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CHILDHOOD OBESITY PREVENTION: A REVIEW OF MULTI-COMPONENT INTERVENTIONS

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Abstract

Objetives: In this research project, we aim to identify potential strategies that comprise a multi-faceted approach to effectively tackle obesity in schooled children. According to most recent evidence, effective interventions to combat childhood obesity are those that involve physical activity, nutrition education, and supportive environments. Likewise, we planned to look for middle, and long follow-ups, monitoring and evaluation, which are critical to support effective action.

Materials and methods: This research included a review of scientific articles published on specialized databases and websites such as Pubmed (Medline), the Cochrane Library, The Cochrane Controlled Trials Register (CCTR), ScienceDirect, Scielo, La Biblioteca Cochrane Plus, and the World Health Organization website (http://www.who.int).

Results: From 199 potential articles, only 8 studies were included in the review. The results showed that long-term multi-component interventions have positive effects on BMI, physical activity, and food choices. However, few studies showed significant changes in overall dietary habits and overweight and obesity prevalence.

Conclusions: this review demonstrates anthropometric measures, physical activity, and food choices changes occur when multidisciplinary interventions are carried out in primary school settings. It was also observed that interventions made in developing countries of Latin America seem to have the same effects observed on developed countries.

Key words: Obesity, childhood, prevention, treatment.

Introduction

According to the World Health Organization, 65% of the world's population live in countries where overweight and obesity kill more people than underweight. Overweight and obesity are defined as excessive body fat accumulation that presents major risk factors for a number of chronic diseases, including diabetes, cardiovascular diseases and cancer.

Obesity rates have increased in recent years. In fact, the epidemic rates have nearly doubled since 1980 worldwide (WHO, 2012). Likewise, we have seen a dramatic increase of deaths associated to chronic diseases since then. As we know, health costs have increased as well. According to some estimates, the cost of obesity can represent up to 12% of health care budget in some countries (Aranceta, 2013). Thus, tackling this problem it is of great importance in order to reduce health costs and improve population´s health quality from now to future generations. According to Baidal (2012), the problem should be focused on early stages of life, being children the key age group.

Children are one of the most vulnerable groups to inadequate nutrition (WHO, 2012), especially those in low and middle-income countries. Currently, children face an additional burden since they are exposed to high-fat, high-sugar, high-salt, energy-dense, micronutrient-poor foods, which tend to be lower in cost but also lower in nutrient quality. Hence, children exposed to those environments may be at higher risk of obesity and malnutrition because of their high intake of empty-calorie foods, especially sugary beverages (Vasanti, 2010). It is worth to say that economy and social status of the family plays an important role alongside with exposure to unhealthy environments. According to WHO, the lower the family socio-economic status is, the higher the risk of overweight and obesity. On the other side, low levels of physical activity are common nowadays among children, which in conjunction with unhealthy dietary patterns mentioned before, result in sharp increases in childhood obesity.

However, obesity is a preventable health problem. There is plenty of evidence suggesting that prevention should be considered as first line intervention for tackling obesity. Therefore, prevention can be the key for combating overweight and obesity rates around the world. Likewise, there is a need to implement effective intervention programs. Aranceta (2013) suggests that interventions to prevent childhood obesity to be effective should consider multiple strategies and last longer. Likewise, it is recognized the importance of implementing policies that encourage supportive friendly environments for physical activity and support decisions to opt for healthy eating habits (Fiese, 2013). Therefore and based on formerly exposed reasons, comprehensive and coordinated interventions seem greatly required to ef-

fectively tackle children obesity. For example, the Centers for Disease Control (2002) recommend the Social Ecological Model (SEM) to combat obesity disparities. The SEM consists on a multi-faceted approach that calls for the action of combined efforts from individuals, community, and supportive policies. This type of programmes support and facilitate physical activity and healthy dietary habits in the context of a social-determinants-of-health approach which represents the best identified way for obesity prevention in childhood (WHO, 2012). Also, it is essential that such interventions occur across the whole population in a variety of settings and through multiple strategies.

In this research project, we planned to identify strategies that comprise a multi-component approach to effectively tackle obesity in schooled children. Therefore, we followed evidence-based guidelines according to various authors and organizations (Aranceta, 2013; WHO, 2012; Sbruzzi, 2013; Hoelscher, 2013). Their studies suggest that effective interventions to combat childhood obesity are those that involve a multi component strategy, which includes physical activity, nutrition education, and supportive environments. Furthermore, interventions that use the existing social structures of a community, such as school systems, reduce barriers to implementation (WHO, 2012). Moreover, Safdie et al, (2013) support that schools are ideal settings for delivering health promotion services and strategies since they provide access to a large number of children in a contained environment. Likewise, we planned to search for middle, and long term follow-ups, monitoring and evaluation, which are critical to support public health action that is effective (Kain et al, NA).

Materials and methods

This research included a review of scientific articles published on specialized databases and websites such as Pubmed (Medline), the Cochrane Library, The Cochrane Controlled Trials Register (CCTR), ScienceDirect, Scielo, La Biblioteca Cochrane Plus, and the World Health Organization website (http://www.who.int).

In order to redefine the results, we searched for recent studies published between 2009 and 2014, since most updated meta-analyses (Sbruzzi et al., 2013; Wang et al., 2013) include very few interventions published during that time period. Interventions should have large sample sizes (n>150 individuals per group), since interventions with small simple sizes (n<100) are more prone to miss relevant subgroups in the target population (Serra et al., 2014; Croker et al., 2012). Hence, if an omitted group has a different response to the condition or treatment, results and estimates may be biased. We also searched for middle and long term follow-up as defined by at least a six-month period of time, considering the usual length of the school academic year. Likewise, according to Wang et al. (2013) durations of less than 6 months may be a too short

time frame to observe the intervention effect on weight outcomes. We searched for multi component interventions that included the evaluation of combined effects of nutrition education, physical activity, and environmental support (which we previously defined as a multi component intervention) on changes in anthropometric measures such as BMI, BMI z-score, or Waist Circumference (WC), physical activity, and dietary habits. BMI z-score (or BMI-for-age) is one of the Child Growth Standards (WHO) measurements to better define children´s anthropometric status instead of BMI for adults (FANTA, 2011). Physical activity must be evaluated by validated questionnaires (NCI, 2014) or other validated methods such as accelerometers or physical activity trackers (Van Cauwenberghe et al., 2011). In regard to dietary habits, we considered adequate the use of any of the validated questionnaires registered at the National Cancer Institute (NCI, 2013). Environmental support implied any change in the school setting that promoted either physical activity or healthy dietary habits (WHO, 2012).

Studies should include at least two outcomes of any of the three components listed above. There was a preference for Randomised Control Trial (RCT) studies, but longitudinal and prospective studies were also included. Interventions must be carried out at primary schools, aimed at children under 18 years old. Although interventions aimed at children aged between 6 to 12 years old had more preference given that certain researchers (Baidal et al., 2012) claim that obesity must be intervened at early ages. Likewise, different theories, such as socio-ecological, social learning theory, health promotion, and the Trans-theoretical Model theory, claim that such age range is the best to carry out interventions on children (Waters et al., 2013).. Also, since most recent reviews (Sbruzzi et al., 2013; Wang et al., 2013) evaluated interventions in developed countries, this review aimed to focus on recent interventions carried out in developing countries (ISI, 2014). Spain, England, and USA were the focused developed countries since obesity prevalence is high in all of them (WHO, 2012; Amigo, 2003; OECD, 2012; Cunningham et al., 2014).

The structure of the process to complete the present review was adapted from the Handbook for Cochrane Reviews Protocol (http://handbook.cochrane.org/) and was performed as follows:

1. Identification of relevant studies from a number of different sources (including unpublished sources).
2. Selection of studies meeting predefined criteria.
3. Collection of data.
4. Appropriate synthesis of data.

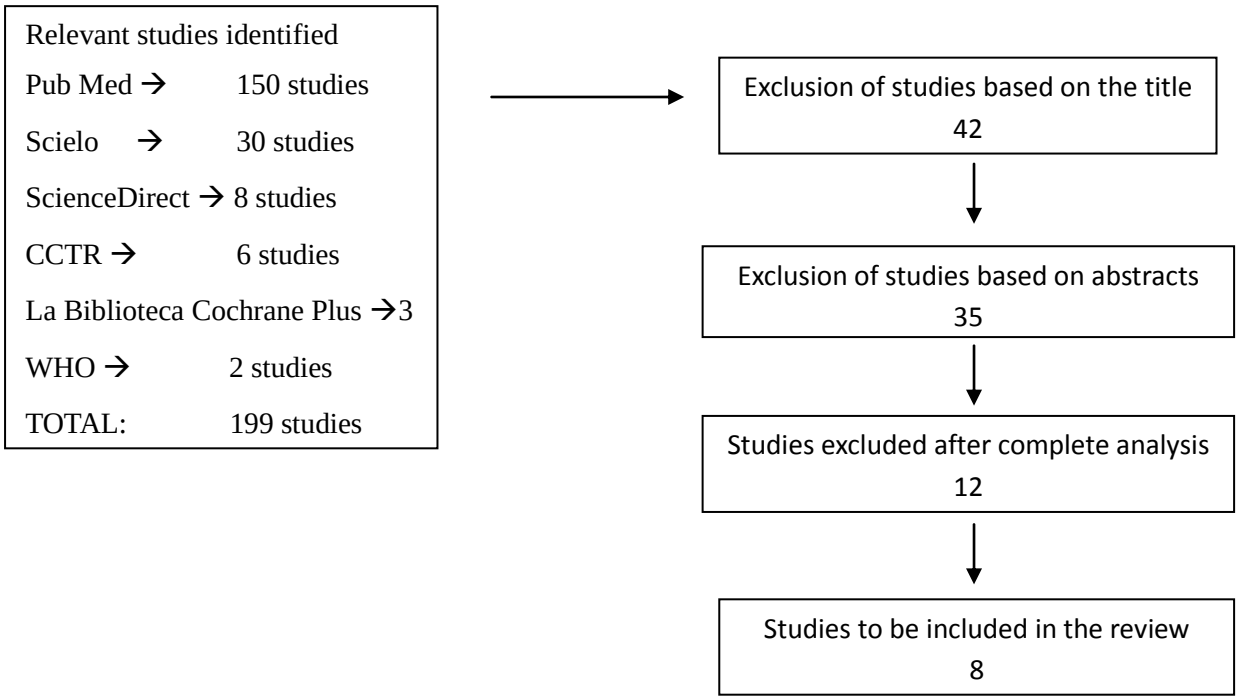
The criteria for the search on scientific databases were as follows:

On PubMed, we introduced limiters such as “last 5 years”, “clinical trial”, “controlled clinical trial”, “randomized controlled trial”, and “review”. On ScienceDirect, limiters included “from 2009 to 2015”

On Scielo database, WHO webpage, the Cochrane, and CCRT databases, we used key words such as ¨Childhood Obesity prevention AND trial; childhood obesity prevention AND randomized AND school AND multifaceted. The same key words were introduced in Spanish as follows Obesidad infantil AND intervención; Obesidad infantil intervención or OBESIDAD INFANTIL or OBESITY TREATMENT.

The next flow chart (Fig. 1) summarizes the process and the number of relevant studies identified and then selected to be included in the final review

Fig 1. Flow diagram of included studies. Legend: no legend



Results

Description of studies

The search strategy yielded 199 citations considered as potentially relevant and were retrieved for detailed analysis. Only 8 studies met the eligibility criteria and were included (n = 7.582 participants). The reasons for exclusion of the studies were because of any of the following limiters: not multi-component approach, small sample size (n<150 participants per group), short-term interventions, out-of-school settings such as primary care or private institutions, and only protocol designs. Finally, eight studies were selected to be included in this review: Llargues et al., 2011; Kain et al., 2012; Feferbaum et al., 2012; Williamson et al., 2012; Bacardí et al., 2012; Herscovici et al.,. 2013; Safdie et al., 2013; and Kipping et al., 2014. From those eight, three studies (Llargues et al., 2011; Williamson et al., 2012; and Kipping et al., 2014) were carried out in developed countries, and the rest of interventions were developed in Latin America. Two studies (Kain et al., 2012; Feferbaum et al., 2012) were not randomised controlled trials (RCTs).

Effects of interventions

All studies reviewed in this research project included at least two of the three components named before, nutrition education, physical activity, and/ or environmental support. All of them evaluated anthropometric outcomes (BMI, BMI z-score, and/or WC), physical activity, and dietary habits by using validated methods registered at the National Cancer Institute (NCI, 2013; 2014).Seven studies reported that teachers were trained to deliver nutrition education. However, training sessions greatly differed from one study to another. For example, Herscovici et al., (2013) trained teachers for 160 minutes in four different sessions (40 minutes each), and Kipping et al (2014) trained 5-year teachers for 8-9 hours during a whole day.). One study (Bacardí et al, 2012) delivered 30-min interactive lessons by nutrition graduate students each week for 8 weeks during the academic year. Physical activity was implemented in the schools curricula and teachers from seven schools were trained. For example, one study (Kain et al., 2012) changed physical activity at school from 3 hours per month to 4 hours per month. Meanwhile another study (Feferbaum et al., 2012) did not implement physical activity restrictions, but promoted and evaluated physical activity through the use of skeletal muscle mass (SSM), which is an indicator for physical activity status (Vicente-Rodriguez et al., 2005). Only one study (Safdie et al., 2013) included specialized Physical education teachers in one (Plus) of the three arms of the intervention.

The overall mean age of children was between 7.5 and 10 years. Five of these studies showed significant changes on BMI. Of these five studies, four (Llargues et al., 2011; Kain et al., 2012; Feferbaum et al., 2012; Bacardí et al., 2012; Safdie et al., 2013) included environmental changes to support the intervention. Llargues et al. (2011) based their intervention in the fact that environment is the main "obesogenic" factor, and that children are actors within the environment. Hence the intervention aimed to provide knowledge about healthy habits, including physical activity and nutrition education. One study (Williamson et al., 2012) changed the school environment by adapting the cafeteria to offer healthier menus. In another study (Safdie et al., 2013) researchers and schools staff modified the environment by teaching food vendors how to offer healthier food choices. Parents were also engaged, and interactive sessions on physical activity and nutrition were included in five studies (Bacardí et al., 2012; Herscovici et al., 2013; Llargues et al., 2011; Kipping et al., 2014; Safdie et al., 2013). One study (Kain et al., 2012) aimed to engage parents but finally the intervention did not implement that area because of the lack of economic sources. Only one study (Safdie et al., 2013) incorporated the socio-ecological model or SEM (CDC, 2002) in the intervention.

With regard to the socio-economic status (SES) of the children and their families, all the studies carried out in developing countries showed that children were from low to very low SES, except of one study (Bacardí et al., 2012) that was carried out in a developing country (Mexico) among children from middle to middle-to-high SES in two private (this was the only study which included private schools) and two public schools in Tijuana. One study (Kain et al., 2012) reported a relationship between Gross Domestic Product and Food intake in Chile, in which GDP decreased, unemployment rose, and food prices rose resulting in adverse economic conditions that may have influenced the poorest families, which account for the purchase of lower price and higher energy dense foods

Finally, the intervention carried out by Herscovici et al. (2013) is the only study to report on gender differences. The authors suggested that future research should consider gender differences when planning obesity prevention interventions for school-aged children.

Below and in Table 2, results of the interventions are showed in more detail.

Anthropometric measurements: Five studies evaluated BMI (Llargues et al., 2011; Williamson et al., 2012; Herscovici et al.,. 2013; Safdie et al., 2013; and Kipping et al., 2014). 6 evaluated BMI z score (Kain et al., 2012; Feferbaum et al., 2012; Williamson et al., 2012; Bacardí et al., 2012; Herscovici et al.,. 2013; Safdie et al., 2013; and Kipping et al., 2014). 3 studies evaluated Waist Circumference (WC) (Kain et al., 2012; Bacardí et al., 2012; and Kipping et al., (2014).

Five studies found significant reductions in BMI. Llargues et al. (2011) found a reduction of

BMI by 0.872 kg/m2 (p<0, 0001) in the intervention group. Kain et al., (2012) show that BMI z-score significantly decreased in obese children (p< 0, 0001), increasing in children of normal weight in the last year although in a non-statistically significant way (p=0,05). Bacardí et al. (2012) shows that BMI decreased by 0.82 kg/m2 (p = 0.0001) at 6 months of the study and significant reductions at 24 months compared to baseline outcomes that included BMI z-score of 0.85 ± 1.4 Mean SD (standard deviation) in the control group, and1.05 ± 1.4 Mean SD 0 in the intervention group (p=0.11). However waist circumference increased from 64.7 cm at baseline in the intervention group to 68.5 cm (p= 0, 0001). Average BMI z-score reduction was significant in the Feferbaum et al. (2012) intervention group (p< 0,01). None of the other studies showed significant changes in anthropometric outcomes. Even more, one study (Kipping et al., 2014) carried out in England obtained no significant results in any of the primary outcomes, which were: accelerometer assessed mean time per day spent doing moderate/vigorous physical activity, accelerometer assessed mean time per day spent in sedentary activity, self reported (validated questionnaire) servings of fruit and vegetables consumed per day. Table 2 shows more details about results of the interventions included in this review.

Physical activity (PA) measurements: All the included interventions promoted physical activity. However, six studies evaluated physical activity (Llargues et al., 2011; Kain et al., 2012; Williamson et al., 2012; Bacardí et al., 2012; Safdie et al., 2013; and Kipping et al., 2014) as primary or secondary outcomes. 3 studies (Llargues et al., 2011; Kain et al., 2012; Bacardí et al., 2012) found significant positive changes in PA. Table 2 shows more details about results of the interventions included in this review.

Food intake measurements: Six studies evaluated dietary intake (Llargues et al., 2011; Williamson et al., 2012; Bacardí et al., 2012; Herscovici et al.,. 2013; Safdie et al., 2013; and Kipping et al., 2014). One study evaluated food knowledge (Kain et al., (2012). Food intake outcomes were evaluated through validated questionnaires such as Krece plus, or food registries. Only in one study (Williamson et al., 2012) children were trained for more accurate food intake reports. That was made through visual aids such as digital photography during three consecutive days. Although most of these studies found that food intake decreased or children made healthier food choices, only four studies found statistically significant changes. None of them observed changes on overall dietary habits: Bacardí et al (2012) observed that vegetable intake increased (p = 0.007). Llargues et al (2011) described an increase of fruit intake after the intervention (p<0,005). Kipping et al. (2014) intervention also resulted in a reduction of snack intake (p< 0,01) and of high-energy drinks (p< 0,002) consumption. Healthier food choices were associated with changes in the environment, and regular nutrition lessons during interventions.

Table 1. Description of studies included in the

Study, year	State, Country	Design of the Study	**Participants	Purpose of the study	Duration of the intervention	Evaluated outcomes
Llargues E., Franco R., Recasens A. et al. 2011	Barcelona, Spain	Cluster-randomised controlled trial (C-RCT)	Control group N=237 Intervention group N=272 Age 5 - 6 y.	To evaluate the efficacy of an intervention on food habits and physical activity in school children from 16 different schools in Granollers, Barcelona.	24 months	BMI, Eating habits, and PA
Kain J., Leyton B., Concha F. et al. 2012	Santiago de Chile, Chile	Longitudinal	597 children, Age 4 - 7 y.	To assess the effectiveness of an obesity prevention intervention which included nutrition education and physical activity applied to low income Chilean children.	Three-year follow-up	BMI Z, WC, 6MWD, Food Knowledge
Feferbaum R., Leone C., Casanova R. et al 2012	Sao Paulo, Brazil	Prospective, controlled intervention	Control group N= 203 Intervention group N= 213 Age: 7 -14 y.	To determine the influence of a nutritional education program in promoting the healthy eating habits, including physical activity and nutritional status of school-aged students.	10 months	BMI z-score, SMM, and FM

Williamson D., Champagne C., Harsha D. et al. 2012	Louisiana, United States	Longitudinal, cluster randomised 3-arm controlled trial (RCT)	PP group N= 713 PP+SP N= 760 Control N=587 Age: 9 -11 y.	The study was designed to test the efficacy of a Primary Prevention program (PP) and a combination of PP and a Secondary Prevention (SP) program in comparison to a Control (C) group for prevention of weight/fat gain in the entire sample and overweight children	28- month follow-up	BMI, BMI z-score, % Body Fat, PA, Food intake
Bacardí M., Pérez M., Jiménez A. 2012	Tijuana, Mexico	Quasi-experimental randomized cluster controlled trial (QE-RCCT)	Control group N= 252 Intervention group N=280 Age: 9 -11 y.	To assess the effect of a six month intervention and an 18 month follow-up intervention on body mass index (BMI) Z- score, food consumption and PA of elementary school children. The specific aim was to reduce sedentary behaviour, consumption of soft drinks and high-fat containing snacks, and to increase the consumption of fruits and vegetables.	24 months	BMI z-score, Food intake, PA, WC, OW/OB prevalence
Herscovici C., Kovalskys I., and De Gregorio M. 2013	Rosario, Argentina	Prospective, Randomised Control Trial (RCT)	Control group N= 164 Intervention group N= 205 Age: 9 -11 y.	To evaluate changes in body mass index (BMI) and food intake among children at schools that received the national Healthy Snack Bars (HSB) intervention throughout PA and healthy diet habits promotion in Rosario.	6 months	BMI, BMI z-score, Food intake

Safdie M., Jennings N., Lévesque L. et al 2013	Mexico-City, Mexico	Cluster Randomized 3-arm Control Trial (C-RCT)	Control N= 383 Basic N= 261 Plus N= 234 Age: 9 -11 y.	To evaluate the effectiveness of an ecologically-based program aimed at promoting healthy eating and physical activity in selected Mexico-City schools of low socioeconomic status.	24 months	BMI, Food intake, PA. OB/OW prevalence
Kipping R., Howe L., Jago R. et al 2014	Southern England, England	Cluster randomised controlled trial (C-RCT)	Control group N= 1064 Intervention group N= 1157 Age: 8 -9 y.	To assess the effectiveness of a multi-faceted programme to increase physical activity, reduce sedentary behaviour, and increase fruit and vegetable consumption in English children.	12 months	BMI, BMI z-score, food intake, PA , WC

*Legend: 6MWD= 6-minute walk distance, BMI= Body mass index, BMI Z= Body mass index z-score, FM= body Fat Mass, OB= obesity, OW= overweight, PA= Physical Activity, PP = Primary prevention, SMM= Average Skeletal Muscle Mass, SP= secondary prevention, WC= Waist circumference, y.= years.

**The mean overall age of children was between 7.5 and 10 years.

Table 2
Results of studies include in the review

Study, year	Main Results
Llargues E., Franco R., Recasens A. et al. 2011	BMI decreased by 0.872 kg/m2 (p<0, 0001) in the intervention group, Fruit intake increased (p<0,005), and physical activity increased (p<0.036) in the intervention group.
Kain J., Leyton B., Concha F. et al. 2012	BMI z-score significantly decreased in obese children (p< 0, 0001), increasing in children of normal weight in the last year (p=0, 05). BMI Z score increased among overweight children in the last year of intervention (p= 0,05). 6MWD improved in the three groups over time. (p< 0,0001) Food knowledge increased
Feferbaum R., Leone C., Casanova R. et al 2012	Average BMI z-score reduction was significant in the intervention group (p< 0,01) SMM increased in both groups (p<0,01) FM increased in the intervention (p= 0,20) and the control group (p=0,01)
Williamson D., Champagne C., Harsha D. et al. 2012	No differences between PP+SP and PP and Control were found for changes in food intake, PA, or sedentary behaviour. Percentage of body fat for boys in the EM arm decreased (p = 0.0004); In C, percentage of body fat did not differ from baseline Comparisons of PP, PP+SP, and C on changes in body fat and BMI z scores found no differences.
Bacardí M., Pérez M., Jiménez A. 2012	BMI decreased -0.82 kg/m2 (p = 0.0001), at six months of the study. At 24 months, BMI z-score and waist circumference increased, abdominal obesity decreased (p= 0.0001) Vegetable intake (p = 0.007) and physical activity (p = 0.0001) increased. Also high-fat, high-salt snacks consumption decreased (p=0, 03), as well as sedentary behaviours (p=0.003).

Herscovici C., Kovalskys I., and De Gregorio M. 2013	There was no significant difference in BMI between experimental and control groups Statistical significance was observed for skim milk (p = 0.03) and for pure orange juice (p = 0.05). Boys in the intervention arm significantly reduced their intake of hamburgers and hot dogs (p = 0.001)
Safdie M., Jennings N., Lévesque L. et al 2013	4.65% (p=0.06) children in basic schools and 2.15% (p=0.03) in plus schools maintained a status of reaching cut off for steps in school relative to students in the control group (12.16%) Availability and intake of highly recommended foods increased in both intervention schools relative to control schools from baseline to 18 (p<0.05) months. The intervention had no significant effect on the prevalence of overweigh and obesity or children's BMI.
Kipping R., Howe L., Jago R. et al 2014	The intervention was only effective for three out of nine of the secondary outcomes: self reported screen time on weekends (p< 0,01), self reported consumption of snacks (p< 0,01) and of high energy drinks (p< 0,002) No evidence of effect on any of the three primary outcomes (average moderate/vigorous physical activity time sedentary activity, self reported servings of fruit and vegetables per day).

*EM arm = Primary Prevention combined with Primary + Secondary Prevention; C = Control

Discussion

The aim of this study was to review recent literature on multi-component interventions focused on childhood prevention at school settings. The search strategy and selection of studies resulted in eight studies, and five of them were randomised controlled trials.

In this review, we observed that multifaceted interventions such as those carried out by Largues et al., (2011); Kain et al. (2012). and Bacardí et al. (2012), resulted in decreased BMI, positive outcomes of physical activity (PA) such as increased 6MWD over time (Kain et al.,2012), or increase and maintenance of steps carried out (Safdie et al., 2013), and positive changes regarding healthy food choices as suggested by increased food knowledge (Kain et al., 2012), increased vegetable intake (Bacardí et al., 2012) and increased fruit intake (Llargues et al., 2011). All of the studies included educational approaches to promote physical activity, and healthy food habits. Also, most of the studies (Llargues et al., 2011; Feferbaum et al., 2012; Williamson et al., 2012; Bacardí et al., 2012; Herscovici et al.,. 2013; Safdie et al., 2013; and Kipping et al., 2014) included environmental changes (Williamson et al., 2012; Kain et al., 2012) in the school settings, as previously mentioned. Additionally, Feferbaum et al., (2012) showed that the success of an intervention did not depend on the duration of the intervention "per se", but it rather depended on the facilitating factors (such as environmental changes) rather than on the individuals themselves or the socioeconomic level.

All anthropometric outcomes considered such as waist circumference (WC), BMI, and BMI z-score were strongly associated with cardiovascular outcomes (Higgins et al., 2001), showing that higher BMI, and WC measures lead to increased risk of type 2 diabetes, hypertension, lipid abnormalities, and atherosclerosis (Juonala et al., 2011). Moreover, Fall et al. demonstrated that rapid BMI gain during childhood and adolescence is a risk factor for metabolic syndrome and impaired glucose tolerance (Fall et al., 2008),. However, it is important to evaluate and include in future studies anthropometric outcomes like Waist-to-Height ratio (WHtR) that seems to further specify the cardio metabolic risk assessment of overweight and obese children (Khoury et al., 2013). The WHtR seems to be an important discriminating measurement in the cardio metabolic risk assessment of children. Hence, WHtR should be considered as useful tool for future research (Mokha et al., 2010). It is worth to mention that promising comprehensive interventions (Xu et al., 2014; Robinson et al., 2013; Blüher et al .,2014) that aim to evaluate metabolic markers to assess cardio metabolic risks, may be carried out in the near future.

Positive PA changes were associated with educative and active lessons included in the school curriculum (Llargues et al., 2011; Williamson et al., 2012; Bacardí et al., 2012; Safdie et al., 2013). These results are consistent with other recent reviews (Sbruzzi et al., 2013; Wang et al., 2013). Likewise, we found that not intensive interventions (those with poor implications from schools, the community and few interactive sessions) did not result in significant outcomes. That was the case of one study (Kipping et al., 2014) which obtained no significant changes in any of the primary outcomes, including PA. Although the intervention was based on a comprehensive approach, the educational method was not intensive (children from 16 classes in 12 of the 30 intervention schools were excluded because their teacher had delivered fewer than 70% of the lessons.). We also found that PA outcomes measured with validated questionnaires were consistent with results obtained with objectives measures of PA such as accelerometers (Bacardí et al., 2012; Kipping et al., 2014).

All included studies showed positive results relative to healthy food habits as evidenced by increased intake of healthier choices, and decreased intake of not recommended foods. However, none of them found statistically significant changes in overall dietary habits. 3 studies (Bacardí et al., 2012; Llargues et al., 2011; Kipping et al., 2014) found significant increases in healthy foods intake or significant decreases in less-healthy foods. Two of those studies (Bacardí et al., 2012; Llargues et al., 2011) showed again that interventions that involve environment changes and parents participation resulted in greater positive outcomes (WHO, 2012), no matter what the socio economic level of the family (Bacardí et al., 2012).

Strengths and limitations of the review

Our study had some methodological strengths (Higgins et al., 2011), which are: 1. The focused review criteria, 2. a comprehensive and systematic literature search in both English and Spanish languages, and 3. Six of eight studies were randomised controlled trials

A limitation of this review is that we only considered school-based intervention and not other interventions such as community-school based, or home-school based studies. Hence we were not able to compare the results obtained in this review.

Conclusions

In conclusion, we conclude that:

1.) Anthropometric measures (such as BMI, BMI z-score, Waist circumference), physical activity, and food choices changes happen when multi-component interventions are carried out in primary school settings.

2.) Sustained periods of time are likely to have the greatest impact.

3.) Multi component interventions may need more intensive designs (more implication from schools, and the community) in order to tackle obesity despite of duration (Kipping et al., 2014). These interventions should be accompanied by public health policies (Nanney, 2014)

4.) Interventions made in developing countries of Latin America seem to have the same effects observed on developed countries. However, further research is needed in other developing countries.

5.) We suggest that future interventions consider the use of promising anthropometric measures such as the Waist-to-Height ratio (WHtR) that seems to further specify the cardio metabolic risk assessment of overweight and obese children (Khoury et al., 2013).

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