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REGULAR ARTICLE

Effect of physical activity intervention on body composition in young children: influence of body mass index status and gender

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Abstract

Aim: To fight overweight and obesity in childhood, this study proposes an additional physical activity (PA) in young children aged 6–10 years. The objective was to evaluate the effect of school-based PA on the body composition according to body mass index (BMI) categories (nonobese vs. obese) and gender.

Methods: This 6-month study examined the effect of this intervention on body composition in 425 children in 14 primary schools (2 weekly PA sessions of 1 h each) compared to 5 control schools. Adiposity indices were evaluated or calculated: BMI, BMI *z*-score, waist circumference, sum of skinfolds and fat-free mass.

Results: No difference in the prevalence of obesity and anthropometric characteristics was found between the intervention and control groups at baseline. In girls, PA intervention had significant effect on all anthropometric variables ($p < 0.05$ to $p < 0.001$), except on BMI. In contrast, in boys only BMI *z*-score ($p < 0.001$) and fat-free mass ($p < 0.001$) were affected.

Conclusions: Six months of preventive PA intervention offer an effective means to improve body composition in obese children. The pattern of response related to PA was similar between girls and boys. In contrast, the pattern was different according to BMI category, with a higher response in obese than nonobese children.

INTRODUCTION

Obese children who tend to remain obese in adulthood have a higher cardiovascular risk (1). So strategies are needed to prevent and to treat childhood obesity (2,3) because lifestyle education is a key element in obesity therapy. The treatment of obese children should aim at decreasing fat mass and avoiding loss of lean mass, ensuring adequate growth and development, and preventing cyclic weight regain (2,3). In fact, exercise or increasing physical activity (PA) is one of the cornerstones of obesity prevention. Exercise can increase energy expenditure and create a negative energy balance (2,3). PA affects total fat oxidation and fat balance through the promotion of a better body composition (loss of fat mass and maintenance of lean mass). As such a multidisciplinary approach proves to be difficult to implement in the usual environment, elementary school have been designed to help children suffering from obesity (4). Despite some controversies in the literature, obese children seem to spend less time in PA and more time in sedentary activities than their age-matched counterparts (5–7). A decrease of PA level was associated with an increased prevalence of obesity and adiposity (8,9), and major reductions of both aerobic and anaerobic capacities (7,10). Consequently, the first aim was to evaluate the effect of school-based PA on body composition in nonobese and obese children. We hypothesized that children taking part in controlled PA intervention for 6 months would show a significant difference in body mass index (BMI) and other adiposity indices compared to control groups. Moreover, this intervention would be more effective in obese children than nonobese children (11) because the magnitude of changes in body composition after PA programme is inversely related to the initial level of adiposity (12).

PA has been promoted as lifelong positive health behaviour in children (4). Andersen et al. (13) showed that a small percentage of children do not exercise vigorously more than twice a week, with higher percentages in girls than in boys. Taking part PA declines as children grow older, particularly girls (14,15) and even younger children (8). A higher BMI was one correlate of this decline (8). If PA begins to decline in girls from 6 to 10 years, we can ask the following question: are girls more responsive to PA programme than boys? In other words, the second aim was to explore the degree to which changes in body composition could be explained by gender differences from PA intervention. Our hypothesis was that the pattern of variation in body composition after PA intervention was different in girls and boys.

METHODS

Population

Four hundred twenty-five (213 girls and 212 boys) healthy children, aged 6–10 years were randomized and recruited from the local state schools to participate in the study. Children were eligible if they met the following criteria:

elementary schools (first and second grades of elementary school), participating in the scheduled school physical education (SPE) classes, participating in less than 3 h of extra-school sports activity per week, free of any known disease and not participating in other studies. The participating children were representative with regard to the community where the study was carried.

This study was reviewed and approved by the French National Plan for Nutrition and Health (PNNS) piloted by the French Ministry of Health and by the schools' governing bodies. Written formal consent from the parents and the child was obtained from all those taking part. The study was performed in accordance with the declaration of Helsinki II.

Design

Among the schools (n = 19) that agreed to take part in the study, a draw was carried out in order to choose the schools with an additional 6-month PA programme (n = 14). The control groups were constituted with the remaining schools (n = 5). According to the French reference charts (16), a child was defined as obese when his BMI > 97th percentile, otherwise he was defined as nonobese. This obesity threshold, which is similar to International Obesity Task Force (17), was used because the population was French. Thus, each child would fall into one of the four study groups according to their BMI:

- group GI_{No} (n = 138): intervention group (GI) composed of nonobese children (No), who will follow the additional PA programme;
- group GI_{Ob} (n = 59): intervention group composed of obese children (Ob), which will follow the same additional PA programme as GI_{No};
- group GC_{No} (n = 187): control group (GC) composed of nonobese children, but which will not follow the PA programme;
- group GC_{Ob} (n = 41): control group composed of nonobese children, but which will not follow the PA programme.

Intervention programme

During SPE and PA programme, there was no difference between girls and boys, or between obese and nonobese children in exposure to different activities. Generally, each SPE and PA sessions were various combinations of the following exercises that were carried out at least for 5 min: exercises on coordination, exercises devoted to posture and balance, relaxation techniques, rhythm and music, exercises devoted to creative movement, games relating to group participation, practices for back training (. . .).

In school timetables: Each week, the children will take part for in two 1-h sessions of SPE. In collaboration with state SPE teachers, we will quantify the PA in terms of PA. SPE will be aimed at providing the children with a rational basis for their activity programmes and for exercise in general. A range of fitness activities will be offered, increasing in intensity and duration throughout the study.

Extra school activities: Eighty students, tutored by physical education teachers, from the Sports Science University Department were in charge of supervising the additional PA sessions. They were all Sports Science students training to become physical education teachers.

Children from GI_{No} and GI_{Ob} were required to follow PA after class, twice a week for 1 h. The exercise programme was designed to enhance the joy of movement, body awareness and team spirit in order to bring about long-term changes in behavioural patterns. Moreover, all the sessions aimed at meeting the same double objective: a playful physical practice and 45 min of dynamic exercise within 1 h of PA. Thus, these sessions were based on traditional games aimed at minimizing the children's inactivity. These activities were monitored uninterruptedly. A constant preoccupation was to reduce the inactivity time. During a session, two children of each intervention group were randomly selected in order to control their energy expenditure. They were then equipped with a cardio-frequency meter (Polar Accurex Plus, Kempele, Finland). From this recording, the average intensity of the sessions was estimated as a function of a percentage of the theoretical heart rate peak according to Robergs and Lanwher (18): $215.4 - (0.9147 \times \text{age})$. In parallel, an observation grid was supplemented in order to quantify the total duration of PA.

Anthropometric measurements

Trained professionals performed the anthropometric measurements. Body mass (BM) was taken without shoes or belts and in light clothing, and recorded to the nearest 0.05 kg with a portable digital scale (Seca model 873 Omega, Germany). Height was measured with a standing stadiometre (Seca model 720, Hamburg, Germany) and recorded with a precision of 1 mm. BMI was calculated as body weight divided by height squared (kg/m^2).

Waist circumference (WC) was measured in a standing position with a nonelastic tape, which was applied horizontally midway between the costal arch and the iliac crest.

Skinfold thicknesses were measured at the biceps, triceps, subscapular and suprailiac points on the left side of the body using a Harpenden skinfolds calliper (British Indicators Ltd., West Sussex, UK), according to the procedures described in the *Anthropometric Standardization Reference Manual* (19). Three sets of measurements were taken to the nearest millimetre at each point, and the mean of the three values was used. Intraobserver reliability was determined for all anthropometric measurements by intraclass correlation coefficient (r-value). Intraclass r-values for bicipital, tricipital, subscapular and supra-iliac skinfolds were 0.94, 0.90, 0.93, 0.93, respectively. The sum of four skinfolds (ΣS) was calculated.

Fat-free mass (FFM) was calculated from BM and percentage of body fat (%BF) was calculated from the Brook equations (20): $FFM = BM - (\%BF \times BM/100)$.

Body mass, height, skinfold thicknesses, WC and HC were measured in all children by experienced anthropometrists. The coefficient of variations for three repeated measurements of skinfold thicknesses have been shown to be 4.2%, 6.8%, 5.1% and 5.3% for bicipital, tricipital, subscapular and supra-iliac skinfolds in a population of children (including obese ones) for an experienced experimental (21).

Statistical analysis

All statistical analyses were carried out using the using the StatView software ("StatView SE+ Graphics®", Version 5.0, Abacus Concepts, SAS Institute Inc, Cary, NC, USA). The limit for statistical significance was set at $p < 0.05$.

Means and standard deviations were calculated for each variable. Normal distribution of data was checked by the Kolmogorov–Smirnov normality test. Variance homogeneity between samples was observed by the F-Snedecor test. Differences between study groups at baseline measurements were assessed using a two-way analysis of variance (ANOVA). When significant differences were found, percentage changes $[\Delta(\%) = ((T1 - T0)/T0) \times 100]$ related to baseline (T0) were calculated and compared between groups using a one-way ANOVA.

The influence of the intervention was assessed using an ANOVA with repeated measures:

1. Significant interactions were followed by: (a) comparisons between groups at each measurement period (T0 and T1) using a one-way ANOVA; and (b) comparisons between measurement periods for each group using an ANOVA with repeated measures.
2. Time effects without any significant interaction were only followed by comparisons between each measurement period for each group using an ANOVA with repeated measures. Significant ANOVA were followed by post hoc comparisons using Fisher's PLSD procedure.

RESULTS

Baseline characteristics

At the beginning of this programme, girls and boys were 7.4 ± 0.8 years of age. The structure of four groups (GI_{Ob}, GI_{No}, GC_{Ob} and GC_{No}) was almost identical with regard to the ages of the children and their gender distribution. Moreover, there were no significant differences with regard to the average age of children and the BMI profile distribution between girls and boys.

The anthropometric characteristics baselines of this cohort are described in Tables S1 and S2 for girls and boys, respectively. Baseline anthropometric data in girls revealed no significant differences between GI and GC for any of the variables: BM, height, BMI, BMI *z*-score, WC, ΣS and FFM. The same outcomes were found in boys. Moreover, for two obese groups (GI_{Ob} vs. GC_{Ob}) and two nonobese groups (GI_{No} vs. GC_{No}) there was no significant difference concerning all anthropometric variables. Considering all values, obese children exhibited significantly higher values for BM ($p < 0.001$), BMI ($p < 0.001$), BMI *z*-score ($p < 0.001$), WC ($p < 0.001$), ΣS ($p < 0.001$) and FFM ($p < 0.001$) compared with nonobese girls and boys. Obese girls and boys were taller than their counterparts ($p < 0.05$ and $p < 0.001$, respectively).

Programme implementation

The intensity of each PA session was estimated with heart rate and an observation grid. On average, children were active 42 ± 18 min per session, and heart rate average recorded 70% of the theoretical heart rate peak.

Anthropometric data were collected after 6 months of intervention for 98.9% of the cohort children. The main reasons for lack of follow-up data were school absences on the day of measurements. A larger proportion of obese children became overweight (90th < BMI < 97th percentile) in GI than GC: 16.3% ($p < 0.05$) versus 9.3% ($p < 0.05$), respectively. In contrast, the proportion of nonobese children becoming obese or overweight was greater in the GC than GI: 14.8% ($p < 0.05$) versus 2.6% ($p = $ ns).

Girls: Table S1 shows the changes of anthropometric variables at follow-up. Average BMI remained unchanged over time in GI and GC, despite an increase in BM ($p < 0.001$) and height ($p < 0.001$). Nevertheless, we observed a significant interaction group ∗ time ($p < 0.01$), and a significant effect of PA intervention between GI_{Ob} versus GC_{Ob} (−1.4% vs. 0.9%; $p < 0.05$) and GI_{No} versus GC_{No} (−0.2% vs. 2.1%; $p < 0.001$; Fig. S1). WC was affected over time and there was a significant interaction group ∗ time ($p < 0.001$). GI decreases their values whereas GC increases them: −3.3% versus 2.8% ($p < 0.001$). ANOVA with repeated measures revealed that BMI *z*-score, ΣS and FFM changes observed during the two sets of measurement (from T0 to T1) were dependent on BMI category (obese vs. nonobese) and the group (intervention vs. control). In fact, BMI *z*-score declined significantly in all groups except for GC_{Ob}. This decrease was greater in GI compared to GC (Fig. S1): GI_{Ob} versus GC_{Ob} (−6.8% vs. −2.4%; $p < 0.001$), and GI_{No} versus GC_{No} (−3.1% vs. −1.8%; $p < 0.01$). ΣS was significantly affected by time ($p < 0.05$), with a significant drop in the intervention groups (Fig. S1): GI_{Ob} and GI_{No}: −4.4% ($p < 0.05$) and −3.2% ($p < 0.001$), respectively, and the control groups' (GC_{Ob} and GC_{No}) values remained unchanged. Similarly, FFM were affected by time ($p < 0.001$) with any significant improvement in GI compared to GC: GI_{Ob} versus GC_{Ob} (5.2% vs. 2.4%; $p < 0.001$) and GI_{No} versus GC_{No} (4.0% vs. 0.6%; $p < 0.05$; Fig. S1).

Whatever the anthropometric variables, the positive effects of PA programme were stronger in obese than nonobese children although significant group differences were still found. The drop of BMI *z*-score and ΣS were: GI_{Ob} versus GI_{No} (−6.8% vs. −3.1%; $p < 0.001$) and (−4.4% vs. −3.2%; $p < 0.05$), respectively (Fig. S1).

Boys: The changes in anthropometric variables over time are shown in Table S2. As with girls, boys' BMI remained unchanged in all groups during the time, despite an increase in BM ($p < 0.001$) and height ($p < 0.001$). BMI *z*-score declined significantly only in GI. This change was significantly different between GI and GC ($p < 0.001$): GI_{Ob} versus GC_{Ob} (−2.8% vs. 1.5%; $p < 0.05$), and GI_{No} versus GC_{No} (−2.4% vs. 2.6%; $p < 0.01$; Fig. S1). WC and ΣS were not significantly affected over time, although a slight decrease in all these anthropometric variables was noted in GI and a slight increase in GC (Fig. S1). These results showed a significant interaction group $*$ time for BMI ($p < 0.05$) and BMI *z*-score ($p < 0.05$; Table S2), indicating a greater drop in GI compared to GC (Fig. S1). Moreover, although no significant differences were found, these decreases were higher in GI_{Ob} than in GI_{No}. FFM improved over time ($p < 0.001$) with higher changes in GI (GI_{Ob} and GI_{No}: 6.4%, $p < 0.001$; and 3.4%, $p < 0.001$, respectively) than in GC (GC_{Ob} and GC_{No}: 1.3%, p = ns; and 0.7%, p = ns, respectively; Fig. S1). Moreover, the increase of FFM was significantly greater in GI_{Ob} than GI_{No}: 6.4% versus 3.4% ($p < 0.01$).

Girls versus boys: Among GI, the results showed different trends in gender response concerning the magnitude of changes of BMI *z*-score ($p < 0.01$), WC ($p < 0.001$) and ΣS ($p < 0.05$). Girls from GI_{Ob} had a decline of BMI z-score significantly higher than boys from GI_{Ob} (−6.8% vs. −2.8%; $p < 0.001$). Similar results were observed with WC for both obese and nonobese children: GI_{Ob} (−3.3% vs. −0.5%; $p < 0.01$) and GI_{No} (−3.1% vs. −0.1%; $p < 0.001$). Boys from GI_{Ob} had a least drop in ΣS than did girls (−2.9% vs. −4.4%; $p < 0.05$). Concerning GC, whatever the BMI, the pattern of response related to all variables was identical between girls and boys, except for BMI *z*-score ($p < 0.05$) and WC ($p < 0.01$).

DISCUSSION

The primary objective of this study was to evaluate, in a controlled way, the effects of PA intervention on obesity and its prevention among school children. The present study showed that obese 6–10 year olds who participated in our PA intervention over a 6-month period showed more favourable changes in BMI, ΣS, WC and FFM than children who did not participate in the PA programme. Furthermore, the pattern of response related to PA is similar between girls and boys, although the magnitude of changes in anthropometric variables was higher in girls than in boys. In contrast, we observed different responses according to BMI category, with a greater response in obese children compared to nonobese children. In order to assess effectiveness, we chose simple variables often used to detect changes in body composition over short-term periods. It has been shown that the anthropometric measurements, which we included in our study, BMI, WC and ΣS can predict total fat content in children and adolescents (22,23). WC is a simple measurement that is associated with the distribution of abdominal fat (22) and consequently with the occurrence of the metabolic syndrome.

The results showed a greater reduction of the prevalence of obesity in GI (35.5% vs. 29.7% = −16.3%) than that in GC (21.9% vs. 19.9% = −9.3%) at the end of our PA intervention. After 6 months, we found a small decrease in BMI for both boys and girls, whereas BMI increased in children from GC. Nevertheless, BMI changes were significantly different between GI_{Ob} versus GC_{Ob} ($p < 0.01$) and between GI_{No} versus GC_{No} ($p < 0.001$). These results showed a positive change in the BMI *z*-score distribution among GI, which significantly decreased their score. Moreover, whatever the gender, it is worth noting that the change in BMI *z*-scores for those obese compared to nonobese was greater, and the obese group weight loss was relative to their size. During periods of rapid growth, a relatively moderate BMI loss can be considered as an achievement. The opposite response between GI and GC could be explained by a loss in BM relative to size.

The data in literature demonstrate that PA may positively affect body composition (3,12,24). Although intervention has little effect on BM and BMI, it is usually associated with countervailing decreases in ΣS and increases in FFM. One of these major limitations concerning BMI is its lack of specificity (17), that is, BMI can change due to alterations in height, bone density, muscle, fat or water. It was shown that the increased PA in the intervention conditions could have improved muscle mass (11). These were confirmed by the highest increase in FFM and by a more important drop of ΣS in GI compared to GC (Fig. S1). Our data are consistent with the results from previous studies using PA intervention (3,12,24). Therefore, preservation of FFM is an effective way of increasing daily energy expenditure and thereby decreasing fat mass. In fact, increasing energy expenditure through PA is a powerful method of creating a negative energy balance and accelerating changes in body composition. This was confirmed by the fact that no significant group differences were found in baseline data, consequently the favourable decreases in adiposity can be attributed to the PA programme itself.

The positive effects of intervention were stronger according to BMI category. In our study GI_{Ob} children usually respond better than GI_{No} ones. Regarding the PA programme, there was no difference between obese and nonobese children during exposure to different activities; so we assume that these results in obese children can be explained by a greater energy expenditure for a given motor skill. A study from Bandini et al. (25) suggests that obese children have a higher energy expenditure and that they require a greater percentage of maximal oxygen uptake (26) compared to nonobese children to complete the same exercise task. Moreover, this difference might be due to the fact that obese children were more active during recess compared to nonobese ones. These periods may have contributed to the overall increase in daily energy expenditure.

Girls and boys have a similar pattern of response related to our PA programme. In fact, the changes in adiposity-related measurements evolved similarly, although they were not always significant, especially in boys. In girls, there was a significant positive effect on BMI *z*-score, WC, ΣS and FFM at follow-up for (Fig. S1), whereas in boys no effect was noted on any adiposity-related indices, except for BMI *z*-score and FFM. The influence of gender was observed on the magnitude of the changes in anthropometric variables. This finding had not been observed in previous studies (1,27). Other studies, except Mo-suwan et al. (28), were either cross-sectional in design or included older age groups (1,27). A study in the same age group as ours (28) found increasing subcutaneous fat in children of both genders with low levels of PA that were significant in girls only. Our study design, on the contrary, was an intervention to change the routine daily activities and we observed different levels of responses for girls and boys. Plausible explanations for this difference are as follows. First, because girls are basically less physically active, adding our exercise programme into girls daily activities might have produced a substantial effect on their energy expenditure, and second, the postexercise eating behaviour may have been different according to gender. A limitation of our study is that daily dietary intake was not recorded. However, our findings show that girls in GI having a greater mean %BF and ΣS changes than boys from both intervention and control groups, and much greater than that of GC boys seem to confirm the last hypothesis.

PA quantity showed significant effects on the body composition. If we consider that the success of a study on obesity prevention is characterized by the reduction in the prevalence of obesity, by the maintenance of BM and BMI by a reduction of ΣS in obese children, our results showed that our intervention consisting of an 1-hour SPE session twice a week and a minimum of two weekly hours of additional PA should be recommended. In other words, school-age children should participate every day in 60 min or more of moderate to vigorous PA (11,29,30). These results lead us to recommend at least 5 hours of PA per week at an intensity of 70% of the theoretical heart rate peak. These PA sessions should be supervised by a qualified exercise leader. However, it remains to be shown whether these recommendations will have long-term effects.

In conclusion, the first results of this study support the belief that body fat composition of obese children can be lowered through a multilevel intervention programme, consisting of behaviour changes towards an active daily lifestyle at school and in leisure time. Furthermore, obese children are more responsive to the intervention compared to nonobese children, and it would be preferable to recommend different intensities and types of PA in order to improve their body composition and obesity.

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Supplementary Material

The following supplementary material is available for this article:

Figure S1 Anthropometric variables changes (Δ) from baseline (T0) to follow-up (T1) expressed in percentage related to baseline values (T0) in girls and boys. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Table S1 Characteristics of the sample at baseline and change in anthropometric variables at follow-up in girls from intervention and control groups. Values are means ± standard deviation. ns: not significant, $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Table S2 Characteristics of the sample at baseline and change in anthropometric variables at follow-up in boys from intervention and control groups. Values are means ± standard deviation. ns: not significant, $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

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