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Successful intervention models for obesity prevention: The role of healthy life styles

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Abstract

Children obesity is considered a serious public health problem around the world. In Spain, the prevalence of overweight/obesity is reaching alarming figures, exceeding 35% of the children. Several hypotheses suggest that the energy balance model does not fit very well when analyzing the causes of the current obesity epidemic and, although genetics seems to explain up to 30% of the likelihood to become obese in infancy, has been suggested that genetics might be influenced by environment factors including vigorous physical activity (PA). Some recent systematic reviews indicate that there is enough evidence about the effectiveness of interventions to prevent obesity in children 6-12 years old; however, the heterogeneity of the effect, and the potential selection, information and publication biases that undermine the validity of these studies, thus their results should be interpreted with caution. In Spain, an extracurricular PA program of leisure-time (MOVI) has evidenced some effectiveness on reducing the adiposity and on improving the lipid profile in schoolchildren. To overcome some weakness of MOVI program, a second edition of this study was designed. The objectives of this review are twofold: 1) to analyze latest data of the obesity epidemic in Spain; and 2) to describe the main features of MOVI-2 program, and overall of the successful interventions to prevent children obesity.

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Key words: *Obesity. Interventions. Children. School. MOVI program.*

MODELOS EXITOSOS DE INTERVENCIÓN PARA LA PREVENCIÓN DE LA OBESIDAD: EL PAPEL DE LOS ESTILOS DE VIDA SALUDABLES

Resumen

La obesidad infantil continúa siendo un serio problema de salud pública en todo el mundo. Las cifras actuales en España son alarmantes, y se sitúan en torno al 35,4%. Hay varias hipótesis que apuntan a que el modelo de balance energético como causa de la obesidad infantil no se sostiene. Y aunque las razones genéticas parecen explicar hasta el 30% de la probabilidad de llegar a ser obeso, se ha sugerido que esta herencia podría ser influenciable por factores ambientales entre los que se encuentra la actividad física (AF) vigorosa. Aunque las últimas revisiones señalan que existe evidencia suficiente sobre la efectividad de las intervenciones para prevenir la obesidad en niños de 6-12 años, la heterogeneidad del efecto encontrado en los resultados y la posibilidad de sesgos de diseño y de publicación de los estudios hacen que los resultados deban interpretarse con cautela. En España la intervención MOVI, un programa extraescolar de AF de carácter recreativo, ha conseguido disminuir la adiposidad, y mejorar el perfil lipídico. Para superar potenciales limitaciones de la primera intervención, se diseñó una segunda edición. Los objetivos de esta revisión fueron: 1) analizar los últimos datos de la epidemia de la obesidad infantil en España; y 2) describir las principales características del programa MOVI-2, y en general de las intervenciones que han sido efectivas para prevenir la obesidad en niños.

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Palabras clave: *Obesidad. Intervenciones. Niños. Escuela. Programa MOVI.*

Introduction

Children obesity remains a serious public health problem around the world[1]. In Spain, current prevalence rates range from 35% to 42%.[2,3] Although recent studies have shown a leveling-off or even a decline in the prevalence of overweight/obesity in children in different countries of the world,[4,5] in the period 2004-2010 prevalence of overweight in boys aged 8-11 years from Cuenca, Spain, increased from 21.6% to 28.0% and the percentage of body fat from 22.6% to 24.0%. In girls, however, the trend seems to have stabilized.[2]

In parallel to the growing trend in the overweight prevalence, during the last decade of the 20th century underweight prevalence was increasing in Spain, from

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2.7% in 1992 to 9.2% in 2004 in children 9-10 years,[6] and in other European countries[7]. Fortunately, latest estimations reported in Spanish children show that from 2004 to 2010 the underweight prevalence has not increased, and stands at around 8.5%.[2]

Therefore, the population approach for addressing the prevention of overweight, as in other public health problems, we should to be into account the classic good practice Latin axiom *primum non nocere,* so that it might be that interventions whose effectiveness on reducing overweight is controversial have also an undesirable effect increasing the proportion of underweight children.

Determinants of the obesity epidemic in Spanish children

At the individual level, body fat accumulation results from an imbalance between energy intake and energy expenditure. If intake exceeds expenditure the excess of energy will be stored as fat. On the other hand, it has been estimated that genetics susceptibility explains about the 30% of the likelihood of child will develop obesity,[8] although this is a polygenic inheritance strongly influenced by the interaction genes, environment and lifestyle.[9]

However, at the population level non-genetic factors are the responsible for the frequency of obesity, including epigenetic,[10] eating behavior patterns at an early age, activity/inactivity patterns, and other psychological, social and environmental factors.[9] Nowadays, the relative importance of energy expenditure and intake in the development of the current obesity epidemic is a debatable issue. A recent review of studies addressing this question in different regions of the world[11] concluded that in view of the great variability in the study designs, in the exposure and outcome measures used, and the wide population range in which the studies were based, the estimation of the importance of each one of these two factors, intake and energy expenditure, was not possible in children and teens.

In Spanish children, however, there are some considerations that worth to examine, and that leading us to suspect a greater importance of the decreasing of energy expenditure as determinant of the current obesity epidemic. First, data from both the AVENA study[12] and the enKid study[13] support the association between overweight and TV hours in Spanish children and adolescents. Furthermore, baseline measurement of an intervention study not yet published by our group,[14] show that children who are overweight or obese consume on average less calories/day than children with normal weight, and these normal weight children less than thinness children. After a first view of these data might be argued that children with overweight/ obesity do less daily physical activity than less normal weigh children, but when we controlled in multivariate models for cardiorespiratory fitness levels, a variable closely related to physical activity levels, these differences in energy intake by weight categories remain unchanged. These results are in accordance with that reported from other studies,[15,16] and support the new hypothesis proposed by Gutin suggesting that vigorous physical activity at early ages would have a pivotal role in the of stem cells differentiation in bone and muscle tissues through stimulation by mechanical influences such as physical activity[17]. If this theory were consolidated would have important implications in determine which is the best age range for implement preventive interventions, and which is the most appropriate type of activity for it.

There are several hypotheses that do not support the energy balance model for explaining the childhood obesity epidemic, and even though no one doubt of the importance of genetics on predicting obesity, it has been suggested that genetics could be very strongly influenced by environmental factors including vigorous physical activity.[18,19]

Efectividad de las intervenciones preventivas sobre obesidad infantil

A Cochrane systematic review aimed to evaluate the effectiveness of interventions for preventing obesity in children and adolescent concluded that there is enough evidence on the effectiveness of interventions to prevent obesity in children aged 6-12 years, although should be considered that the heterogeneity of the effect found in the studies, as well as the risk of design and publication biases, and therefore this results should be interpreted with caution. Furthermore this review concludes by recommending for future studies: 1) analyze the long-term results, 2) assess how those interventions that are effective can be maintained over time in a sustainable manner, 3) include economic evaluations, 4) potential damage reporting (i.e. eight reduction in thinner children, reduction of essential nutrients, etc.), 5) subgroup analysis by gender, location, race or socioeconomic status, 6) describe in detail the activities carried out in the intervention (to facilitate their applicability and transferability to other populations), and finally, 7) to focus on children 0-5 years.[20]

A recent meta-analysis whose objective was to assess the efficacy of intervention programs on the body mass index (BMI) of children and adolescents, as well as explore the possible differences between the school and after-school intervention programs showed school or after school interventions had a similar effect.[21] Considering that in Spanish context seems very complicated to propose legislative changes aimed to include interventions to tackle children obesity in the schools curricula, the implementation of interventions at recess or after school seems to be more feasible.

The conclusions of a review that examines the systematic reviews and meta-analysis aimed to evaluate the effectiveness of programs addressing the prevention and control of childhood obesity indicates that information about the barriers and challenges encountered

when designing and implementing interventions in real life situations will provide important information on feasibility and sustainability, and identify if failure or modest success of the intervention was due to a problem with the intervention's development, content or implementation.[22]

Most of the systematic reviews emphasize on the importance of taking into account the theoretical models of behavior's changes in which the intervention is based.[23] The usefulness of these models in in the development of intervention strategies that affect multiple areas has been proven in several studies.[24,25] One of the most commonly used is the socio-ecological model.[26,27] This model distinguishes several levels on influence on behavior usually depicted as a graph with concentric circles (fig. 1). At the central level are represented the biological/genetic, physiological and sociocultural influences that make-up the individual's identity. In the second circle are placed personal relationships, the environment close to the children; this micro-system consisted of relationships with parents, teachers, sibling, and friends. A third level of influence it's known as exosystem, and includes physical and social environments that influence children's behavior, but without interacting (neighborhood and its built environment, media, location of the school, working conditions of parents, etc.). Finally, the macro-system (fourth level) influences the child's behavior; this macro-system includes traditions, social, culture, laws, history, etc., of the country where the child growths.

This paper review the characteristics of the most promising interventions.

Results

Table I shows characteristics of 12 effective school-based interventions on prevention obesity in children (6-12 years). All studies were randomized controlled trials, implemented in school area, and included as outcome BMI or prevalence of overweigh/obesity.

Six studies were conducted in the United States, one in South America, one in Australia and four in different countries of the European Union (Spain, Switzerland, Germany and Sweden). Most of the studies were done in school (with modifications into curriculum),[28-36] two studies were done in after school schedule (FitKid and MOVI),[37-40] and one was done jointly in school and after school (STOPP).[41] The duration of follow-up ranged from 3 months to four years; of these 12 studies, 2 studies had a follow-up period of 3 months, 5 studies between 8 months and one and a half year, and 6 studies more than one and a half year (two, three o four years). Seven of the interventions included increase in phys-

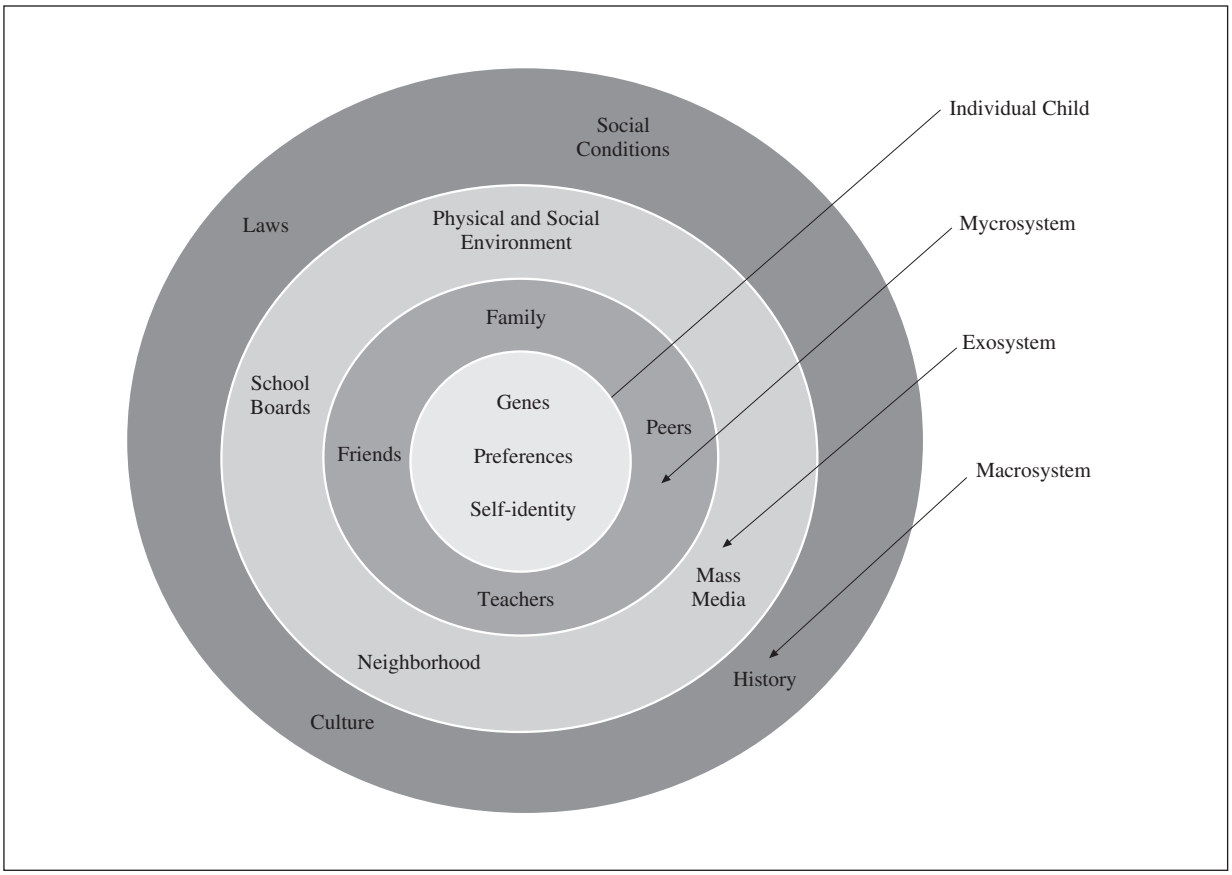

Fig. 1.—Ecological Model. Adapted from Bronfenbrenner's Ecological Model describing the environmental influences on a child.[27]

Table I *(Cont.)*
Characteristics of effective school-based interventions on prevention obesity in children (6-12 years)

Authors/year/ country/ name of program	*Setting/ Duration (month or years)*	*Sample sizes/ age (years)/ gender*	*Theory/Intervention*	*Outcome measures*	*Results*
Interventions based on increase PA and reduce sedentary time					
Flores R, 1995 *California*, USA **Dance for Health**[28]	School 3 months	At baseline: 81 At follow up: 49 10-13 Only girls	*NA* School based aerobic dance replaced usual PE class and education in health	– BMI – Attitude to PA	– Reduction BMI – No changes in the attitude to PA
Robinson TN, 1999 *California*, USA[29]	School 3 months	At baseline: 192 At follow up: 192 8-9 Boys and girls	*NA* Reducing time TV, videotape and video game. The intervention consisted of 18 lessons lasting 30' into the-standard curriculum	– BMI – TST – WC – TV time	– Reductions BMI and all other measures of body fat – Reductions reported TV time
Yin, Z. et al, 2005; Gutin B, et al, 2008 *Georgia*, USA **The Medical College of Georgia Fitkid Project** [37,38]	After-School 3 years	At baseline: 601 At 3 years follow up: 316 8-9 Boys and girls	*Environmental change* 2 hour after-school sessions, 5 days/week on school days. The programme included: • 40 min of academic enrichment activities, during which healthy snacks were provided. • 80 min of moderate-to-vigorous PA (40 min vigorous) including activities to improve sports skills, aerobic fitness, strength, and flexibility.	– % body fat – Bone density – Fat mass – Fat-free mass – BMI – WC – Fitness – CV risk factors	**1st year:** – Reduction % body fat – Increasing bone density – No differences fat mass and fat-free soft tissue between groups post-intervention – Increasing fitness **3 year:** – Reduction body fat during school months – Significant group by time interaction in favour of intervention participants in bone density and fat-free soft tissue – No differences between groups post intervention in fat mass – Increasing fitness – No difference in BMI, WC and CV risk factors
Salmon J, et al, 2008 Melbourne, *Australia* **Switch-play**[30]	School 1 year	At baseline: 295 At follow up: 268 10-11 Boys and girls	*Social cognitive theory and behavioral choice theory* Three intervention groups: • Behaviour Modification (BM) group: In addition to the usual PE and sports classes, 19 lessons (40-50 min each) were delivered in classroom by one qualified PE teacher for 1 school year • Fundamental Motor Skills (FMS) group: In addition to the usual PE and sports classes, 19 lessons (40-50 min each) were delivered either in the indoor or outdoor PA facilities at each school for 1 school year • BM/FMS group: children in this group received both BM and FMS lessons	– BMI – Overweight/ Obesity – Objectively assessed PA	– Reduction in BMI post-intervention in the BM/FMS – On average, those in the BM/FMS group were over 60% less likely to be overweight or obese – Compared with controls, FMS group children recorded higher levels and greater enjoyment of PA; and BM children recorded higher levels of PA across all four time points

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Authors/year/ country/ name of program	*Setting/ Duration (month or years)*	*Sample sizes/ age (years)/ gender*	*Theory/Intervention*	*Outcome measures*	*Results*
Martínez-Vizcaíno V, et al, 2008; Salcedo-Aguilar F, et al, 2010) *Cuenca, Spain* **MOVI programme**[39,40]	After-School 2 years	At baseline: 1119 At 2 years follow up: 921 9-10 Boys and girls	*NA*. Non-competitive recreational PA programme consisted of 3 × 90-min sessions per week for 24 weeks. These were held after school. 90-min session included 15 min of stretching, 60 min of aerobic resistance and 15 min of muscular strength/resistance exercise.	– BMI – TST – % body fat – CV risk factor	**1 year:** – Reduction in TST. – Reduction in % body fat in girls. – Intervention children had lower apolipoprotein B levels and higher apolipoprotein A-1 levels. **2 year:** – Intervention girls reduced the frequency of overweight. – Intervention was associated with an increase in the % of body fat in boys – Children in the IG had lower total cholesterol level and apolipoprotein B level.
Donnelly JE, et al, 2009 *Northeast Kansas, USA* **PAAC**[31]	School 3 years	At baseline: 1527 At follow up: 1490 7-9 Boys and girls	*Environmental model*. Programme promoted 90 min/week of moderate-to-vigorous physically active academic lessons delivered to children intermittently throughout school day. This is in addition to the existing 60 min/week PE which would result in a total of 150 min of PA/week.	– BMI – Objectively assessed PA (sub-sample only)	– Schools with ≥ 75min of PAAC/week showed significantly less increase in BMI at 3 years compared to schools with < 75min. – Children in PAAC schools had greater levels of PA during the school day and on weekends.
Kriemler S, et al, 2010 *Aargau and Baselland, Switzerland* **KISS**[32]	School 9 months	At baseline: 502 At follow up: 498 6-12 Boys and girls	*Socio-ecological model*. Multi-component PA programme that included structuring the three existing PE lessons each week and adding two additional lessons a week, daily short activity breaks, and PA homework.	– Skin folds – Fitness – Objectively assessed PA – Quality of life – BMI – CV risk factor	– Children showed more negative changes in the z score of the sum of four skin folds. – Z scores for aerobic fitness increased more favorably, as did those for moderate-vigorous PA in school, all day moderate-vigorous PA, and total PA in school. – Z scores for overall daily PA and physical quality of life as well as psychological quality of life did not change. – Children showed smaller increases or larger reductions in BMI and in most CV risk factors.
Interventions based on PA and Diet combined					
Gortmaker SL, et al, 1999 *Massachusetts, USA* **Planet Health (33)**	School 18 months	At baseline: 1560 At follow up: 1295 11-12 Boys and girls	*Social cognitive theory*. 32 classroom sessions taught by regular teachers to reduce time spent in front of the TV, increase PA, reduce intake of fat and increase the intake of fruit and greens.	– BMI – Skin folds. – Diet – PA	– Lower prevalence of overweight in girls. – Both boys and girls in the IG decreased time spent with TV. – Girls in the IG eat more fruit and green and had reduced their total energy intake.

Table I

Characteristics of effective school-based interventions on prevention obesity in children (6-12 years)

Authors/year/ country/ name of program	*Setting/ Duration (month or years)*	*Sample sizes/ age (years)/ gender*	*Theory/Intervention*	*Outcome measures*	*Results*
Muller MJ, et al., 2001 Kiel, Germany **KOPS**[34]	School 8 months	At baseline: 322 At follow up: 272 5-7 Boys and girls	*NA.* 8 hour course of nutrition education including "active" breaks was given by a skilled nutritionist and a trained teacher. The course included the following messages: "eat fruit and vegetables each day", 'reduce intake of high fat foods', keep active at least 1 hour each day', "decrease TV consumption to less than 1 hour per day". In addition a family-based intervention plus a structured sports programme (twice a week) were offered to families with overweight or obese children and to families with normal weight children but obese parents.	– BMI – Skin folds and % fat. – Knowledge on diet – PA – Intake of fruit and greens and food with a low fat percent.	– The IG had a lower prevalence of obesity measured by Skin folds – No difference regarding BMI – Increase in nutrition knowledge, daily PA and decrease in TV time
Kain J, et al., 2004 *Santiago, Curico and Casablanca, Chile* **Healthy schools**[35]	School 1 year	At baseline: 3577 At follow up: 3086 7-11 Boys and girls	*NA.* School-based multi-component intervention aimed to change adiposity and PA levels, delivered by a nutritionist and a PE teacher. Nutrition education was available for children and parents supported by healthier food kiosks. Sessions included 90 minutes additional PA weekly for 3rd to 8th grade for 6 months and 15minutes of activity in recess per day, for last 3 months.	– BMI – Skin folds – WC – Fitness	– No difference regarding BMI and skin folds – Lower waist circumference – Increasing fitness
Coleman K J, et al., 2005 Texas, USA El Paso Catch[36]	School 4 years	At baseline: 896 At follow up: 744 8-9 Boys and girls	*NA.* Intervention schools: received money ($3500 in first year, $2500 in second year, $1500 for third year and $1000 for fourth year) for purchasing equipment and paying substitutes so that PE teachers and food service staff could attend training, and for promotion of CATCH programme at each school.	– BMI – Waist-to-hip ratio – Fitness	– Lower increase of BMI – No difference in fitness
Marcus C, et al., 2009 *Sweden* **STOPP**[41]	School and After school 4 years	At baseline: 3135 At follow up: 2838 6-10 Boys and girls	*NA.* Intervention was designed to change the school environment to promote healthy eating and PA during school and in after school care. Including: 1. 30 minutes of daily PA time was added to the curriculum. 2. The teachers were instructed to encourage the children to increase the intake of vegetables during the school lunch. 3. Intervention schools were encouraged to eliminate sweets, sweet buns and ice cream in association with festivities.	– Prevalence over-weight/obese – Objectively asse-ssed PA – Eating habits	– Prevalence of overweight/obesity decreased in IG com-pared with an increase in CG – No difference in PA – Differences between children in intervention and control schools were found for high-fat dairy products, sweetened cereals and sweet products

ical activity levels or reduce sedentary time, and the rest combined increase in physical activity levels or reduce sedentary time and diet. It is noteworthy that none study exclusively focused on diet was identified. Five of them were designed from the perspective of theoretical models of behavior change (FitKid, Switch-play, PAAC, KISS and Planet Health).

Participants' characteristics

One study included girls only (Dance for Health) and the rest included both girls and boys, although only two of these reported sex specific results (MOVI and Planet Health). The mean age at baseline varied from 6 to 12 years (median 9.5 years). One study involved a participants group with overweight/obese (KOPS), and the rest involved children recruited from all body mass index categories.

Types of outcome measures

Five studies reported BMI or prevalence of overweigh/obesity and seven studies reported furthermore BMI or prevalence of overweigh/obesity of at least one measure of adiposity. Three of them measured cardiovascular risk factors (FitKid, MOVI and KISS); four, objectively physical activity (KISS, Switch-play, PAAC and STOPP); four, fitness (FitKid, KISS, Healthy school, El Paso Catch); three, physical activity related behaviours (Dance for Health, Planet Health, KOPS) and three, diet-related behaviours (Planet Health, KOPS, STOPP). Only one study included results on quality of life (KISS).

Effectiveness of the interventions in Spanish settings

The MOVI interventions in schoolchildren

Two interventions focused on the promotion of physical activity in the school setting have been tested in the last years by our group. The distinguishing characteristics of MOVI interventions are the following: 1) in children in 4th and 5th of Primary School (age ranged 9-11 years); 2) recreational, non-competitive, leisure time physical activity; 3) open to all the children, and suitable for everyone, regardless of their body composition or motor skills; and 4) takes place outside school hours but in the school sports facilities (see www.movidavida.org).

This intervention, in its first edition (three sessions per week, each one of 90 minutes of moderate and vigorous intensity physical activity, lasting two school years) showed moderate effect in reducing adiposity and improving the lipid profile, but did not significantly improve overall cardiometabolic risk because of did not reduce insulin levels.[39,40] Our working hypothesis was that another intervention increasing the intensity of the program, putting more emphasis on the development of muscle strength, and including a weekend session on Saturday morning because we suspected that in the first edition compensating behaviors during weekend might be responsible of mitigate the effects of the intervention; therefore we implemented a 2nd edition of MOVI including two after school 90 minute sessions on school days and a 150-minute session on Saturday morning, during a school year) hypothesizing that this new intervention could be more effective on reducing obesity, but also remain acceptable to parents and school authorities. In addition, the MOVI-2 intervention,[14] included as objectives to produce behavioral changes in children and parents similarly to other effective previous interventions (CATCH, M-SPAM).

The main objective of MOVI-2 was to evaluate the effectiveness of an intervention that essentially consisted of implementing a standardized leisure time physical activity program aimed to reduce overweight/obesity and other cardiovascular risk factors, and lasting one academic year. As secondary objectives we plan to evaluate the impact of MOVI-2 on other health-related variables: physical fitness, duration and quality of sleep, health-related quality of life, and academic performance. Among the most notable results of this cluster randomized clinical trial, in preliminary analysis, worth noting a decrease in body fat, an increase in lean mass, and a decreased in insulin levels.

The experience of these two consecutive interventions makes us feel able to provide some recommendations for future interventions to tackle against childhood obesity in the Spanish context:

1) Because of the magnitude and consequences of childhood obesity not only at this moment but also in the future, it is a priority testing the effectiveness of interventions for controlling this epidemic in Spain; otherwise we would expect an increase in morbidity/ mortality and other cardiovascular diseases in the coming years.
2) The most appropriate interventions in Spanish children to prevent obesity should be based on the promotion of physical activity so that: a) it has been repeatedly reported low levels of physical fitness in Spanish schoolchildren, particularly from data of the AVENA study;[12] b) unpublished data from our group indicate that the caloric intake of overweight children is not greater than in normal weight or underweight children; c) a exclusively diet based intervention may not be free of risk for thinness children; and d) an intervention to promote physical activity based on playground games could improve other health-related aspects such as quality of life, academic performance, time and quality of sleep, etc.
3) Although it is generally accepted that BMI is the most useful and practicable indicator of excess of adiposity on clinical and population based studies, it should taken into account that BMI does

not distinguish between fat and lean body mass. Therefore, it seems advisable include in population interventions focused on promoting physical activity in children as the main outcome, in addition to BMI, an indicator of body fat such as skinfold thickness or body fat measured by bioimpedance,[22] so that physical activity might reduce fat while increasing muscle mass, and as consequence the weight/height ratio would remain unchanged.[17,39]

4) Early infancy is probably the best opportunity to intervene, so that is considered the best age to establish perdurable healthy behaviors. Furthermore, it is known that the risk of obesity in adulthood is much higher when early adiposity rebound occurs.[42]
5) Consistent evidence indicate that genes explain up to 30% of the likelihood of becoming obese; however epigenetic hypothesis support that genetic expression could be influenced by environmental factors, and vigorous physical activity is one of the most influential factor.[18,19]
6) The school environment is considered the most suitable setting for carrying out physical activity interventions on children because of: it is possible targeting to large segments of the youth population, students spend a considerable amount of day in school, most of schools provide health education (physical activity and nutritional habits) and, finally, the school environment provides a powerful social network of teacher and peers.[22]
7) The design of the interventions should be based on theoretical models of behavior change. A main limitation for most of obesity interventions in children is that the lack of theoretical underpinning on behavioral change models threats the perdurability over time of the effect.

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