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Effects of an Intervention to Promote Physical Activity and Reduce Sedentary Time in Disadvantaged Children: Randomized Trial

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ABSTRACT

BACKGROUND: In our society, children are particularly vulnerable to physical inactivity and excessive sedentary time (ST). The aim of this study was to evaluate the effectiveness of a school-based intervention designed to promote physical activity (PA) and reduce ST in 6- to 10-years-old children from a disadvantaged neighborhood.

METHODS: The first intervention of this randomized trial was carried out in School 1 in 2017/2018 and 2018/2019, School 2 benefited from the same intervention in 2018/2019. Baseline assessments were realized using accelerometers prior to the intervention (T₁-T₂), after the first intervention (T₃) and after the second intervention (T₄). School-based actions targeted children, parents, teachers, physical, and organizational environment of school and politics. The chi-square test of independence was used to analyze the evolution of the moderate and vigorous physical activity (MVPA) and ST.

RESULTS: For School 1, an increase in the percentage of very active children (over 40 minutes MVPA/day) and of having a very low ST (less 240 minutes/day) ($p = .00$) was found. No further evolution was revealed during the intervention (T₂-T₃) and 1 year after (T₃-T₄). For School 2, similar effects on PA and ST were found at T₃ ($p < .05$).

CONCLUSIONS: Positive effects occurred before the intervention in each school and then remained stable.

Keywords: physical activity; sedentary time; children's health; school health; school interventions.

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Current personal energy expenditure is at its lowest since the post-war period.¹ Children live in a society characterized by a sedentary lifestyle and exhibit passive behaviors from an early age. As a result, they are particularly vulnerable to physical inactivity and excessive sedentary time (ST). From the age of 5 years, children decrease their total physical activity (PA) by 4.2% each year and ST increases similarly.²

The risk of physical inactivity is higher among the most socially disadvantaged children in their early

years of life.³ Many factors can explain the higher prevalence of physical inactivity among children from disadvantaged neighborhoods. First, money is perceived by families as a barrier to participation in PA. As a result, they are less likely to provide financial and logistical support for institutionalized after-school sports or weekend fee-based activities than upper income families. Several authors have described the influence of the environment on PA.^{4,5} For example, some stressors like traffic lead to a reduction of

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recreational PA in the neighborhood.⁶ Thus, it is important to propose interventions to promote PA and reduce ST among children in these settings who do not benefit from favorable environmental conditions.⁷ Interventions to promote active behaviors in disadvantaged neighborhoods are in accordance with 2 specific goals established by World Health Organization (WHO) guidelines⁸: (1) to reduce the prevalence of physical inactivity among adults and adolescents by 15% by 2030; (2) to reduce drastically reducing inequalities.

One of the most promising strategies to promote PA and reduce ST is the implementation of school-based interventions.⁹ School is accessible to all children and can help increase the PA of children during this specific period of time.¹⁰ International guidelines recommend 30 minutes of moderate and vigorous physical activity (MVPA) during school time, that being half of the 60 minutes per day recommended.¹¹ To motivate children to practice PA, school-based interventions can be a single component or multicomponent and can be carried out on one or many levels in accordance with the socioecological models applied in the context of health.^{12,13} Thus, actions can be conducted directly with the child at the individual level by promoting an active recess or active classroom or by providing sensitization workshops. Additional actions at higher levels can be implemented having workshops for parents and teachers, modifying the physical and organizational environment of the school, and involving local political actors. Furthermore, self-determination theory principles can be associated with the socioecological model at the individual level.¹⁴ The social factors activated during the intervention have a positive impact on basic psychological needs, which then have a decisive impact on the child's motivation to participate in PA. Thus, the most effective school-based interventions that can change children's behavior in both the short-term and long-term would be multileveled and multicomponent.⁹

However, few school-based interventions have been conducted with children from disadvantaged neighborhoods particularly using an objective method to measure active behavior.¹⁵⁻¹⁸ These studies represent less than 10% of those published since the last systematic review and therefore there is a lack of evidence regarding the effectiveness of such intervention.⁹ Thus, further studies are essential to achieve the 2 objectives established by the WHO.⁸

The aim of this study was to evaluate the effectiveness of a school-based intervention designed to promote PA and reduce ST in 6- to 10-years-old children of a disadvantaged neighborhood. The intervention was multileveled and multicomponent, based on the different factors of the socioecological model.

METHODS

Study Design

The study was designed as a randomized trial and was conducted within the framework of a Pyrenean cross-cultural structure.¹⁹ Both the primary schools contacted to participate in the study were located in disadvantaged neighborhoods in a mid-sized city in the southern part of France. They both agreed to participate in the project. The 2 schools included children from grade 1 (6 years old) to grade 5 (10 years old).

The total duration of this study, over the 2 interventions, was 3 academic years. During these interventions, several assessments were conducted to measure PA and ST. During the first academic year 2016/2017, baseline measurements were taken to assess PA level of children at the beginning and at the end of the year to control seasonal effects (T1, November 2016; T2, June 2017). During the second academic year 2017/2018, a first intervention to promote PA and reduce ST was carried out in one of the schools (hereafter called School 1) while the other school (hereafter called School 2) was used as control. The choice of the experimental and control schools was random. PA and ST measurements were conducted at the end of this first intervention (T3, June 2018). During the third academic year 2018/2019, the same intervention was carried out in School 2. A final assessment was carried out at the end of this school year (T4, June 2019). It represented a postintervention assessment for School 2 and a long-term final assessment for School 1.

Participants

The baseline measurements T1 and T2 included, respectively, 181 and 107 children in both schools. There were 88 at the first follow-up assessment (T3) and 68 at final assessment (T4). Table 1 gives a more detailed description of participants' characteristics. Parents/guardians were informed of the project by a written letter. Once they were aware of the protocol and of the possible risks and benefits, they signed a consent from giving permission for their child to wear the accelerometer for PA and ST measurement. Such a consent form was required for each measurement period. As a result, children's participation was not uniform throughout the 3 years. Only children with valid accelerometer data were included in the study.

Instrumentation: Measurement of PA and ST

Measurements of PA and ST were made in T1, T2, T3, T4 by accelerometers (Actilife, Pensacola, FL) as a valid objective measure.²⁰⁻²² Children had to wear the accelerometer for 8 consecutive days from morning to evening. It was placed on the right side of the hip. According to the optimal methodological approach for accelerometry, the minimum wear time required to be

Table 1. Number and Characteristics of Children With Valid Accelerometer Data Integrated Into the Analysis at Each Measurement Time

		Baseline Assessment		Follow-Up assessment	Final assessment
		T1, November 2016	T2, June 2017	T3, June 2018	T4, June 2019
School 1	N	73	46	41	28
	% valid data	80.21	47.91	91.11	39.43
	% female	40.36	43.28	40.51	39.02
	Mean age in years (EC)	8.66(1.36)	9.06(1.31)	8.83(1.48)	9.07(1.48)
School 2	N	108	61	47	40
	% valid data	89.25	52.58	92.15	46.51
	% female	59.63	56.71	59.48	60.97
	Mean age in years (EC)	8.87(1.40)	9.11(1.38)	9.17(1.40)	9.36(1.47)

included in the analysis was 10 hours on weekdays and 8 hours on weekend day.²³ Wear-time had to be sufficient for at least 3 weekdays and 1 weekend day.²⁴ When the accelerometer detected an activity of 0 counts (cts) over a period of at least 10 minutes and allowing a quota of time 1 to 2 minutes between 0 and 100 cts, this period of time is considered as no-wear time. We used a 1-second epoch as it is more accurately to measure different intensities of children PA.²⁵ Then, 4 cut-points were used to establish different intensity categories²⁶: ST 0-300 cts, light PA 301-2295 cts, moderate PA 2296-4011 cts, vigorous PA 4012 cts and more. MVPA was the addition of the 2 final cut-points. Corresponding to the French cultural children's schedule, PA and ST were analyzed for the whole day (8:00 AM-9:00 PM) for weekdays and weekend days, and more specifically during school time for the schooldays (morning and afternoon school time: 8:30 AM-12:00 PM and 2:00 PM-4:00 PM). To be considered as a valid measure during school time, 2 conditions had to be met: (1) children had to wear the accelerometer at least 80% of the morning and afternoon's school time (2) 70% of the participants had to wear the monitor during each period.²⁰

Procedure: Intervention

The intervention was conceived as a school-based approach. All the children in each grade (1 to 5) participated in the intervention, independent of their participation in PA and ST measurement. It proposed multiple actions at different levels of the socioecological model.¹³ Some actions were directed personally at the children (ie, workshops in the classroom, activities in the playground, active classroom). Further actions were conducted at the interpersonal level and were directed at parents and teachers (ie, sensitization, reflective, and formative workshops). Other actions were carried out in the school environment (ie, physical and material modification of the schoolyard, lunchtime, and recess reorganization). Finally, the local, national, and international political levels were also involved.

The intervention in each school was implemented in a similar way by the research team. Adaptation to the specific needs of each school was made by the teaching teams, particularly in the implementation of active classroom and sedentary breaks.

Data Analysis

MVPA levels were measured over the weekdays for each assessment period by classifying children into 4 categories, from the less active to the more active: (1) less than 40 minutes; (2) 40-60 minutes; (3) 60-80 minutes; (4) more than 80 minutes MVPA, on average per day. The same was done with the ST over the weekdays by classifying children into 4 categories, from less sedentary to more sedentary: (1) less than 540 minutes; (2) 540-600 minutes; (3) 600-660 minutes; (4) more than 660 minutes, on average per day. The same analysis was conducted on the weekend days, with the same categories as mentioned above. The same analyses were done during school time. The 4 categories of MVPA and ST were modified to be consistent with international school guidelines that recommend that half of the daily MVPA should be done at school. For MVPA: (1) less than 20 minutes; (2) 20-30 minutes; (3) 30-40 minutes; (4) more than 40 minutes; and for ST: (1) less than 240 minutes; (2) 240-260 minutes; (3) 260-280 minutes; (4) more than 280 minutes.

For each measurement period, for each school, the percentage of children in each category was calculated considering the mean and SD of MVPA and ST obtained for each measurement period.²⁷ Children who had valid accelerometer data at each measurement time were included in the analysis (Table 1).

The change in the number of children in the 4 categories of MVPA and ST were analyzed between T1-T2, T2-T3, and T3-T4 during weekday, weekend day, and school day, independent of the school. Comparisons between the 2 schools were then done for each measurement period.

The aim was to explore the change in children's PA and ST levels over the different measurement times

Table 2. Percentage of Children in the 4 Categories of MVPA and ST on Weekday and Weekend Day at Each Measurement Time

Variables and Categories	T1		T2		T3		T4		
	School 1	School 2	School 1	School 2	School 1	School 2	School 1	School 2	
Weekday									
MVPA (% children)									
1. <40 min	2.99	5.94	8.16	10.45	2.22	3.92 ^{††}	8.70	8.33	
2. 40-60 min	40.30	36.63	28.57	50.75	26.67	29.41	32.61	33.33	
3. 60-80 min	41.79	41.58	32.65	22.39 ^{***}	40.00	43.14	23.91	28.33	
4. >80 min	14.93	15.84	30.61	16.42	31.11	23.54	34.78	30.00	
ST (% children)									
1. <540 min	14.93	6.93	18.37	1.49 ^{***}	11.11 ^{††}	9.80 [†]	39.13	33.33	
2. 540-600 min	37.31	43.56	46.94	32.84	46.67	41.18	36.96	35.00	
3. 600-660 min	43.28	48.51	30.61	47.76	37.78	43.14	23.91	25.00	
4. >660 min	4.48	0.99 ^{**}	4.08	17.91 ^{***}	4.44	5.88	0.00	6.67	
Weekend day									
MVPA (% children)									
1. <40 min	14.67 [*]	19.19 ^{**}	39.71 [§]	41.11	50.00	50.98	22.92	18.87	
2. 40-60 min	44.00	37.37	35.29	37.78	29.17	27.45	37.50	37.74	
3. 60-80 min	30.67	19.19	16.18	11.11	14.58	15.69	22.92	28.30	
4. >80 min	10.67	24.24	8.82	10.00	6.25	5.88	16.67	15.09	
ST (% children)									
1. <540 min	40.00	42.42	58.82	42.53	60.42	58.82	70.83	67.92	
2. 540-600 min	38.67	32.32	23.53	29.89	14.58	21.57	22.92	16.98	
3. 600-660 min	18.67	18.18	14.71	14.94	20.83	11.76	2.08	11.32	
4. >660 min	2.67	7.07	2.94	12.64	4.17	7.84	4.17	3.77	

Detailed differences are given below:

^{**}Significant differences between T1 and T2 at $p < .01$ and $p < .001$, respectively.

^{***}Significant differences between T2 and T3 at $p < .05$.

^{†,††}Significant differences between T3 and T4 at $p < .05$ and $p < .01$, respectively.

[§]Significant differences between School 1 and School 2 at $p < .001$.

to examine the effect of each intervention on PA and ST levels. To achieve this, chi-square independence analysis were performed with the R software ($p < .05$).

RESULTS

Weekdays and Weekend

The percentage of children in the 4 categories of MVPA and ST on weekdays and weekend days at each measurement point are presented in Table 2.

Moderate and vigorous physical activity. In School 1, during the weekday, the results revealed no significant differences in the percentages of children classified in the 4 categories of MVPA between T1-T2 ($p = .092$), T2-T3 ($p = .585$), and T3-T4 ($p = .267$). During the weekend, the results only revealed an increase in the percentage of children with a very low level of PA at T2 compared to T1 ($p = .006$; 68% of the significant link).

In School 2, during the weekday, the results indicated an increase in the percentage of children with a moderate level of PA at T3 compared to T2 ($p = .023$; 42% of the significant link). In the weekend, the results revealed an increase in the percentage of children with a very low level of PA at T2 compared to T1 ($p = .001$; 50% of the significant link). The results also indicated a decrease in the percentage of children with a very low level of PA at T4 compared to T3 ($p = .005$; 62% of the significant link).

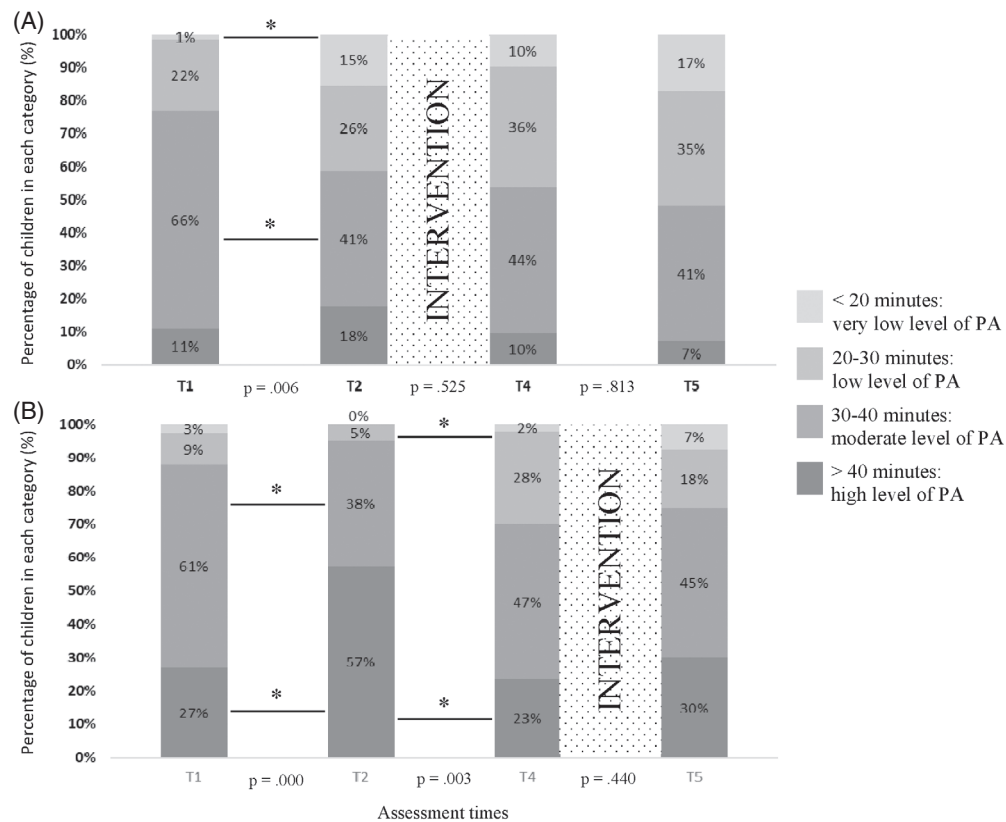
During the weekday, there were no significant differences in the percentage of children in each category between both schools at T1 ($p = .824$), T2 ($p = .060$), T3 ($p = .837$), and T4 ($p = .943$). It was the same during the weekend day (T1: $p = .055$; T2: $p = .828$; T3: $p = .996$; T4: $p = .914$).

Sedentary time. In School 1, on the weekdays, there was an increase in the percentage of children with a very low ST at T4 compared to T3 (64% of the significant link; $p = .011$).

As the weekend, no significant differences were found in the percentages of children classified in the 4 categories of ST between T1-T2 ($p = .137$), T2-T3 ($p = .597$), and T3-T4 ($p = .477$).

In School 2, on the weekdays, there was an increase in the percentage of children with a high ST at T2 compared to T1 ($p = .000$; 80% of the significant link). There was also an increase in the percentage of children with very low ST at T3 compared to T2 ($p = .047$; 49% of the significant link) and a decrease in the percentage of children with a high ST ($p = .047$; 41% of the significant link). Finally, there was an increase in the percentage of children with a very low ST at T4 compared to T3 ($p = .020$; 69% of the significant link). No significant differences were found for the weekends in the percentages of children classified in the 4 categories of ST between T1-T2 ($p = .621$), T2-T3 ($p = .345$), and T3-T4 ($p = .711$).

Figure 1. Evolution of PA Levels of Children in School 1 (A) and in School 2 (B) During the School Day



On weekdays, the results indicated significant differences between both schools at T2: more children have a very low ST in School 1 compared to School 2 ($p = .000$; 54% of the significant link). During the weekend, there were no significant differences in the percentage of children in each category between both schools at T1 ($p = .540$), T2 ($p = .075$), T3 ($p = .478$), and T4 ($p = .309$).

School Days

Moderate and vigorous physical activity. Figure 1 presents the percentages of children in School 1 and School 2 divided in the 4 categories of MVPA at each measurement point.

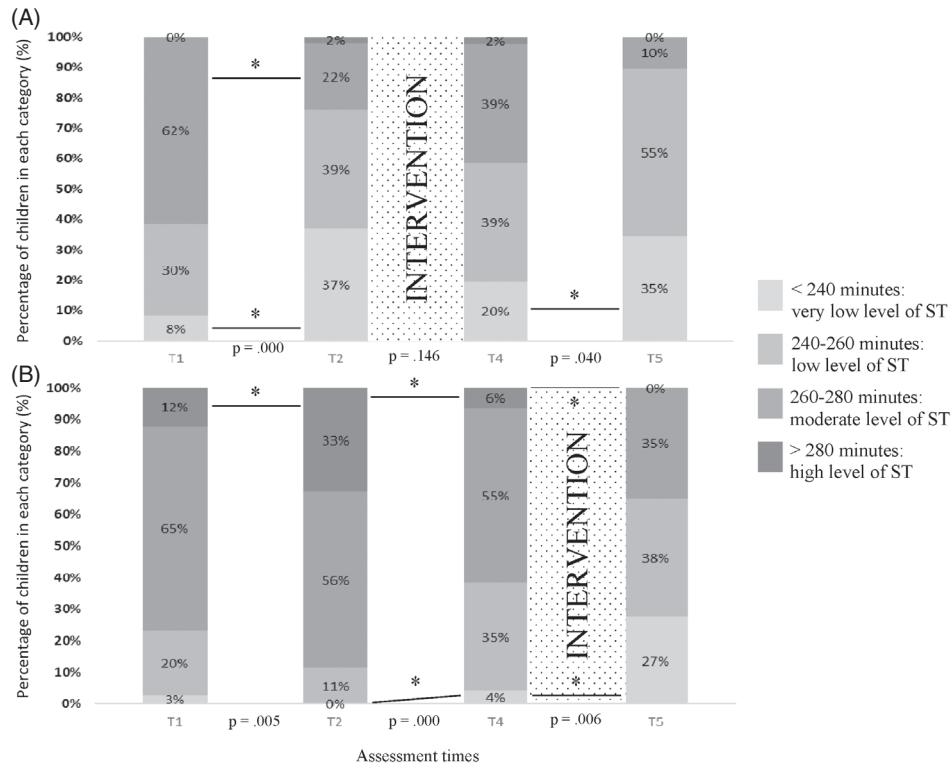
In School 1, there was an increase in the percentage of children with a high level of PA at T2 compared to T1 ($p = .006$; 66% of the significant link) and a decrease in the percentage of children with a low level of PA (24% of the significant link; $p = .006$). There were no significant differences in the percentages of children in the 4 categories of MVPA between T2-T3 ($p = .525$) and T3-T4 ($p = .813$).

In School 2, there was an increase in the percentage of children with a very low level of PA at T2 compared to T1 ($p = .000$; 58% of the significant link) and a decrease in the percentage of children with a low

level of PA at T2 ($p = .000$; 24% of the significant link). There was also an increase in the percentage of children with a moderate level of PA at T3 compared to T2 ($p = .003$; 50% of the significant link) and a decrease in the percentage of children with a very low level of PA at T3 ($p = .003$; 39% of the significant link). There were no significant differences in the percentages of children in the 4 categories of MVPA between T3-T4 ($p = .440$).

There were significant differences between both schools at T1: fewer children had a very low level of PA in School 1 than in School 2 ($p = .012$; 49% of the significant link). There were more children with a moderate level of PA in School 1 than in School 2 ($p = .012$; 45% of the significant link). There were significant differences between the schools at T2: fewer children had a very low level of PA in School 1 than in School 2 ($p = .000$; 37% of the significant link) while more children had a high level of PA in School 1 ($p = .000$; 33% of the significant link) and less children had a moderate level of PA ($p = .000$; 30% of the significant link). At T3, there were no significant differences in the percentage of children in each category between the schools ($p = .156$). Finally, the results indicated that at T4, fewer children had a very low level of PA in School 1 than in School 2 (56% of the significant link; $p = .049$).

Figure 2. Evolution of ST of Children in School 1 (A) and in School 2 (B) During the School Day



Sedentary time. Figure 2 presents the percentages of children in School 1 and School 2 in the 4 categories of ST at each measurement point.

In School 1, there was an increase in the percentage of children with very low ST at T2 compared to T1 ($p = .000$; 50% of the significant link) and a decrease in the percentage of children with moderate ST at T2 ($p = .000$; 40% of the significant link). There were no significant differences in the percentages of children in the 4 categories of MVPA between T2-T3 ($p = .146$). There was an increase in the percentage of children with a very low ST at T4 compared to T3 ($p = .040$; 62% of the significant link).

In School 2, there was an increase in the percentage of children with a high ST at T2 compared to T1 ($p = .005$; 71% of the significant link). However, this percentage decreased from T2 to T3 ($p = .000$; 49% of the significant link). There was also an increase in the percentage of children with low ST at T3 ($p = .000$; 36% of the significant link). Finally, there was an increase in the percentage of children with a very low ST at T4 compared to T3 ($p = .006$; 63% of the significant link) and a decrease in the percentage of children with high ST at T4 ($p = 0.006$; 25% of the significant link).

There were significant differences between both schools at T1: fewer children had high ST in School 1 than in School 2 ($p = .004$; 67% of the significant

link). There were also significant differences between the schools at T2: more children had very low ST in School 1 than in School 2 ($p = .000$; 44% of the significant link) while fewer children had high ST in School 1 ($p = .000$; 24% of the significant link). At T3 and T4, there were no significant differences in the percentage of children in each category between both schools (respectively $p = .085$ and $p = .062$).

DISCUSSION

The aim of this study was to evaluate the effectiveness of a duplicated intervention conducted in primary schools with children from disadvantaged neighborhoods. The intervention was based on the socioecological model with the aim of having a decisive impact on the psychological factors of children.¹³ Chi-square analyses were conducted to assess the changes in the percentages of children in MVPA and ST levels at each measurement point.

In School 1, significant positive outcomes were clearly found during the school day at T2 compared to T1 for MVPA and ST. However, these effects did not appear on weekdays and weekend days. During the intervention (T2-T3) and 1 year after (T3-T4), no significant differences were revealed in the 4 categories of MVPA during the school day, weekday, and weekend day. However, 1 year after the

intervention (at T4), there were more children with a low level of ST during the school day and weekday (less than 270 and 540 minutes per day, respectively).

In School 2, the percentages of children in the lowest MVPA categories increased from T1 to T2 during the school day. These results were the opposite of School 1. From T2 to T3, there was a clear change: the percentages of children who reached the recommended levels of PA increased significantly during the school day and weekday, indicating that a larger number of children had higher levels of PA in T3 than in T2. During the year of the intervention (T3-T4), additional effects occurred on MVPA. We found the same pattern of results with ST on the school day and on the weekday. More specifically, in T3 compared to T2, as well as in T4 compared to T3, there was a significant decrease in the number of sedentary children. Thus, at the end of the intervention (T4), there were a greater percentage of children who were less sedentary.

It seems that “early” effects had occurred in both schools. Intervention also seems to have contributed to a maintenance of, or a progression toward, more active categories. The effects on ST were complementary to those on MVPA but supplementary effects were also seen at the end of the intervention. However, disparities were found between the schools. While beneficial effects on MVPA during the intervention year at School 2 were found at the weekend, no improvements were shown for School 1 during the intervention year. In School 2 positive effects on ST were found at the end of the intervention (at T4) during the school day and weekdays, but these effects were only visible 1 year after the end of the intervention (T4) on the school day and on weekdays for School 1.

The early effects of the duplicated interventions could potentially be explained by a Hawthorne effect.²⁸ It is possible that the presence of the research team at each school during the measurements in the year prior to each intervention may have influenced the behavior of the children and the teachers. These actions may have been sufficient to generate conscious or even unconscious actions by children and teachers during the previous year before the interventions that were being planned for the following year. Alternatively, it is also possible that teachers have anticipated some modification in their classroom because they did not want to wait the official start of the intervention as it was a long time before the first measurement point. The Hawthorne effect may have occurred as teachers may have been impatient to engage in the intervention.

The implementation of multicomponent interventions could possibly maintain these early effects. All effects were principally observed during the school day. These results are in accordance with a 2-year

multicomponent study intervention in a primary school.²⁹ They also reported effects on MVPA and ST only during the school day, while no effects were observed on the weekdays. This result suggests that the children may have compensated their MVPA during the school day by decreasing the MVPA outside school hours. Moreover, this present study also found delayed effects on ST. Similar to our study, an intervention conducted with disadvantaged children found continuing improvements in ST levels during the 3 years of intervention.¹⁵

Our study reported more effects on ST-related behaviors than on PA. Similarly, a study found reduced ST but no increase in PA.³⁰ As in our study, this intervention include several actions intended to reduce ST. Therefore, it seems that these specific strategies on school ST are really effective and are even more beneficial than PA-related actions. Moreover, the beneficial effects on ST were preserved 1 year after the intervention. This can be compared to an intervention study carried out with children from a disadvantaged background, which found no increase in MVPA and ST during the intervention but did find an effect 1 year after the end of it.¹⁶ Conscious behaviors aimed at decreasing ST were possibly used by the children over periods of nonschool time (weekends).

These results suggest that school actions may have a different impact on PA and on ST on weekend day, these being quite distinct behaviors. Children from disadvantaged backgrounds may not have the material and organizational resources to practice PA outside school but they are able to reduce ST at home without financial resources.

This study has several strengths. The intervention was multicomponent and multilevel. It was carried out with children from disadvantaged neighborhoods, a population which rarely has such interventions. However, it was difficult to get the involvement of the parents in the intervention. Many children were not allowed to wear the accelerometer, and this resulted in high rates of missing data. In addition, there was a significant turnover of disadvantaged children in these schools. Thus, it was not possible study longitudinal effects by following the same children over the 3 years.

IMPLICATION FOR SCHOOL HEALTH AND EQUITY

This study highlighted that positive effects on PA and ST seems to have occurred before the intervention in each school. Initiative and motivation to engage quickly in the project can explain these results. These results suggest that simply describing a new motivational project and giving independence to the teachers and children could help to improve active behaviors. Moreover, perception of autonomy of the educational team could play a major role with disadvantaged children. Thus, to promote PA

among disadvantaged children, future school-based intervention should consider some specific strategies:

- Intervention project should be first presented to teachers and parents before being implemented with the children.
- Educational team should implement actions independently, like sedentary breaks with the support of external partners engaged in PA promotion.
- Actions should remain attractive to children during the entire intervention, particularly by proposing various active moments such as team games.
- Policymakers should be associated with sport clubs to reduce financial costs of extracurricular physical activities for disadvantaged children.

It should be important to consider that the circumstances of COVID-19 may change the strategies used to promote PA at school. Group activities may be compromised and the use of games areas in the schoolyard may be reduced. As a consequence, on the coming years, future interventions should experiment alternatives strategies that can ensure compliance with hygiene guidelines. They should favor new technologies that provide personalized and motivating sessions for each child and online meetings involving parents, teachers and children which can maintain a successful follow-up.

Human Subjects Approval Statement

This study has been approved by the Comité de Protection des Personnes Sud Méditerranée III (the local ethics committee) under number: 2018-A00713-52 and has been registered at ClinicalTrials.gov under the Identifier: NCT03983447.

Conflict of Interest

The authors declare no conflict of interest.

REFERENCES

1. Ng SW, Popkin BM. Time use and physical activity: a shift away from movement across the globe. *Obes Rev.* 2012;13(8):659-680.
2. Cooper AR, Goodman A, Page AS, Sherar LB, Esliger DW, van Sluijs EM. Objectively measured physical activity and sedentary time in youth: the international children's accelerometer database (ICAD). *Int J Behav Nutr Phys Act* 2015;12(1):1-10.
3. Cheval B, Sieber S, Guessous I, Orsholits D, Courvoisier DC, Kliegel M. Effect of early-and adult-life socioeconomic circumstances on physical inactivity. *Med Sci Sports Exerc.* 2018;50(3):476-485.
4. Davison KK, Lawson CT. Do attributes in the physical environment influence children's physical activity? A review of the literature. *Int J Behav Nutr Phys Act.* 2006;3(1):5868-5873.
5. King AC, Stokols D, Talen E, Brassington GS, Killingsworth R. Theoretical approaches to the promotion of physical activity: forging a transdisciplinary paradigm. *Am J Prev Med.* 2002;23(2):15-25.
6. Cohen S, Evans G, Stokols D, Krantz D. Behavior, health and environmental stress. *Appl Ergon.* 1986;18(3):253-254.
7. Bradley RH, Corwyn RF. Socioeconomic status and child development. *Annu Rev Psychol.* 2002;53(1):371-399.
8. World Health Organization. *Global Action Plan on Physical Activity 2018-2030: More Active People for a Healthier World.* Geneva, Switzerland: WHO; 2019.
9. Kriemler S, Meyer U, Martin E, van Sluijs EM, Andersen LB, Martin BW. Effect of school-based interventions on physical activity and fitness in children and adolescents: a review of reviews and systematic update. *Br J Sports Med.* 2011;45(11):923-930.
10. Dai CL. School health program: impacting physical activity behaviors among disadvantaged students. *J Sch Health.* 2019;89(6):468-475.
11. Pate RR, Davis MG, Robinson TN, Stone EJ, McKenzie TL, Young JC. Promoting physical activity in children and youth. *Circulation.* 2006;114(11):1214-1224.
12. Sallis JF, Cervero RB, Ascher W, Henderson KA, Kraft MK, Kerr J. An ecological approach to creating active living communities. *Annu Rev Public Health.* 2006;27:297-322.
13. Sallis JF, Owen N, Fisher EB. Ecological models of health behavior. In: Glanz K, Rimer BK, Viswanath K, eds. *Health Behavior and Health Education: Theory, Research, and Practice.* 4th ed. San Francisco, CA: Jossey-Bass; 2008:465-486.
14. Deci EL, Ryan RM. Self-determination theory: a macrotheory of human motivation, development, and health. *Can Psychol.* 2008;49(3):182-185.
15. King KM, Ling J. Results of a 3-year, nutrition and physical activity intervention for children in rural, low-socioeconomic status elementary schools. *Health Educ Res.* 2015;30(4):647-659.
16. Kipping RR, Howe LD, Jago R, Campbell R, Wells S, Chittleborough CR. Effect of intervention aimed at increasing physical activity, reducing sedentary behaviour, and increasing fruit and vegetable consumption in children: active for life year 5 (AFLY5) school based cluster randomised controlled trial. *BMJ.* 2014;348:g3256.
17. Nyberg G, Sundblom E, Norman Å, Bohman B, Hagberg J, Elinder LS. Effectiveness of a universal parental support programme to promote healthy dietary habits and physical activity and to prevent overweight and obesity in 6-year-old children: the healthy school start study, a cluster-randomised controlled trial. *PLoS One.* 2015;10(2):e0116876.
18. Vander Ploeg KA, Maximova K, McGavock J, Davis W, Veugelers P. Do school-based physical activity interventions increase or reduce inequalities in health? *Soc Sci Med.* 2014;112:80-87.
19. Zaragoza Casterad J, Sevil-Serrano J, Bois JE, Generelo E, Lhuisset L, Aibar-Solana A. Centre for the promotion of physical activity and health (CAPAS-City): a pyrenean cross-cultural structure to lead the way in the design, implementation, and evaluation of multilevel physical activity interventions. *Int J Environ Res Public Health.* 2019;16(19):1-19.
20. Catellier DJ, Hannan PJ, Murray DM, et al. Imputation of missing data when measuring physical activity by accelerometry. *Med Sci Sports Exerc.* 2005;37(11 suppl):555-562.
21. Lubans DR, Hesketh K, Cliff D, Barnett L, Salmon J, Dollman J. A systematic review of the validity and reliability of sedentary behaviour measures used with children and adolescents. *Obes Rev.* 2011;12(10):781-799.
22. Sirard JR, Pate RR. Physical activity assessment in children and adolescents. *Sports Med.* 2001;31(6):439-454.
23. Ridgers ND, Fairclough S. Assessing free-living physical activity using accelerometry: practical issues for researchers and practitioners. *Eur J Sport Sci.* 2011;11(3):205-213.
24. Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. *Med Sci Sports Exerc.* 2005;37(11):531-243.

25. Rowlands AV, Powell SM, Humphries R, Eston RG. The effect of accelerometer epoch on physical activity output measures. *J Exerc Sci Fit.* 2006;4(1):52-58.
26. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. *J Sports Sci.* 2008;26(14):1557-1565.
27. Kotsiantis S, Kanellopoulos D. Discretization techniques: a recent survey. *Gests Int Trans Comput Sci Eng.* 2006;32(1):47-58.
28. Adair JG. The Hawthorne effect: a reconsideration of the methodological artifact. *J Appl Psychol.* 1984;69(2):334-345.
29. Haapala HL, Hirvensalo MH, Kulmala J, Hakonen H, Kankaanpää A, Laine K. Changes in physical activity and sedentary time in the Finnish schools on the move program: a quasi-experimental study. *Scand J Med Sci Sports.* 2017;27(11):1442-1453.
30. Taylor S, Noonan R, Knowles Z, et al. Evaluation of a pilot school-based physical activity clustered randomised controlled trial - active schools: Skelmersdale. *Int J Environ Res Public Health.* 2018;15(5):1-17.