helsinki and approved by the ethics committee of Heinrich-Heine-University Düsseldorf. The parents of the children gave written informed consent prior to participation. For the evaluation phase (09/2012–06/2013), 3rd and 4th grade classes from 3 schools (each providing at least one intervention and control class) participated. 4 classes received the intervention and 6 classes formed the control group. The schools were chosen after consultation with the Municipal Sports Office of the cap-

▶ **Table 1** Characteristics of the children of the intervention and control group for the subgroups used for analyses of body composition, fitness tests, and dietary intake and knowledge.

	Body composition			Fitness tests			Dietary intake and knowledge		
Variable	**Intervention**	**Control**	**p ***	**Intervention**	**Control**	**p ***	**Intervention**	**Control**	**p ***
N (% males)	70 (51 %)	125 (51 %)	1.000	70 (51 %)	122 (52 %)	1.000	69 (52 %)	106 (51 %)	0.879
Age at baseline [years]	9.0 ± 0.7	9.3 ± 0.8	**0.002†**	9.0 ± 0.6	9.2 ± 0.8	**8.0E-04†**	8.8 ± 0.6	9.2 ± 0.8	**5.0E-04†**
Mother with migrant background [n (%)]	47 (67 %)	67 (34 %)	0.071	47 (67 %)	65 (53 %)	0.069	47 (68 %)	57 (54 %)	0.083
Father with migrant background [n (%)]	49 (70 %)	64 (51 %)	**0.015**	49 (70 %)	62 (51 %)	**0.001†**	47 (68 %)	52 (49 %)	**0.019**
At least one parent with migrant background [n (%)]	54 (77 %)	81 (65 %)	0.078	54 (77 %)	78 (64 %)	**0.007**	53 (77 %)	69 (65 %)	0.130
Overweight at baseline [n (%)]†	8 (11 %)	8 (6 %)	0.278	8 (11 %)	8 (7 %)	0.282	9 (13 %)	7 (7 %)	0.183
Overweight at follow-up [n (%)]†	9 (13 %)	9 (7 %)	0.205	9 (13 %)	9 (7 %)	0.303	10 (14 %)	9 (8 %)	0.224
Obesity at baseline [n (%)]†	5 (7 %)	6 (5 %)	0.528	5 (7 %)	6 (5 %)	0.533	3 (4 %)	5 (5 %)	1.000
Obesity at follow-up [n (%)]†	4 (6 %)	7 (6 %)	1.000	4 (6 %)	7 (6 %)	1.000	2 (3 %)	6 (6 %)	0.482

Data are given as mean ± SD or n (%). * P for differences between intervention and control (Fisher's exact test for categorical variables and unpaired t-Test (in case of homogeneity of variance) or Welch test (in case of heterogeneity of variance) for normally distributed continuous variables). † Overweight defined as 90th percentile < BMI ≤ 97th percentile, obesity defined as BMI > 97th percentile. **Bold** indicates significant differences ($p < 0.05$). † P-values still significant after Bonferroni correction (significance level $p < 0.05/9 \triangleq p < 0.006$)

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ital city Düsseldorf based on their results of the physical fitness status in 2nd grade classes. Schools which revealed deficits and increased need for support were contacted. A high proportion of the children of the classes participating in the initiative had a migration background. In the intervention and the control group, about 77 % and 65 % of the children, respectively, had at least one parent with migration background (▶ **Table 1**), resulting in at least 15 different countries of origin. The 10-month intervention was integrated into the school routines of the children and comprised 3 parts, i.e., additional physical activity, nutrition lessons, and extra-curricular activities outside the classroom.

Physical activity intervention

The children of the intervention group participated in the program 'Fitness für Kids' by Dr. Kerstin Ketelhut [13] (see also http://www.fitnessfuerkids.de/index.php) for 2 additional school hours weekly, with each school hour lasting 45 min. The standard physical education according to the school curriculum is 3 h weekly. The sport lessons were conducted by qualified trainers, recruited by the Municipal Sports Department of the capital city Düsseldorf, and offered a very diverse exercise program with extensive motor training and a high amount of moderate-intensity exercise time. It consists of different activity games and tasks, such as psycho-motoric activity games, activity stories, and dances with the aim to improve strength, endurance, and coordination skills of the children. Furthermore, the high motivating tasks and games aim to increase the interest for physical exercise which may lead to a more active lifestyle of the children.

Dietary intervention

The children of the intervention group additionally received 10 school lessons of nutritional education, i.e., about one school lesson monthly, per school year. According to the school curriculum, the children receive a basic introduction into 'nature and live' with the focus on the human body, human senses, nutrition, and health. Thus, the nutritional education within the SMS initiative provided dietary knowledge far beyond the standard nutritional component of the school curriculum. The teachers were trained by qualified dieticians on basic dietary aspects and provided with educational material for the children which formed the basis of their lessons. The child-oriented paper-based material was specifically developed for the SMS initiative by nutrition experts and pedagogues. The dietary intervention comprised the following topics: (1) food pyramid and balanced diet, (2) macro- and micronutrients and their functions, (3) importance of milk, (4) human digestion, (5) beverages, (6) breakfast, (7) lunch, (8) dinner, (9) snacks and fast food, (10) food-related diseases. The topics were presented in a hands-on, playful manner including puzzles, e.g., on the ingredients of different beverages, experiments, e.g., on the ingredients of milk, and recipes, e.g., for a balanced breakfast and self-made alternatives to fast food.

Extra-curricular activities

Extra-curricular activities outside the classroom, which formed the third part of the intervention program and were conducted once per school year, included a soccer training session in the youth academy center of a German soccer league team, an aqua fitness training session, a visit of an interactive musical on human health, and a visit of a bakery where the children baked their own bread. Optionally, the children attended home matches of a German ice hockey or table tennis league team. The intention of these activities were, first, to involve the parents within the otherwise mainly school-focused intervention and, second, to additionally get the children enthusiastic about physical activity and balanced nutrition.

Physical fitness and motor skills testing

At the beginning of the school and at the end of the intervention period, the intervention and control group underwent a test on physical fitness and motor skills. The intervention was supported through funding by the health insurances IKK classic and Kaufmännische Krankenkasse – KKH. Of note, the funding organizations did not participate in the collection, analysis, or interpretation of the data. They also did not have the right to approve or disapprove the publication of the finished manuscript.

Anthropometric measurements were performed prior to the fitness test. Body height and weight were measured without shoes and in light clothes to the nearest 1 cm and 100 g, respectively, using a calibrated scale with stadiometer (seca 877, seca GmbH & Co. KG, Germany). For body weight, 500 g were subtracted during post-processing to account for clothes. Body mass index (BMI) was calculated from body weight and height. Muscle and fat mass and percentage body fat were assessed to the nearest 0.1 kg and 0.1 %, respectively, using bioimpedance analysis (InBody 720, JP Gobal Markets GmbH, Eschborn, Germany).

Physical fitness and motor abilities were assessed by trained personnel using the 'CHECK!' test [14], which was administered at the beginning and the end of the intervention period among children of the control and the intervention group. The 'CHECK!' test – which has been described in German elsewhere – was developed based on an existing fitness test for children [15] and covers 5 aspects of physical fitness and motor skills, i.e., speed, coordination, strength, mobility, and endurance which are assessed by 8 test items [14]. All test items fulfill the test statistical quality criteria, i.e., objectivity, reliability, and validity [16]. Speed is tested by a 10 m sprint which is performed twice by each child. The time is measured electronically using light barriers to the nearest 1/100 s and the better time of each child is kept. Coordination is assessed using 2 tests, the obstacle race and the ball legs wall test. The obstacle race includes four 2.5 m runs to a flag, followed by a 90 ° turn to the left and a 2.5 m run to an element of a vaulting box used as a barrier. When first passing the barrier, the children need to crawl beneath it; at their second pass, they need to jump over the barrier. The children then run to the flag, followed by a 90 ° turn and a run to the next barrier, resulting in a total distance of 20 m (8 × 2.5 m). The time needed to perform this obstacle course is measured to the nearest 1/100 s using a stopwatch. The ball legs wall test evaluates the whole-body coordination when performing precision tasks. The child is standing in 3 m distance to a wall and throws a gymnastic ball backwards through his or her straddled legs against the wall. The child then makes a half turn and catches the ball without the ball touching the ground. The test is repeated 10 times per child and each attempt is scored with 0 to 5 points depending on the child's performance. The test value is then derived

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by summing up the points of the 10 individual attempts. Strength is assessed in 3 individual tests, namely medicine ball throw, long jump, and sit-ups. The medicine ball throw measures the explosive strength of the upper limb by pushing a 1 kg medicine ball with angled arms as far forward as possible. The distance that is reached is then measured to the nearest 10 cm. The strength of the lower extremity is assessed by the standing long jump. The distance of the jump is measured to the nearest 1 cm. Sit-ups are used to measure the strength of the abdominal and hip flexor musculature. The number of sit-ups performed within 40 s is counted. Mobility is tested using the stand and reach task. The child stands on the top element of a vaulting box without shoes and bends the upper body with stretched legs as far down as possible along a scale. The scale value of the deepest point that is reached by the finger tips and can be held for 2 s is documented. A 6 min run is used to test the endurance of the children. The children are asked to run as many rounds of 54 m as possible in 6 min. The number of rounds plus the distance of the last started round was assessed to the nearest 1 m. The fitness and motor skills tests are carried out in the following order: 10 m sprint, ball legs wall, obstacle race, medicine ball throw, standing long jump, sit-ups, stand and reach, and 6 min run, whereas the second 2 tests are exchangeable in sequence. The 'CHECK!' test mean value equals the mean value of the sum of the percentile ranks of all tests. The percentile ranks were derived as described previously [17].

Age- and sex-specific standard deviation scores (SDS_{LMS}) were calculated for BMI (based on data from the KiGGS survey) [18] and test values for physical fitness and motor skills (based on data from primary school children in Düsseldorf, Germany, and neighbor cities) [19].

Accelerometer

After 6 months of the intervention, a subsample of children of both groups was randomly chosen for accelerometer-based monitoring of their daily activity for 6 days, with the intention to assess whether the total daily activity differed between the children of the intervention and the control group during the intervention. As the accelerometer-based activity assessment was only conducted at a single time point instead of a pre-/post-measurement, these data only allow a comparison between the intervention and the control group. In contrast to the other measurements (i.e., body composition, physical fitness and motor skills, dietary knowledge and behavior), which were performed before and after the intervention, the accelerometer-based monitoring does not allow to measure changes in daily activity triggered by the intervention. Accelerometers were distributed 6 months after the intervention had been initiated to measure the longer-term rather than possible acute increases of daily physical activity. Accelerometers (Polar Active and Polar Webservice GoFit, Polar Electro GmbH Deutschland, Büttelborn, Germany) were worn on the wrist, at the position of a watch and assessed the number of steps, daily activity (minutes of moderate-to-vigorous activity), and total energy expenditure based on activity measurements and calculation of basal metabolic rate from age, sex, weight, and height. Children started wearing the accelerometer of a weekday morning and kept it for the following 7 days during daytime. For analysis, the parameters were retrieved for the 6 days at which the device was worn all-day.

Questionnaires on dietary knowledge and behavior

Effects of the nutritional education were assessed by the dietary knowledge and behavior of the children. 2 self-administered questionnaires were filled in the classroom. The questionnaire 'What do you know' on dietary knowledge is a modified version of the 'Test zum Ernährungswissen für Kinder und Jugendliche' [test on the dietary knowledge of children and adolescents] (TEW-K) [20], which was adapted to the age of the participants in collaboration with the developer of the questionnaire. The original questionnaire was evaluated in 1 470 children and adolescents [20]. The modified questionnaire covers the content of the nutrition education sessions in 20 questions (**Appendix 1**). Each correct answer was assigned a value of 1, each incorrect answer a value of 0. The values of the 20 individual questions were then summed up to yield the dietary knowledge score.

To assess the dietary behavior of the children, a modified version of the food frequency questionnaire 'What do you eat' from KiGGS was used. The questionnaire assesses the usual consumption frequencies of 34 foods/food groups of the last few (referring to about 4) weeks in 7 frequency categories ranging from 'never' to 'several times per day' [21, 22]. Due to practical considerations, the questionnaire was filled in at school without parental assistance. Thus, a modified version without portion sizes was used (**Appendix 2**). For analysis, the foods were grouped according to the optimized mixed diet into 'beverages and plant foods' (beverages, vegetables, fruits, bread/cereals, potatoes/pasta), 'animal foods' (milk/milk products, meat/sausages, eggs, fish), 'fats' (butter, margarine, nuts), and tolerated foods (sugar, sweets, chocolate, fast food) [23]. Consumption frequencies were summed up for each category.

Statistical analyses

Statistical analyses were conducted using SAS (version 9.2; SAS Institute, Cary, NC). Differences between the intervention and control group and differences in changes from baseline to follow-up between groups were calculated using Fisher's exact test for categorical and unpaired t-Test (in case of homogeneity of variance) or Welch test (in case of heterogeneity of variance) for continuous variables. Fat mass, muscle mass, tolerated foods, animal foods, beverages, and plant foods were not normally distributed and ln-transformed prior to analyses. In order to give a quantitative measure of group differences on the original scale, the relative percentage changes of these variables were calculated from the corresponding regression coefficients (β) using the equation $100 * (\exp(\beta)-1)$. Multivariable linear regression models (ANCOVA) were used to analyze differences between the intervention and control group for changes of body composition, fitness test variables (SDS_{LMS}), food consumption frequencies, and dietary knowledge score (dependent variables) between baseline and follow-up. For accelerometer-based activity, ANCOVA models were applied to analyze differences between the 2 groups. Due to the study design involving a non-randomized approach, regression analyses were adjusted for potential confounders. Model 1 was adjusted for the baseline value of the respective dependent variable with the exception for model 1 for accelerometer-based activity measurements which was unadjusted. Model 2 additionally considered the school [school 1/school 2/school 3] and migration background of the par-

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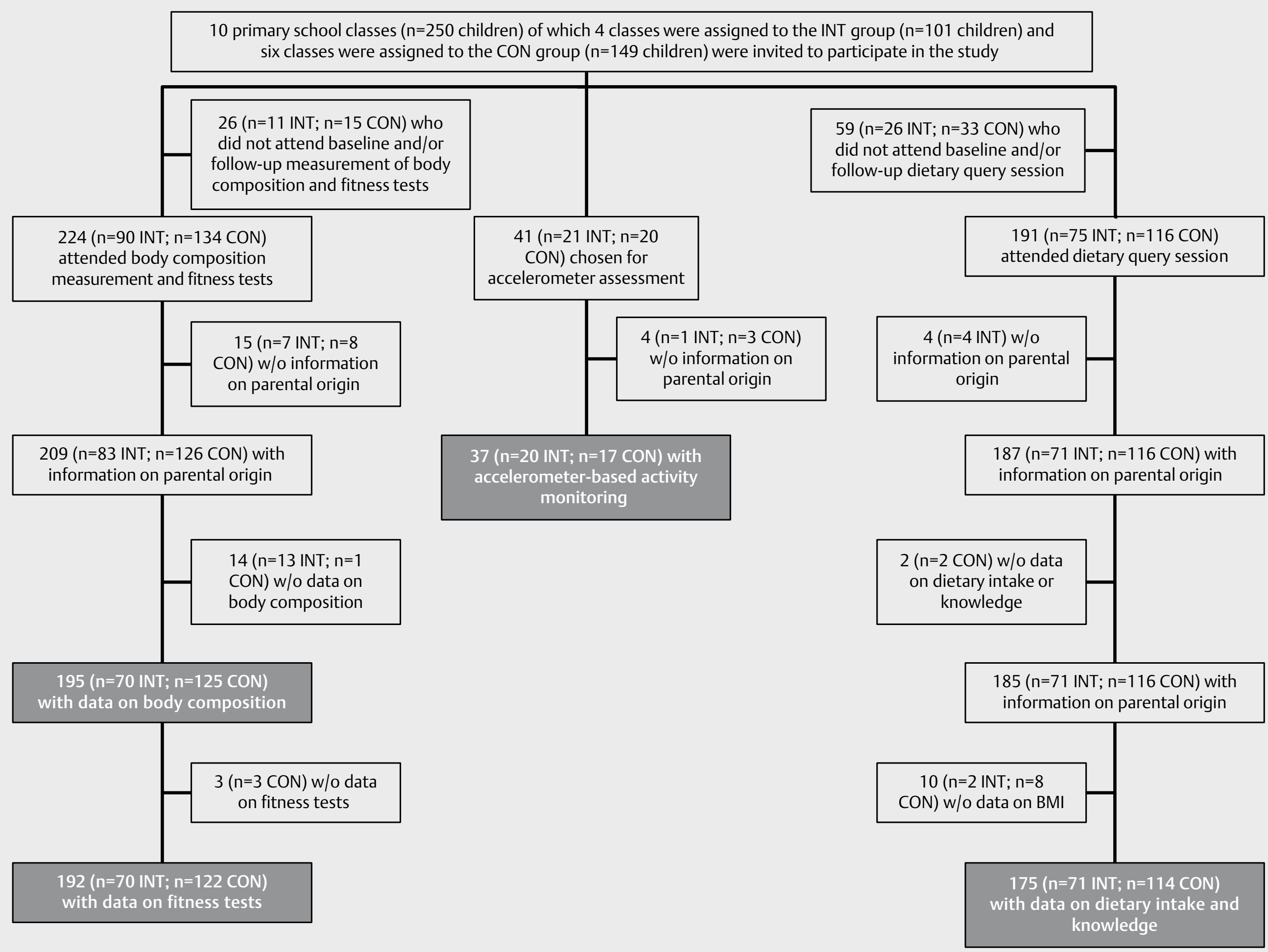

▶ **Fig. 1** Flow diagram showing the number of children included in the analyses from those invited to participate in the tests. CON, control. INT, intervention.

ents (at least one parent with migration background) [yes/no]. Model 3 was additionally adjusted for the BMI (SDS_{LMS}) at baseline and follow-up (except for models with BMI as the dependent variable). $P<0.05$ was considered statistically significant. In addition, Bonferroni correction was applied to counteract the problem of multiple testing. The correction was applied individually for each set of analyses using $p<0.05/m$ as significance level, with m indicating the number of dependent variables to be analyzed.

Sensitivity analyses

ANCOVA models to analyze differences between the intervention and control group for changes (baseline to follow-up) of body composition, fitness test variables, food consumption frequencies, and dietary knowledge score were repeated as sensitivity analysis only including children who had at least one parent with migration background.

Results

Of the 10 school classes comprising 250 school children, 4 classes (equaling 101 children) were assigned to the intervention group and 6 classes (equaling 149 children) to the control group. Complete baseline and follow-up data on body composition and tests of physical fitness and motor skills were available for 195 (n = 70 intervention group, n = 125 control group) and 192 (n = 70 intervention group, n = 122 control group) children, respectively; 175 children (n = 71 intervention group, n = 114 control group) had provided complete data on dietary intake and knowledge. Children in the intervention compared to the control group were slightly younger and more likely to have a father with migration background. The prevalence of overweight and obesity did not differ between the groups (▶ **Table 1**). A subsample of 20 children of the intervention group (65 % with at least one parent with migration background) and 17 children of the control group (65 % with at least one parent with migration background) were assigned to the accelerometer-based activity assessment (▶ **Fig. 1**).

Body composition at baseline, follow-up, and changes between baseline and follow-up for boys and girls of the intervention (n = 70) and control group (n = 125) are provided in Supplementary **Table S1**. After adjusting for potential confounders including BMI, boys of the intervention group had a larger decrease in their fat mass and percentage body fat between baseline and follow-up in

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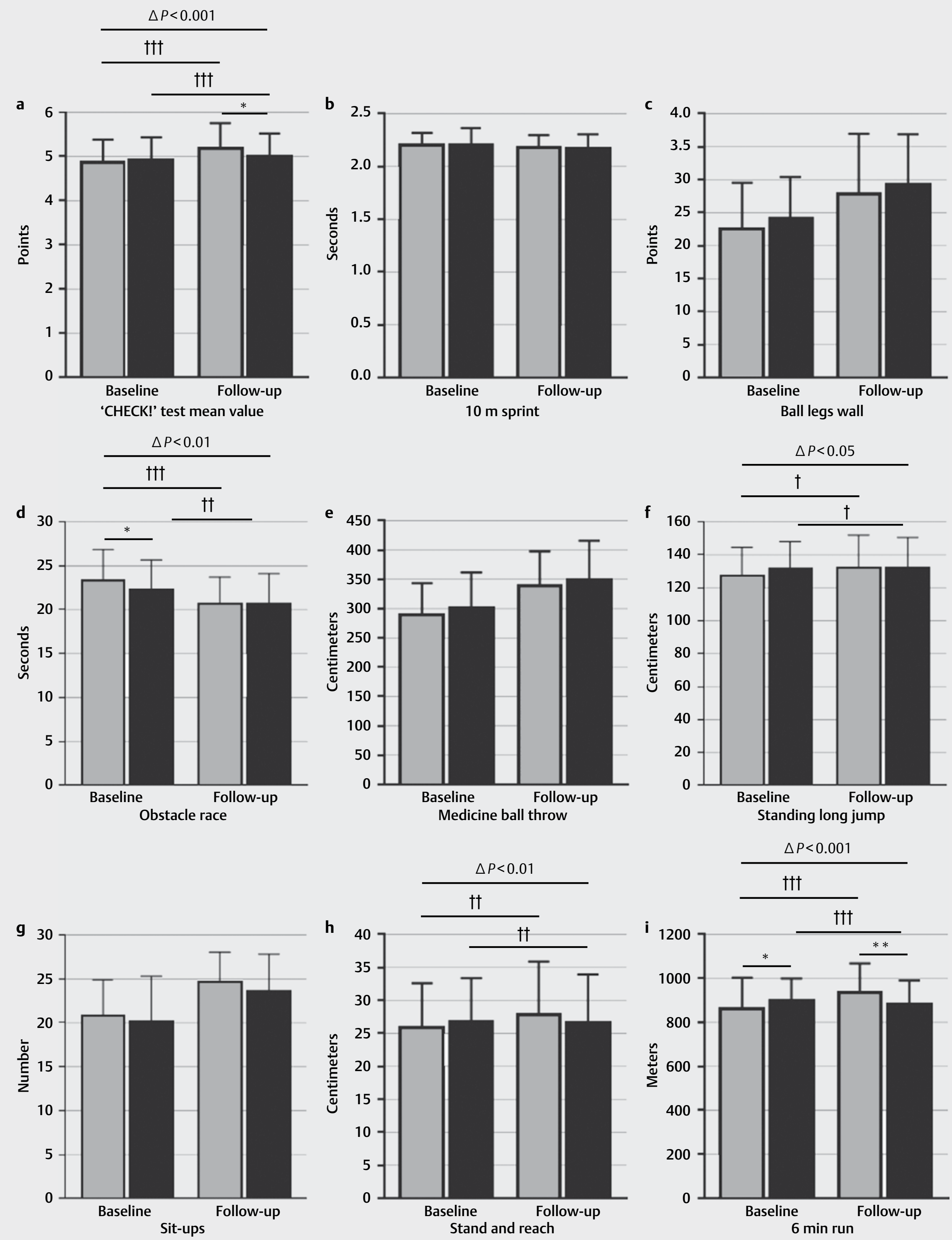

▶ **Fig. 2** Results of the fitness tests at baseline and follow-up stratified for intervention and control group. Data are mean ± SD for fitness tests including 'CHECK!' test mean value **a**, 10 m sprint **b**, ball legs wall **c**, obstacle race **d**, medicine ball throw **e**, standing long jump **f**, sit-ups **g**, stand and reach **h**, and 6 min run **i**. White bars indicate intervention group, black bars indicate control group. Unpaired t-Test (in case of homogeneity of variance) or Welch test (in case of heterogeneity of variance) was used to test differences between intervention and control at baseline and follow-up, respectively (* p < 0.05 and ** p < 0.01), changes between baseline and follow-up within one group (†p < 0.05, ††p < 0.01, and †††p < 0.001), and differences in changes from baseline to follow-up between intervention and control group (Δ p < 0.05, Δ p < 0.01, and Δ p < 0.001).

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▶ **Table 2** Differences between the intervention and control group for changes in fitness test variables between baseline and follow-up (n = 70 children of the intervention group, n = 122 children of the control group).

Variable	Intervention vs. control group for changes between baseline and follow-up		Intervention vs. control group for changes between baseline and follow-up		Intervention vs. control group for changes between baseline and follow-up	
	Model 1		Model 2		Model 3	
	β (95 % CI)	p	β (95 % CI)	p	β (95 % CI)	p
'CHECK!' test mean value [SDS_{LMS}]	0.40 (0.26; 0.54)	**1.3E-07** *	0.38 (0.22; 0.53)	**3.1E-06** *	0.38 (0.22; 0.53)	**3.5E-06** *
10 m sprint [SDS_{LMS}]	0.06 (−0.11; 0.23)	0.501	0.02 (−0.17; 0.20)	0.861	0.02 (−0.17; 0.20)	0.860
Ball legs wall [SDS_{LMS}]	0.04 (−0.20; 0.28)	0.740	0.13 (−0.13; 0.39)	0.324	0.13 (−0.13; 0.40)	0.313
Obstacle race [SDS_{LMS}]	0.26 (0.05; 0.46)	**0.013**	0.25 (0.02; 0.47)	**0.032**	0.22 (0.00; 0.44)	**0.049**
Medicine ball throw [SDS_{LMS}]	−0.01 (−0.19; 0.17)	0.879	0.05 (−0.14; 0.23)	0.625	0.05 (−0.13; 0.23)	0.592
Standing long jump [SDS_{LMS}]	0.25 (0.06; 0.44)	**0.009**	0.37 (0.16; 0.57)	**5.0E-04** *	0.35 (0.16; 0.55)	**4.8E-04** *
Sit-ups [SDS_{LMS}]	0.25 (0.04; 0.45)	**0.019**	0.33 (0.11; 0.54)	**0.002** *	0.33 (0.12; 0.54)	**0.002** *
Stand and reach [SDS_{LMS}]	0.32 (0.13; 0.51)	**0.001** *	0.23 (0.01; 0.44)	**0.039**	0.22 (0.01; 0.44)	**0.042**
6 min run [SDS_{LMS}]	0.66 (0.45; 0.88)	**9.4E-09** *	0.41 (0.19; 0.63)	**2.5E-04** *	0.40 (0.19; 0.62)	**2.9E-04** *

The table gives regression coefficients (β), 95 % confidence intervals (95 % CI), and p values from linear regression analyses modelling differences between intervention and control group (intervention minus control group) for changes between baseline and follow-up for standard deviation scores (SDS_{LMS}). Model 1 adjusted for the fitness variable at baseline. Model 2 additionally adjusted for age at baseline, sex, school [school 1/school 2/school 3] and migrant background of the parents [yes/no] (at least one parent with migrant background). Model 3 additionally adjusted for BMI [SDS_{LMS}] at baseline and follow-up. **Bold** indicates significant associations ($p < 0.05$). * P-values still significant after Bonferroni correction (significance level $p < 0.05/9 \triangleq p < 0.006$)

comparison to the control group. Yet, girls of the intervention compared to the control group indicated a larger increase of their fat mass after adjustment for confounders. Changes in BMI and muscle mass between baseline and follow-up did not differ between the 2 groups (Supplementary **Table S2**). When only considering the children with migration background, no differences between both groups for changes between baseline and follow-up for any of the body composition parameters were observed (data not shown).

The 'CHECK!' test mean value (▶ **Fig. 2a**) and the results of the individual items of the fitness and motor skills test (▶ **Fig. 2b–i**) for the intervention (n = 70) and control group (n = 122) at baseline and follow-up are shown in ▶ **Fig. 2**. Between baseline and follow-up, children of the intervention group improved in the obstacle race (speed) by about 2.7 s, in the standing long jump (strength) by about 5 cm, in the stand and reach (mobility) by about 2 cm, and in the 6 min run (endurance) by about 74 m (data are mean values) (▶ **Fig. 2**). When comparing both groups, children in the intervention group compared to the control group yielded a higher improvement in the 'CHECK!' test mean value, which was driven by higher improvements in the obstacle race, the standing long jump, sit-ups, stand and reach, and the 6 min run between baseline and follow-up based on SDS_{LMS} values (▶ **Table 2**). These results were replicated when considering only children with migration background (data not shown).

Mean number of steps, time spent in moderate-to-vigorous activity, and estimated energy expenditure during the 6 days of accelerometer-based activity measurement and for the weekend days are provided in Supplementary **Table S3**. A comparison between the 2 groups yielded lower estimated energy expenditure during the whole period for the children of the intervention (n = 20) compared to the control group (n = 17) after adjustment for potential confounders. Yet, additional adjustment for BMI attenuated the difference towards a trend (p = 0.068). No differences between the groups were observed for any further accelerometer-based measure (Supplementary **Table S4**).

Consumption frequencies (based on n = 71 children of the intervention group and n = 114 children of the control group) for the tolerated foods, fats, animal foods, and beverages and plant foods at baseline and follow-up are displayed in ▶ **Table 5**. In the dietary knowledge test, children scored with a mean of about 10 (intervention) and 11 (control) points out of a potential maximum of 20 points at baseline and with about 12 and 13 points at follow-up, respectively (Supplementary **Table S5**). Changes in food consumption frequencies or dietary knowledge score between baseline and follow-up did not differ between the groups (Supplementary **Table S6**), which was equally true when considering only children with migration background (data not shown).

Discussion

A school-based intervention for promoting physical activity and dietary education in primary school children with a high proportion of migration background showed positive effects on physical fitness and motor skills of the children when compared to a group of primary school children without an intervention. Changes in dietary knowledge and food consumption frequencies did not differ between groups. The higher improvements of children in the intervention compared to the control group for the 'CHECK!' test mean value, the standing long jump, sit-ups, and the 6 min run remained significant after Bonferroni correction.

The prevalence of overweight and obesity in our study was comparable to a representative German cohort [1]. In our trial, BMI was not affected by the exercise intervention. Yet, the additional weekly guided exercise lessons positively affected physical fitness and motor skills of the children. Similar results have previously been

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obtained in pre-school children [13]. The effectiveness of school-based interventions promoting physical fitness has been confirmed before [9, 11]. However, the evidence for interventions targeting children with migration background is scarce [9, 24]. The present intervention successfully improved physical fitness and motor skills in children with a high proportion of migration background, which has been described as a challenging target group [9, 24].

Accelerometer-based activity measurement within a subgroup suggested that the children were broadly within the recommendations of international guidelines (≥12 000 steps, ≥60 min of moderate-to-vigorous activity daily) [5, 25]. We observed no differences between the groups for the accelerometer-derived parameters. However, in combination with the larger improvements of the intervention compared to the control group for the fitness and motor skills test items, these results suggest that guided activities rather than the number of steps or the energy expenditure per se might be crucial to improve physical fitness and motor skills in children.

The changes in consumption frequencies and dietary knowledge score between baseline and follow-up did not differ between the intervention and control group. This is against expectations from previous school-based interventions indicating positive effects from dietary intervention [11]. Possible reasons for this discrepancy are: The questionnaires on dietary knowledge and habits used in the present study might have been not sensitive enough to capture potential effects of the intervention. Also, evidence suggests lower responsiveness to dietary intervention for children with migration background [8] and parental involvement has been identified as a crucial factor for the success of school-based interventions [11]. In our trial, parental involvement was limited to participation in evening meetings and accompanying their children to extra-curricular activities.

Strengths and limitations

A major strength is the inclusion of school classes with a high percentage of children with migration background. Additionally, a structured and validated exercise program developed for primary school children was used for the exercise intervention [13]. Standardized tests on physical fitness and motor skills were used for which reference values from a large German population of primary school children exist [19]. The limitations comprised firstly, attributable to the school-based setting, that children could not be matched for age and migration background and that classes could not be randomized to intervention and control group. Regression analyses were adjusted for these parameters to minimize potential effects on the results. Second, the FPQ used in this trial was modified from the KiGGS survey. However, within KiGGS, only children aged ≥11 years completed the questionnaire without parental assistance [21]. As the children participating in our trial were younger and FPQs were filled in at school without the opportunity of parental assistance, a modified version without portion sizes was applied. The reduction of diet assessment burden by excluding portion sizes might have improved reporting compliance [26] at the cost of obtaining only qualitative dietary intake data.

Conclusions

In conclusion, a school-based intervention providing exercise lessons and nutrition education in 3rd and 4th graders with a high proportion of migration background effectively increased parameters of fitness and motor skills but did not change self-reported food consumption frequencies or dietary knowledge when compared to control classes. Thus, additional guided physical activity in primary schools might be a successful means of enhancing physical fitness and motor skills. The non-measureable success of the dietary intervention indicates the need to adapt the dietary assessment methods in order to assess whether an improved food choice in children with a high proportion of migration background can be achieved by this type of intervention.

Authors' Contributions

KSW wrote the manuscript and researched data; MM, AF, BK, and CB researched data; KSW and KS performed the statistical analysis; OS, BK, CB, KD, TS, AEB contributed to discussion and reviewed/edited the manuscript; KM designed the study, contributed to discussion and reviewed/edited the manuscript. All authors critically reviewed the manuscript. KM is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Conflict of interest

The authors have no conflict of interest.

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