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# Socio-cultural determinants of adiposity and physical activity in preschool children: A cross-sectional study

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## Abstract

**Background:** Both individual socio-cultural determinants such as selected parental characteristics (migrant background, low educational level and workload) as well as the regional environment are related to childhood overweight and physical activity (PA). The purpose of the study was to compare the impact of distinct socio-cultural determinants such as the regional environment and selected parental characteristics on adiposity, PA and motor skills in preschool children.

**Methods:** Forty preschools ( $N = 542$  children) of two culturally different urban regions (German and French speaking part of Switzerland) participated in the study (Ballabeina Study). Outcome measures included adiposity (BMI and skinfold thickness), objectively measured sedentary activities and PA (accelerometers) and agility performance (obstacle course). Parental characteristics (migrant status, educational level and workload) were assessed by questionnaire.

**Results:** Children from the French speaking areas had higher adiposity, lower levels of total and of more intense PA, were more sedentary and less agile than children from the German speaking regions (percent differences for all outcome parameters except for BMI  $\geq 10\%$ ; all  $p \leq 0.04$ ). Differences in skinfold thickness, sedentary activities and agility, but not in PA, were also found between children of Swiss and migrant parents, though they were  $\leq 8\%$  ( $p \leq 0.02$ ). While paternal workload had no effect, maternal workload and parental education resulted in differences in some PA measures and/or agility performance (percent differences in both:  $\leq 9\%$ ,  $p \leq 0.008$ ), but not in adiposity or sedentary activities ( $p = \text{NS}$ ). Regional differences in skinfold thickness, PA, sedentary activities and agility performance persisted after adjustment for parental socio-cultural characteristics, parental BMI and, where applicable, children's skinfolds (all  $p \leq 0.01$ ).

**Conclusions:** The regional environment, especially the broader social environment, plays a prominent role in determining adiposity, PA and motor skills of young children and should be implicated in the prevention of obesity and promotion of PA in children.

**Trial Registration:** clinicaltrials.gov NCT00674544

## Background

Childhood overweight and obesity have been increasing dramatically worldwide, even in young children. Despite a possible stabilization, the high prevalence remains a great public health concern [1]. Among several

environmental factors, a sedentary behaviour (especially TV viewing) and a reduction in physical activity (PA) are implicated in this increase in body fatness [2]. Some data indicate that children have become less physically active [3-5]. One potential environmental influence on children's PA that may be implicated in this decrease is the amount of time spent outdoors [6]. It has recently been reported that 3- to 5-year old children spend around 80% of their time in activities classified as

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sedentary or at most light PA [7]. Furthermore, a trend towards a decline in motor performance has already been noticed in young children [8].

Individual socio-cultural determinants such as selected parental characteristics (migrant background, low educational level and high workload) are known risk factors for childhood overweight/obesity and sedentary behaviours [9-12]. In addition, there exist also regional variations of overweight and PA [13,14]. Even within Europe, prevalence in overweight differs among countries, ranging from 5 to 25% [13,14]. However, there is a lack of data on the respective roles of individual and environmental determinants in a well defined setting. With its linguistic and cultural diversity, Switzerland offers the opportunity to study diverse cultural environments within the same country. It can thus serve as a model to examine the impact of the regional environment on adiposity, PA and motor skills in children.

In the present study, we assessed differences in adiposity, objectively measured PA, sedentary behaviour and agility performance in preschool children according to different socio-cultural determinants (parental migrant status, education, and workload) and the regional environment.

## Methods

### Study design and participants

All children participated in the Ballabeina-Study, the description of which has been reported previously [15]. Briefly, 40 public preschools with a high migrant prevalence (>40% migrants) were randomly selected in two distinct similar-sized urban areas at the north-eastern and south-western edge of Switzerland, respectively. Of note, the majority of preschools in Switzerland are public. Twenty schools were located in the German speaking region (north-eastern part of Switzerland; city of St. Gallen: 70'000 inhabitants) and 20 in the French speaking region (south-western part of Switzerland; urban surroundings of Lausanne: 50'000 inhabitants). The study was approved by both cantonal ethical committees and the parents or legal representatives of each child provided written informed consent. Of the initial 727 preschool children, informed consent was obtained from 655 (participation rate: 90.1%) and valid PA measures were obtained from 542 children (83% of the participating children). This data set was used for further analyses. Children without valid PA data had higher BMI ( $16.0 \pm SD 1.9$  vs.  $15.6 \pm SD 1.4$ ,  $p = 0.01$ ), but did not differ in body fat, agility performance, migrant status and parental education compared to children with valid PA-data ( $p > 0.20$ ). Of those with valid PA measures, complete questionnaire data were obtained from 485 children (74% of the participating children).

### Adiposity

Body height and weight were measured by standardized procedures [15]. Body mass index (BMI) was calculated by dividing weight by height squared. Prevalence of overweight/obese children was calculated according to IOTF criteria [16]. We used the sum of 4 skinfold thicknesses (triceps, biceps, subscapular and suprailiac) as indicator of body fat. Skinfold thicknesses were measured with a Harpenden caliper using standard procedures [17].

### Physical activity and sedentary activities

PA was measured over 6 consecutive days with an accelerometer (GT1M, Actigraph, Florida, USA), worn around the hip and programmed to save data in 15-second intervals (epochs). The Actigraph/CSA is the most common used motion sensor in children and has a good reproducibility, validity and feasibility [18]. This type of PA assessment has been shown to be valid across different activities in 3- to 5-year old children, with a Pearson correlation coefficient between  $VO_2$  (ml/kg per min) and epochs of  $r = 0.82$  [19].

To consider data as valid, at least 3 days of recording (2 weekdays and 1 weekend day) [20] with a minimum of 6 h registration per day were needed. The 6-h-validity was highly correlated with 10-h-validity ( $N = 502$ ,  $r = 0.92$ ,  $p < 0.001$ ). Data from monitored days were extrapolated by weighing weekdays and weekends (5:2). Sequences of at least 10 minutes of consecutive zero values were removed and interpreted as "accelerometer not worn" [21].

Total PA, moderate-vigorous physical activity (MVPA) and vigorous physical activity (VPA) were chosen as markers of PA. Total PA was expressed as counts per minute (cpm, total counts recorded divided by daily wearing time). MVPA and VPA were based on cut-offs published by Pate et al. [19]:  $\geq 420$  counts/15 s for MVPA and  $\geq 842$  counts/15 s for VPA. Sedentary activities were defined as 0-25 counts/15 s [22]. Each 15-second-interval over or under the specific cut-off was summarized in the corresponding intensity level group and data are presented as the amount of 15-second-intervals per day. Differences in daily wearing time between the groups were negligible. Therefore, we did not adjust for this variable (mean wearing time 10.8 h/day).

### Motor skills

Agility was chosen as a measure of motor skills [23] and was assessed by the time needed to complete an obstacle course. This test was described by Vogt and Kunz [24,25] for 3- to 6-year old children. It includes running 1 m from a marking cone to a transversally positioned bench, jumping over the bench (36 cm high, 28 cm

wide), crawling under the bench and running back to the marking cone three times in a row as fast as possible. Time was measured in seconds. Each child had two attempts and the faster trial was used for further data analysis. The intra- and interobserver correlations in our pilot study ( $n = 14$ ) were  $r = 0.99$  ( $p < 0.01$ ) and  $r = 0.82$  ( $p < 0.01$ ), respectively.

### Socio-cultural determinants

We investigated the respective role of different socio-cultural determinants: the broad regional environment on one side and individual socio-cultural determinants, such as parental migrant status, educational level and workload (parental characteristics) on the other side. The regional socio-cultural environment was defined by language and geographical region (German speaking, north-eastern versus French speaking south-western part of Switzerland) [26]. Both regions have a very similar climate. For information about parental socio-cultural characteristics (migrant status, education and workload), parents filled out a general health questionnaire. Parental migrant status was determined by their country of birth (e.g. born outside of Switzerland) the educational level as the respective highest grade of school completed (5 levels). Low educational level was defined as no education beyond mandatory school (9 years). For analyses, migrant status and low parental education were divided in two categories (at least one parent migrant/with low education - no parent migrant/with low education). Maternal and paternal workloads were divided into three categories: no professional activity, part-time and full-time. Due to school legislation, no information could be obtained about economic (i.e. earning, wages) data.

Time spent playing outdoors (min/day) as an additional measure of PA [6] and television (TV) time (min/day) as an additional measure of sedentary behaviour were also asked to the parents. The questionnaire also asked for ways of commuting to school and barriers to play outdoors such as road traffic, lack of playgrounds or courtyards, danger of crime or simply the lack of interest to play outdoors.

### Statistical analyses

All analyses were performed using STATA version 11.0 (Statacorp, College Station, Tx, USA). Differences in the subjects' characteristics between the 2 regions were compared using independent t-tests for continuous variables and Chi square-calculations for categorical variable. Measures of adiposity, PA and agility performance are presented as means  $\pm$  standard deviations (SD), as all variables were normally distributed. We used mixed linear or logistic regression models with adiposity measures, PA, sedentary behaviour and agility performance

as outcome variables; regional environment or parental characteristics, as respective fixed factors and preschool class as random effect. Between-group differences were also expressed in percentages using the healthier behaviour (i.e. higher PA) or lower adiposity measure as a denominator. To test the independent effect of the regional environment (fixed factor), regression models were subsequently adjusted for sex, age, parental migrant status, educational level, workload and BMI & children's skinfolds. Significance was assumed at  $p < 0.05$ .

## Results

### Baseline characteristics

Baseline characteristics of the study population are presented in Table 1. Significant regional differences in parental socio-cultural factors were observed (all  $p < 0.05$ ). In the French part, more parents were migrants, had a low education and a higher workload (all  $p < 0.05$ ). For migrant parents, years living in Switzerland did not differ between the German and the French parts ( $p > 0.1$ ). The most important migrant regions in both parts of Switzerland are shown in Table 1.

### Differences due to the regional environment

Differences in adiposity, PA measures and agility performance between the children in the German and French speaking part are shown in Table 2. BMI, skinfold thickness, sedentary activities and TV viewing time were higher and total PA, MVPA, VPA and agility performance were lower in the French speaking compared to the German speaking part (all  $p \leq 0.04$ ). Percent differences in all measures except for BMI were 10% or more.

When considering only children of migrant parents ( $n = 391$ ), regional differences in all outcome parameters were similar to those observed in the total population (all  $p < 0.05$ ). This was also true for children of Swiss parents ( $n = 151$ ), except that the differences in BMI ( $p = 0.20$ ), % body fat ( $p = 0.07$ ) and agility performance ( $p = 0.1$ ) were not significant. Finally, mentioned barriers to play outside (road traffic, lack of playgrounds or courtyards, danger of crime or lack of interest to play outdoors) did not differ between both regions (all  $p = \text{NS}$ ).

### Differences due to parental characteristics

#### Migrant status

Compared to children of Swiss parents, children of migrant parents had higher skinfold thickness, were more sedentary, spent more time watching TV and were less agile (all  $p \leq 0.02$ , Table 3). Those differences generally ranged from 4-8%, while a stronger difference was found for time watching TV (75%). Conversely, there were no differences in BMI and PA.

**Table 1 Subjects' characteristics**

	Total n = 542	German speaking n = 267	French speaking n = 275	p-Value
Mean age (years)	5.1 ± 0.60	5.1 ± 0.59	5.2 ± 0.62	0.2
Sex: Boys/Girls %	264/278 49/51	131/136 49/51	133/142 48/52	0.8
Parental migrant status: migrant <sup>1</sup> /non-migrant %	391/151 72/28	176/91 66/34	215/60 78/22	< 0.001
Parental education: low <sup>2</sup> /middle, high %	179/306 37/63	68/165 29/71	111/141 45/55	< 0.001
Paternal workload: no/part time/full time %	17/24/445 3/5/92	7/9/216 3/4/93	10/15/229 4/6/90	0.5
Maternal workload: no/part time/full time %	182/213/99 37/43/20	88/117/28 38/50/12	94/96/71 36/37/27	< 0.001
Most frequent migrant countries		Balkan area 37% Asian countries 13% Germany 10%	Portugal 28% African countries 18% France 6%	

<sup>1</sup> at least 1 parent born outside Switzerland

<sup>2</sup> at least 1 parent with no education beyond mandatory school (9 year)

Data are shown as means +/- SD or as percentage

#### Parental educational level

No significant differences were found in adiposity or measured PA according to the parental educational level (low vs. middle/high). However, children of parents with low education were less agile (mean difference: 1.5 s,  $p < 0.001$ ) and watched more TV (mean difference: 33 min,  $p < 0.001$ ) than children of parents with middle/high educational level. Differences in agility amounted to 8%, but a stronger difference was found for time watching TV (75%). Similar results were obtained when maternal and paternal educational levels were analyzed separately according to 5 educational levels (data not shown).

#### Parental workload

Nine out of ten (92%) fathers worked fulltime. Paternal workload was not related to differences in adiposity, PA and agility performance of the children. Conversely, compared to children of mothers without professional activity, children of part-time working mothers had higher total PA (mean difference: 45 cpm,  $p = 0.006$ )

and spent more time in VPA (mean difference: 10 intervals of 15 s,  $p = 0.02$ ), were more agile (mean difference: -1.2 s,  $p = 0.008$ ) and watched less TV (mean difference: 10 min,  $p = 0.03$ ), while children of full-time working mothers were more sedentary (mean difference: 61 intervals of 15 s,  $p = 0.04$ ). Children of working mothers (both part-time and full-time) spent more time in MVPA than children of mothers without professional activity (mean difference: 25 resp. 26 intervals of 15 s,  $p = 0.02$  resp.  $p = 0.046$ ). Altogether, these differences amounted to  $\leq 9\%$ , while a large difference was found for time watching TV (20%).

#### Effect of the regional environment

Effect sizes of differences between the French compared to the German region are presented in Table 4 before and after adjustment. Regional differences in body fat, PA, sedentary activities and agility performance persisted after adjustment for sex, age, parental socio-

**Table 2 Differences in adiposity, PA and agility performance between the German and French speaking region**

	German speaking (mean ± SD) n = 267	French speaking (mean ± SD) n = 277	p-Value
BMI (kg/m <sup>2</sup> )	15.5 ± 1.5	15.7 ± 1.4	0.04
Skinfold thickness (mm)	25.5 ± 7.8	28.2 ± 8.3	< 0.001
Percentage overweight/obese children (%)	9.0	11.0	0.5
Total PA (counts per minute, cpm)	771 ± 169	684 ± 151	< 0.001
MVPA (number of 15-s-intervals/day)	400 ± 110	361 ± 101	0.001
VPA (number of 15-s-intervals/day)	110 ± 45	95 ± 42	0.006
Time spent playing outdoors (min/day)	110 ± 59	74 ± 47	< 0.001
Sedentary activities (number of 15-s-intervals/day)	1276 ± 216	1400 ± 253	< 0.001
TV time (min/day)	45 ± 43	67 ± 50	0.001
Obstacle course (s)	18.3 ± 3.3	20.0 ± 5.1	< 0.001

Variables were analyzed using mixed linear or logistic regression models with preschool class as a random effect. Data are shown as means +/- SD or as percentage.

**Table 3 Differences in adiposity, PA and agility performance between children of migrant and non-migrant parents**

	Non-migrants (mean ± SD) n = 151	Migrants <sup>1</sup> (mean ± SD) n = 393	p-Value
BMI (kg/m <sup>2</sup> )	15.5 ± 1.1	15.7 ± 1.5	0.2
Skinfold thickness(mm)	25.3 ± 5.7	27.4 ± 8.9	0.01
Percentage overweight/obese children (%)	7.0	11.0	0.1
Total PA (counts per minute, cpm)	752 ± 176	717 ± 161	0.2
MVPA (number of 15-s-intervals/day)	379 ± 103	380 ± 109	0.5
VPA (number of 15-s-intervals/day)	104 ± 45	102 ± 44	0.8
Time spent playing outdoor (min/day)	99 ± 58	86 ± 54	0.1
Sedentary activities (number of 15-s-intervals/day)	1291 ± 229	1357 ± 247	0.02
TV time (min/day)	34 ± 30	65 ± 48	< 0.001
Obstacle course (s)	18.2 ± 3.5	19.5 ± 4.7	0.005

<sup>1</sup>at least one parent born outside Switzerland

Variables were analyzed using mixed linear or logistic regression models with preschool class as a random effect. Data are shown as means +/- SD or as percentage.

cultural characteristics, parental BMI and children's skinfolds. Only differences in BMI did not remain significant ( $p = 0.3$ ). Adjusting only for parental characteristics (either analyzing migrant status, educational level and workload separately or together) did not alter these results (data not shown). On the other hand, only the following differences according to parental characteristics remained significant: higher time spent watching TV (children of migrant and low educational level parents), higher adiposity (children of migrant parents) and a higher total PA and MVPA (children of part-time working mothers compared to children of mothers without professional activity); all  $p \leq 0.03$ . In most circumstances, their effect was attenuated compared to the non-adjusted values (data not shown).

## Discussion

Our results strengthen the importance of the regional environment on lifestyle behaviours and obesity in very

young children. The main findings of this study are: Within the same country with the same national health policy, preschool children from the French speaking, south-western part of Switzerland had an increase in adiposity, were more sedentary, less physically active and less agile compared to the German speaking, north-eastern part. Those differences were in the range of 10% or more and persisted after adjustment for parental characteristics. On the other side, parental characteristics like migrant status, low educational level or workload had less impact on adiposity and lifestyle behaviour and their impact was attenuated after adjustment for the regional environment.

Children of migrant parents had more body fat, were more sedentary, less active, and less agile than children of Swiss parents. These findings are in agreement with several studies, which reported that children with a migration background had higher BMI and were less active [10,11,27,28]. Maternal workload and low parental

**Table 4 Multivariate-adjusted regression model analyzing differences of the French compared to the German speaking region in Switzerland**

Outcome variable	Crude model: Adjusted for sex & age		Adjusted Model: Adjusted for sex, age, parental characteristics and adiposity	
	$\beta$ -coefficient (95% CI)	p-value	$\beta$ -coefficient (95% CI)	p-value
BMI	0.3 (0.02; 0.5)	0.03	0.2 (-0.1; 0.4) <sup>1</sup>	0.3
Skinfolds (mm)	2.7 (1.3; 4.1)	< 0.001	2.1 (0.4; 3.7) <sup>1</sup>	0.01
Total PA (cpm)	-88 (-127; -50)	< 0.001	-99 (-133; -64)	< 0.001
MVPA (15-s-intervals/day)	-52 (-77; -27)	0.001	-52 (-73; -31)	< 0.001
VPA (15-s-intervals/day)	-15 (-26; -5)	0.004	-18 (-29; -7)	0.001
Time spent outdoors (min/day)	-35 (-48; -21)	< 0.001	-30 (-44; -16)	< 0.001
Sedentary activities (15-s-intervals/day)	125 (85; 165)	< 0.001	134 (85; 182)	< 0.001
TV time (min/day)	22 (10; 34)	< 0.001	16 (4; 28)	0.01
Obstacle course (s)	1.8 (1.0; 2.6)	< 0.001	1.4 (0.6; 2.3)	0.001

<sup>1</sup> adjustment was done without children's skinfolds.

Variables were analyzed using mixed linear regression models with preschool class as a random effect with adjustment for sex and age (crude model) or for sex, age, parental migrant status, educational level, workload and BMI & children's skinfolds (adjusted model). Results are expressed as  $\beta$ -coefficient (95% CI).

educational level resulted in differences in some PA measures and/or in agility performance, but, in contrast to previous studies [10], not in adiposity. Ethnic and genetic factors can contribute to the increase in adiposity in some migrants, while economic reasons, lack of parental time and support and individual socio-cultural attitudes might also explain some of our data [29]. We could hypothesize that the healthy behaviour found in children of part-time working mothers could be a combination of time, motivation and sufficient financial resources. Parental characteristics had a particularly strong influence on the time spent watching TV. Existing differences in parental characteristics between the two regions could theoretically explain the observed differences in the regional environment. However, the impact of the regional environment on adiposity and all lifestyle behaviours except TV viewing was much larger and persisted after adjustment for the above mentioned parental characteristics.

The regional environment represents the broader social, cultural, economic and built environment, within which individual behaviour occurs [30]. Differences in the socio-cultural environment could explain our findings which are also in concordance with the observed North-South gradient in overweight and obesity within Europe [13,14]. In those studies, a particularly high prevalence of overweight/obesity was described among southern European countries [13,14]. This North-South gradient has also been reported within Italy [31]. Moreover, lower levels of overweight and obesity were found among children in countries of Central and Eastern Europe compared to Western Europe [13,14]. Different regional patterns have been observed for reported PA in children across European countries [13,32,33]. According to our results, the German speaking part of Switzerland reflects the trends in the north-eastern countries, whereas the French speaking region reflects those in the south-western (and Latin) European countries. Even within the same country, with almost identical climatic conditions, we could observe this North-South gradient in two urban areas. This could be explained by different prevailing cultural norms, priorities, attitudes and beliefs. Indeed, differences in health beliefs have been associated with differences in PA in young adults [33]. Furthermore, similarly to many northern countries, general efforts in health promotion have a stronger tradition in the north-eastern part of Switzerland compared to the south-western counterparts. Indeed, differences in health between the German and French speaking part of Switzerland have been shown to reflect broader European patterns [26]. Similar differences in PA within Switzerland were also observed in large representative samples of adults, where PA levels, reported by questionnaires, were found to be higher in citizens of the

German compared to the French speaking part of Switzerland [26,34]. In addition, reported time spent playing outdoors has been shown to be higher in school-aged children and adolescents of the German compared to the French speaking part of Switzerland [35]. Similarly, substantial differences in “active transportation to school” have been documented between German- and French speaking school children and adolescents that were independent of socio-demographic characteristics and environmental factors like distance to school or bike availability [36]. On the other side, lifestyle behaviours in different regions within the French or within the German part of Switzerland, respectively, are reported to be very similar [26,34,35]. In our sample, the observed regional differences were comparable, if the whole population or the subgroup of non-migrant children were analyzed. On an even larger perspective outside of the health sector, differences between the German and French speaking part exist regarding educational and employment levels [37]. But also public transport and school system differ between the two parts and are possibly tightly linked to the key outcome measures of our study. For example, preschool in the French part of Switzerland resembles primary school more than it does in the German part of Switzerland (choice of academic objectives, classrooms).

A range of social and environmental factors have been described as potential influences on children’s PA and sedentary behaviours [38]. The social environment includes social factors in the home and neighbourhood environments, as well as social peer networks. Within the social environment, the social network plays a major role. In adults, it can even influence adiposity more strongly than first grade relatives [39]. Since diverse phenomena can spread within social networks, it seems also possible that obesity or PA might spread from person to person [39]. Adults as well as children are embedded in social networks and are influenced by the evident behaviours of those around them. This fact suggests that weight gain or activity levels in one person might influence weight gain or activity levels in others. Having obese or sedentary social contacts might influence the adoption of such specific behaviours. In adolescent girls, the role of peer social network factors is crucial for participating in PA [40]. It is quite possible, that also in younger age not only home support and parental modelling, but also larger social peer networks play an important role [38].

The built environment has also been associated with PA and adiposity and includes access to recreation facilities, parks, playgrounds and traffic [30]. Our regional differences in the outcome parameters observed within the same country could also be influenced by differences in the built environment. Observed differences in time

playing outdoors may reflect potential disparities in the access to playgrounds between the two regions, but might also be influenced by the social environment. In this age group, playing outdoors has been shown to be a good marker of PA [6]. Perceived barriers for children to play outdoors like road traffic, lack of playgrounds or courtyards and danger of crime did not differ between both regions, but the parental perception of barriers might be influenced by socio-cultural factors. Furthermore, ways of commuting and school-based structured PA as important factors of PA did not have a large impact on our results, as the great majority of preschoolers in both areas (90%) still walked to school and physical education at school did not differ.

Strengths and novelties of the study include the joint comparison of regional and individual determinants within the same small country taking advantage of two distinct socio-cultural regions of similar size and with a similar climate. Further strengths are the comprehensive assessment of adiposity and objectively measured PA and the inclusion of motor skills in a very young population. In this study, we focused on socio-cultural characteristics and therefore we did not take into account other essential factors that influence lifestyle and adiposity, such as parenting practices and beliefs. On the other side, parenting practices and beliefs may also be influenced by individual and regional socio-cultural characteristics. Since our investigation is not based on a representative sample, we cannot be certain to draw conclusions for the whole population, although differences in reported PA between the French and German regions in large representative samples of adults and in a population of school-aged children and adolescents confirm our findings [26,34-36]. Another limitation is the cross sectional design of the study that limits the investigation of clear cause-effect relationships.

## Conclusions

Differences in the regional and especially the broader social environment have a major impact in determining adiposity, sedentary behaviour, PA and motor skills of young children. Although the magnitude of their influence may depend on the specific lifestyle behaviour, their impact on adiposity, PA and motor skills may even exceed the influence of parental socio-cultural characteristics. Should our data be confirmed in future longitudinal studies, high-risk regions in addition to high-risk groups should be identified for future interventions. Thereby, a priority should be made for community-based programs that influence social norms and priorities and integrate also other sectors like the school and public transport system as well as the adaptation of the environment. Specifically, this could include a raising awareness for the benefits of a healthy lifestyle

behaviour and provision of opportunities for recreational activities and outdoor playing.

## Abbreviations

BMI: Body Mass Index; PA: physical activity; MVPA: moderate and vigorous physical activity; VPA: vigorous physical activity; cpm: counts per minute; TV: television;

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## Authors' contributions

JJP and SK designed the study. JJP was the principal investigator and is guarantor. JJP, SK, FB, IN, VE, UM, UG and PM established the methods and questionnaires. FB, IN, VE and JP were the main coordinators of the study. FB, IN, VE, UM, PM and JJP conducted the study. PM gave statistical and epidemiological support. FB wrote the article under the assistance of JJP and got additional help from SK, UG and PM. JJP obtained the funding, with the assistance of SK. All authors provided comments on the drafts and have read and approved the final version.

## Competing interests

The authors declare that they have no competing interests.

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