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**Clinical and School-based Intervention strategies for Youth Obesity Prevention:
A systematic Review**

Abstract:

In the last decades, numerous interventions strategies (IS) have been set up in school/community or clinical sectors using physical activity (PA) in order to prevent youth obesity. Those two sectors have shown interesting elements in terms of efficient results and best practices mechanisms but they have been rarely compared to learn one from the other. The aims of the systematic review was to analyze and synthesize PA IS from school/community or clinical domains, for the period 2013-2017, in French or English, targeting youth 5-19 years old through primary, secondary and tertiary prevention. In total, 68 full articles were kept for data extraction and synthesis and 617 were excluded because didn't meet eligibility criteria. Results identified a number of differences between the studies of the various IS sectors and identified a third type of IS: mixed sectors. They should be privileged because it can add at a time school/community-based and clinical-based strength. Mixed IS showed the most promising results. This review also showed differences between sectors and their IS on intervention team, prevention objective, duration, material and efficiency. Future studies should focus on establishing a prevention program in a given geographical area involving all stakeholders with their respective skills/knowledge, in decision making and in the development of the IS, that it be the most efficient and best adapted to its environment.

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1. Introduction

Nowadays, we know that obesity is a chronic pathology with multifactorial origins; characterized by the World Health Organization (WHO) as an abnormal or excessive fat accumulation that presents a risk to health (e.g., vascular, endocrine)^{1,2}. Its prevalence and incidence never stop increasing among adults and also among children and adolescents. A study reported that in the last four decades, the number of young obese (aged 5-19) was multiplied by 10 worldwide³. Another one reported an increasing youth obesity prevalence by 47% in the last three decades⁴. To struggle against the epidemic, the WHO made some recommendations (e.g., physical activity; nutrition)^{5,6} to follow, to adopt a healthy lifestyle, to reduce health problems and the risk of obesity.

In parallel, it is also known that Physical Activity (PA) has many health benefits (physical, mental, social among others) that can help to reduce obesity and to maintain a certain weight when associated with nutrition⁷. Moreover, the adoption of a healthy lifestyle during childhood or adolescence tends to linger into adulthood. Nevertheless, 80% of youth aged 13-15 did not follow those PA recommendations⁸ and tend to have a sedentary lifestyle⁹. This sedentary and inactivity may lead them to overweight or obesity¹⁰. To struggle this tendency, intervention strategies (IS) and programs integrating PA have been developed and implemented into different settings to prevent overweight and obesity¹¹. Following Gadais¹¹, IS are initiatives, programs, thematic days, events that directly or indirectly aim to enable people to adopt healthy lifestyles for their immediate and future health. When we look closely at the literature on obesity prevention, few different settings emerged and two of them have been widely studied. On the one hand, the clinical setting on how to manage childhood obesity. And on the other hand, the school/community setting on how to deal with obesity prevention and what is the role of school in obesity prevention. From this point, we decided to focus our work on these two promising intervention sectors.

As we may have suggested earlier and to quote Lydecker et al.¹², “prevention assumes that individuals have some degree of susceptibility to obesity and would benefit from medical and psychosocial interventions to counter that susceptibility”¹². If the degree of susceptibility to obesity varies from one individual to another, prevention must also take place at different levels: primary, secondary, tertiary. Primary prevention targets every individual without distinction. For example, the ads on television which invite people to move and eat better. Secondary prevention targets subsamples of the population; people at risk of becoming overweight or obese. As an illustration, children in the upper range of BMI or who make very few physical activities. Tertiary prevention targets specifically individuals already overweight

or obese with complications. On this case, interventions which aim at obtain a sufficient weight loss to reduce comorbidities ¹²⁻¹⁴. Those three types of intervention are generally implemented in two major sectors: clinical or school and community sectors.

Clinical setting is the place where people are treated (e.g., hospital, health centers). In this context, clinical IS seems to have financial resources (e.g., exergaming) ¹⁵ and human resources/expertise to be a source of quality and reliable information ¹⁶. Clinical IS also showed significant results to struggle against childhood obesity ^{17,18}, making it an important contributor in the management of obesity. Nevertheless, not all the studies showed interesting results and the prevention does not consist only on treatment; that is frequently the last step of prevention, making the other sector for IS implementation useful.

School and community sector could be understood as a place dedicated to learning where children develop their knowledge and skills (e.g., physical, social, cognitive skills). Many authors agree to say that school is a privileged place for the prevention of obesity ¹⁹⁻²¹. Indeed, children and adolescents spend most of their time at school and it is “possible to globally reach the population of interest without stigmatize or discriminate and without being primarily dependent on families” ²². According to those authors, school/community sector could assume an important role to promote positive change in children lifestyle, to learn them how to adopt a healthy way of life ^{11,23}. Yet, some studies demonstrated that school-based obesity prevention interventions with children demonstrated limited efficacy ^{24,25}, generally missing financial or human resources among others.

According to the literature, school/community-based IS and clinical IS seems to be different because they are not conducting the intervention on the same level of childhood obesity prevention. Interestingly, they both seem to show promising results to prevent obesity. From this point, could it be possible to consider a global prevention (i.e., primary, secondary, tertiary) to reduce youth obesity prevalence and incidence in the coming years by bringing best-practices from one sector to another? We therefore sought to know if there were relevant elements in the IS from these two sectors, which would improve the prevention of obesity among young people through a mutual enrichment.

The purpose of this study was to:

- 1) Conduct an extensive inventory on the recent literature regarding programs and IS which aimed at preventing youth obesity, from clinical or school-community perspectives;
- 2) Extract information in order to identify the mechanisms that make programs effective in a clinical or school/community sector;

- 3) Propose some recommendations for both sectors perspectives (clinical and school/community) and improve current IS for future studies

2. Methods

To conduct this systematic review, we followed the six steps of the PRISMA²⁶ for preparing to flow chart (Figure 1).

Insert Figure 1 here

2.1 Phase 1: Identification of the studies

In the first phase, an exhaustive research through computerized databases was performed to identify scientific publications targeting youth obesity prevention. More especially, we used specific search equations to conduct the first overall research. Relevant articles were identified by means of a computerized search through three databases (i.e., SportDiscus, PubMed, Science Direct) with different combinations of keywords (e.g., program; obese; physical activity, child) (Appendix A) and Equations/Mesh-terms (Appendix B).

2.2 Phase 2: Screening

In phase two, 40 duplicates were eliminated and 685 papers were considered. We started looking for non-systematic reviews and prioritized peer-reviewed articles. Some reports from credible organizations, like government agencies, international agencies or academic centers were also considered as an extent to our research (e.g., WHO) but none of them were considered.

2.3 Phase 3: Eligibility

The selection of abstract was performed based on inclusion criteria. To remove any doubt, the second author was consulted. Six inclusion criteria were applied for article eligibility: 1) published between 2013 and 2017, 2) written in French or in English, 3) full text available online, 4) youth 5-19 years old targeted by the studies, 5) PA as a part of the IS, 6) IS targeted obesity prevention and not only co-morbidities or physiological risks factors (e.g., diabetes). In total, 68 full articles were kept for data extraction and synthesis and 617 were excluded because didn't meet eligibility criteria.

2.4 Phase 4: Inclusion

The fourth phase of the literature search was to obtain copies of the articles previously identified in phase 3. After articles collection, the overall sample was reassessed. A complete reading was made in order to eliminate non-relevant articles (according to inclusion criteria). At the end, 61 articles were retained for the data extraction by meeting all inclusion criteria.

2.5 Phase 5: Data extraction

A data sheet was used to extract information concerning the date of the study; intervention sector (school/community or clinic); design (collaborative IS or not); variables studied; data collection (equipment, hardware); participants (non-obese, overweight, obese, age); synthesized results; synthesized IS. The first and the second author performed the data extraction. To remove any doubt, data synthesis tables were discussed until agreement was reached on the presentation shape and what should be extracted. Once phase 5 was completed, the content analysis of the 61 articles began.

2.6 Phase 6: Data analyse

To identify the differences, the results will be presented throughout five different angles (i.e., intervention team, prevention objective, duration, material, efficiency). As previously mentioned, the intervention sectors are different but show interesting results. Therefore, it is interesting to see who is conducted the intervention, what is the purpose, what are the means available, how long IS last and for what results.

The first author performed the initial selection in the literature search based on the abstract and title ($n = 725$). He also performed the initial analyse of the data and wrote the first draft of the manuscript. The second author helped for data analysis and for results presentation. He also revised the whole manuscript.

3. Findings

3.1 School and Community IS

Insert Table 1 here

3.1.1 Intervention Team

Of the 36 school/community-based studies (Table 1), 11 only use one type of stakeholder. On these 11, 6 studies only involved teachers^{19,27-31}. For example, Grao-Cruces et al.²⁸ mentioned “weekly follow-up and control by PE teachers” and Sachetti et al.¹⁹ “taught by the ordinary classroom teacher”. The use of the teacher as the only intervener increases from 54.5% (6/11) to 75% (6/8)³²⁻³⁴, if we excluded studies occurring only in the community. 25 studies used at least two types of stakeholders^{15,20,21,35-56}, and eight involved health professionals (e.g., doctors, nurses, psychiatrists)^{15,21,35,38,41,44,55,56}. Among these eight, 2 relied solely on school nurse^{38,44}. Globally, six studies involved non-school-based stakeholders with experience in health.

3.1.2 Prevention objective

Regarding all the studies aimed to prevent childhood obesity throughout school/community IS, 9 looked for secondary or tertiary obesity prevention, since they are only interested in young people being already overweight or obese^{15,21,33,34,43,44,47,55,56}. For example, Larsen et al.⁴⁴ selected “One hundred fifteen 11-13 year-old children with overweight and obesity” and Wright et al.²¹ mentioned “Students (n=251) were English or Spanish speaking, had a BMI > the 85th percentile”. Majority of the studies (27)^{19,20,27-32,35-42,45,46,48-54,57,58}, tend toward a relatively primary prevention of obesity, and do not target a population that is necessarily overweight or obese, but an entire population. For example, Lau et al.⁴⁵ mentioned “the average BMI was 17, which was within a healthy range”. However, this remains a trend, these studies also include children “at risk” in their participants because of the absence of selection criteria. As an illustration, Smith et al.⁵³ had in the intervention group two underweight children, 110 normal weights, 39 overweight and 30 obese.

3.1.3 Duration

On the duration, 19 of the studies spend a year or more^{19,20,27,29,32,35,37-39,41,47,48,50-52,54,55,57,58}. As an example, Erfle et al.³⁸ reported “30 minutes of daily PE throughout 1 academic year” and Santos et al.²⁰ “performed during the 2009-2010 school year”. Of the 17

remaining with a shorter duration, 14 of them spend 6 month or less^{15,21,28,30,33,34,36,40,42-45,49,56}.
Larsen et al.⁴⁴ used “the six-week intervention” and Parra-Medina et al.⁴⁹ “a 12-week family
focused healthy lifestyle program”.

3.1.4 Material

Studies from the school/community sector do not automatically consider BMI with age
and sex in their anthropometric measurement (e.g., BMI z-score, BMI percentile). Two studies
do not consider anthropometric measurement in their outcomes^{36,42} and two others consider
only BMI (not for age and sex)^{45,55}. Further considering the 34 studies with anthropometric
measurements, 23 are based on a measurement related to BMI or abdominal circumferences
(e.g., BMI score, waist circumference). Others studies (considering anthropometric
measurements) systematically considered at least a second objective measure such as DXA: (1
study), Skinfold Thickness (3 studies) or Impedance (7 studies). Ning et al.³³ mentioned that
“body composition was assessed by bioelectrical impedance analysis (...) body composition
was also estimated at baseline and 6 months using dual x-ray absorptiometry” and Johnston et
al.⁴³ mentioned that “body composition was assessed using triceps skinfold thickness”.
Regarding PA with studies that take PA measurement (32/36), 20 used one objective
measurement (not a self-reported). Among these, the most common instruments are
accelerometer (9 studies), pedometer (5 studies) and various fitness tests (13 studies) (e.g.,
Fitnessgram). As an example, Larsen et al.⁴⁴ used a “progressive bicycle ergometer protocol
(...) Actigraph GT3X+ for ten consecutive days” and Grao-Cruces et al.²⁸ reported that “a
pedometer was used for evaluation and follow-up purposes”. Finally regarding nutrition, 19
studies conducted a measurement. Most of them are carried out through three types of
instruments: survey (15 studies), recall/diary (6 studies) and interview (1 study). For example,
Ning et al.³³ mentioned that it was “assessed by a 48-h diet recall”.

3.1.5 Efficacy

In the school/community sector, major objective tends to be the primary prevention of
obesity. And interestingly, “lose weight” objective is not the first goal to consider.
However, 26 studies still showed significant positive results regarding the anthropometric
measurements of the participants (e.g., BMI, Waist circumferences)<sup>15,19-21,27-31,33-
35,37,38,41,43,44,46-48,51,52,55-58</sup>. Nevertheless, some studies showed only effects on part of the
population^{21,29}, or “mixed effects”^{19,37,52}. Of the 10 remaining studies, which did not clearly
show an effect on BMI, 9 had, at least, a significant influence on health factors

32,36,39,40,42,45,50,53,54 (e.g., physical, psychological or nutritional ones). To illustrate, Smith et al.⁵³ showed that “significant intervention effects were found for screen time (mean $\pm$ SE: -30 ± 10.08 min/d; $p=.03$), sugar-sweetened beverage consumption (mean: -0.6 ± 0.26 glass/d; $P=.01$)”. Only the article of Parra-Medina et al.⁴⁹ showed no significantly interesting effect in children because “child participants that completed the program ($n=72$) showed no improvements”.

3.2 Clinical IS

Insert Table 2 here

3.2.1 Intervention team

Of the 19 studies we identified (Table 2) in the literature and which took place in a clinical setting, three of them^{16,59,60} only used a single type of contributor. And it is systematically a doctor who delivers recommendation on psychological, nutritional or PA. For Brennan et al.⁵⁹, “the clinician discuss topics such as physical activity, nutrition, helpful thoughts and emotions” and for Davis and al.⁶⁰ “the clinician covered several topics as self-esteem, energy balance, portion size, screen time and sedentary”. The 16 remaining studies always used a multidisciplinary team, which is composed by at least two types of specialists⁶¹⁻⁷⁶. As an example, for Nemet et al.⁶⁹ “the intervention team was composed of 3 specialists, dietitian, coach and physician” and Endevelt, et al.⁶⁴, used a “multi-disciplinary team including a pediatrician, a dietician, a physical activity expert, and a social worker”.

3.2.2 Prevention objective

None of the studies targeted primary prevention of obesity and 18 of them worked on secondary or tertiary prevention of obesity, because they only targeted participants with a BMI $>85^{\text{th}}$ percentile. As an illustration, Staiano et al.⁷⁵, selected only participants with a BMI percentile $\geq 85^{\text{th}}$, according to the Center of Disease Control (CDC) growth chart and Serra-Paya et al.⁷², selected children overweight or obese according to the International Obesity Task Force (IOTF) criteria. Only one study¹⁶ used a BMI comprise between the 75^{th} and the 95^{th} percentile as an inclusion criterion. Nevertheless, participants were judged at risk of weight gain due to their BMI, based on their last medical consultation.

3.2.3 Duration

Regarding the duration of the IS, 16 studies spend at least one year^{59-65,67-75}. Luca et al. (2015) mentioned a “2-year interdisciplinary obesity management program”. Moreover, 10/19 studies have an effective duration less than or equal to 6 months^{60,61,65,68-71,73-75}. Martín-García, et al.⁶⁸ implemented a 3-month vigorous physical activity, and Staiano et al.⁷⁴ a 12-week group exergaming intervention. It should also be noted that all studies spending one year or more, are spread over time that consist of only a few meetings a year. As an illustration, for Stettler et al.¹⁶ the IS consisted of 12 meetings of 15-25 minutes over 12 month, and for Luca et al.⁶⁶, it was 6 meetings of 2h per week, then 1h30 every two weeks the first year and 1h30 monthly until the 18th month.

3.2.4 Material

Anthropometric measurement at the clinical level consistently considers BMI by age and sex (BMI score). Nevertheless, in 10 studies, BMI is coupled with a second measure related to body composition and something more^{16,59,61,65,67,68,72-75} (Dual Energy X-ray Absorptiometry (DXA)(4 studies), Skinfold thickness (2 studies), WHtR (2 studies), Impédance (1 study)). As an example, Staiano et al.⁷⁴ used DXA to assess body composition and quantify body fat, and Gerards et al.⁶⁵ measured skinfold thickness to evaluate percentage body fat. Regarding PA, 12 studies used one or more objective measurement^{59,61,62,65-70,72,74,75}. In these 12, the pedometer has been used in 2 studies; PA was tested in 5 studies and accelerometers in 7 studies. Brennan et al.⁵⁹, made a cycle ergometer test to assess cardiovascular fitness and participants had to worn an accelerometer to assess their physical activity. Regarding nutrition, measurements are made in 14 studies^{16,59-66,68-72} and three tools are frequently used. Survey (3 studies), interview (4 studies) and dietary recall (5 studies). Nemet et al.⁷⁰ mentioned the “use of a 48h dietary recall”; Davis et al.⁶⁰, mentioned the “use of a 24h dietary recall”, and Brennan et al.⁵⁹, the “use of a dietary checklist and of the Fat, Fruit and Vegetables Diet Questionnaire (FFVDQ)”. We can also highlight the fact that some studies do not clearly mentioned their measurement instruments.

3.2.5 Efficacy

In the context of secondary or tertiary prevention of obesity, one of the main objectives remains BMI decrease and fat loss in favor of lean mass. 14 studies out of 19 (73.68%) showed significant effects on BMI or participant body fat^{16,59-61,64,67-71,73-76}. For example, Marild et al.

⁶⁷ “reported a significant reduction in BMI and BMI-sd in the Nurse-dietician-physiotherapist managed treatment compared to the control group with obesity ($p=0.0007$ and $p=0.0005$ respectively)”. Nevertheless, some studies only showed significant effects on some part of their participants. As an illustration, Martín-García et al. ⁶⁸, “They found that, in the intervention group, boys decreased their whole-body fat mass ($p<0.04$) and reduced their percentage body fat ($p<0.001$); moreover, boys body lean mass increase significantly ($p=0.003$)”. Of the 5 other studies that do not have a direct effect on BMI, 4 had at least a significant influence on physical, psychological or nutritional health factors ^{62,65,66,72}. Furthermore, in these studies, the intervention group is compared to a control group performing a “less advanced” intervention. Serra-Paya, et al. ⁷² mentioned that “the intervention group received organized physical activity sessions, theoretical and practical sessions for parents, behavior counseling for children and parents, 3 weekend activities organized outside family for children; unlike counseling group received only the behavior counseling sessions.” Only one article showed no effect ⁶³.

3.3. *Mixed IS*

Insert Table 3 here

3.3.1 *Intervention team*

Of the six studies we identified (Table 3) and which took place in a “mixed” setting (school/community and clinical), all of them used at least two types of contributors; with one (or more) who have health-related skills or knowledge. Rito et al. ⁷⁷ reported “four individual counseling sessions performed by trained nutritionists (...) healthy cooking workshops performed by a certified renowned ‘chef’ in a school kitchen”. All of these studies used a multidisciplinary team by having in common a dietitian. Maatoug et al. ⁷⁸ mentioned that the IS “included a multidisciplinary team with a pediatrician, dietitian, physical activity teacher and psychologist”.

3.3.2 *Prevention objective*

All these studies are part of a secondary or a tertiary prevention of obesity, because they are only interested in children already overweight or obese. 4 of them are based on data on overweight and obesity for age and sex of CDC ($BMI>85^{th}$ percentile). As an example, Morano et al. ⁷⁹ selected participants “with a $BMI \geq 85^{th}$ percentile for age and sex according to the CDC growth reference” and Sanders et al. ⁸⁰ selected “overweight or obese based on the CDC

growth chart”. The two remaining studies are based on different data from the WHO, Maatoug et al.⁷⁸ used “Z-score were derived using the world health organization references” or from English references Kokkvol et al.⁸¹ “ $\geq 98^{\text{th}}$ centile according to the UK references”. None of these studies are directly concerned with the primary prevention of the pathology.

3.3.3 Duration

Regarding these mixed studies, 2 have duration above or equal to 1 year^{78,81}. Kokkvol et al.⁸¹ IS lasted 2 years, Maatoug et al.⁷⁸ IS lasted 1 year and 50% last 6 month or less^{77,79,80}. Sanders et al.⁸⁰ had a 4 weeks IS. Only Rieder et al.⁸² have an “intermediate” duration equal to 9 months. It should be noted that, unlike the clinical studies previously seen, the frequency of proposed activities or meetings with professionals is higher in mixed programs lasting one year or more. For example, Kokkvol et al.⁸¹ used “weekly group-based physical activity” and Maatoug et al.⁷⁸ used “twice a week physical activity session in school”.

3.3.4 Material

Anthropometric measurements, in these mixed studies, systematically consider BMI for age and sex (e.g., BMI z-score, BMI percentile). Nevertheless, it is not the only measurement, because in 3 studies, this is coupled at least with a second measurement of body composition (WC (3 studies), Skinfold thickness (2 studies), Impedance (1 study)). For example, Kokkvol et al.⁸¹ used “bioelectrical impedance”; in Morano et al.⁷⁹ “Skinfold thickness was determined (...) with a skinfold caliper” and Rito et al.⁷⁷ “waist circumference were obtained for every child”. Regarding PA, 3 studies clearly used an objective measurement coupled with a second self-reported. This enables not to sur-/underestimate the results. Sanders et al.⁸⁰ mentioned that “pre- and post-intervention fitness tests were administered to participants (...) program participants and their parents completed a physical activity and nutrition behavior questionnaire”. The other studies are only based on self-reported data (Maatoug et al.⁷⁸ mentioned that participants “responded to a 24-h food and physical activity recall questionnaire”) or they do not take any PA measurement⁸¹. Regarding nutrition, 3 tools are mainly use. The questionnaire (2 studies); the 24h recall (2 studies); 7 days dietary diary (1 study). As an illustration, Morano et al.⁷⁹ “dietary habits were assessed with a 7-day food diary”. Only one study does not use nutritional measurement⁸¹.

3.3.5 Efficacy

As mentioned previously, all the mixed studies focused on secondary or tertiary prevention of obesity. One of the major objectives of this work is therefore to influence downward the BMI and weight in order to reduce fat mass of the participants. Of these 6 programs, 5 had direct effects on BMI⁷⁷⁻⁸¹. One article did not show significant BMI reduction even though it indicated a tendency to slow its growth. Rieder et al.⁸² mentioned that percentile BMI measurements taken before and after the intervention indicate a general upward trend ($\beta=0.0003$). Nevertheless, during the intervention period, the slope of the BMI percentile experienced a downward trend ($\beta=-0.0001$). Moreover, the comparison of the results on the pre-intervention phase and the intervention phase shows significant variations ($p=0.003$). “For intervals T-12 to T0 versus T0 to T9, there were significant decreases in rates of gain in BMI (0.13 vs 0.04, $p<0.01$, BMI percentile (0.0002 vs -0.0001, $p<0.01$)” Each of these studies also show, at least one positive variation on one of the various health, physical, psychological or nutritional factors. As an example, Maatoug et al.⁷⁸ showed positive effects on PA, p-value (pre-post)=0.001 and reduction of caloric intake, p-value (pre-post) <0.001; Rito and al.⁷⁷ mentioned “vigorous physical activity (d/week), CI 95% 0.1-0.5, p-value = 0.008 » and Morano et al.⁷⁹ showed that “Actual ($p<0.001$) and perceived ($p<0.03$) physical abilities, physical activity enjoyment ($p=0.03$), and psychosocial HRQoL ($p<0.05$) also improved from pre- to post-intervention”.

4. Discussion

4.1 Summary of the findings

This study identified a number of differences between the studies of the various IS settings (Table 4); those differences could be grouped into five elements (intervention team, prevention objective, duration, material, results).

Intervention team

The intervention team, in the school/community IS is mostly composed of a single stakeholder which is often the teacher (54.5% of cases). In the clinical and mixed sectors, the IS largely lean on a multidisciplinary team with various members specialized in health. In both sectors, stakeholders contributed meanly to the success of the IS as keyactors.

Prevention objective

The school/community IS mainly targets primary prevention because there is no selection of the participants, while in the other sector, participants are chosen by targeted criteria such as overweight or obese (according to their BMI for age and sex), same for mixed studies.

Duration

One interesting point in the school/community setting is that it allows relatively longer intervention duration and IS aimed at preventing obesity need time to embed, develop before being evaluated ⁵⁶. On the other hand, clinical and mixed IS tend to spend for a shorter period of time. More than 3/4 of the studies made in the clinical setting and 2/3 of the studies made in the mixed setting spend less than a year.

Material

Clinical and mixed IS tend to use more objective instruments, requiring more skills and knowledge. This allows them to associate and combine certain measurements to bring more precise and not sur-/underestimate their results.

Efficacy

Many authors agreed ¹⁹⁻²¹ that school is a privileged place for prevention. Our results seem to confirm this tendency because school/community IS shows significant and promising results both on anthropometrics measurements relative to obesity (72%) and on health-related factors (90%). The clinical setting is also a privileged place for the treatment of obesity (secondary/tertiary preventions). This setting is seen as a source of quality and reliable information ¹⁶ and it shows important results on both obesity (74% of the studies) and health-related factors (83% of the studies) ⁸³.

Insert Table 4 here

4.2 Prospects

In view of those findings, mixed studies should be privileged. These ones can add at a time school/community-based and clinical-based strength. Indeed in our study, mixed IS shows the most promising results. 83% of the studies show positive influence on obesity and 100% on health-related factors. Nevertheless, those we considered seek to apply a relatively clinical model to the school/community setting ⁷⁸ but do not join in an exchange relationship, so that the strengths of school/community-based IS are “left behind”. To have global obesity

prevention and to be in line with health recommendation to stop childhood obesity, we propose in the table below (Table 5) some recommendations for futures studies, to be more effective.

CLINIC:

- Multidisciplinary team with specialists;
- Objective measurements;
- Relative efficiency to treat.

SCHOOL /COMMUNITY:

- Pleasure / enjoyment;
- Various activities;
- Relative efficiency to prevent;
- Time (place where children spend most of their time).

Insert Table 5 here

To synthesize, we recommend the implementation of a transparent local council involving the entire local community (e.g., school children, representatives, clinical specialist, stakeholders, parents, associative representatives)²¹ responsive of thinking about the development, improvement, implementation of prevention programs at the local level. The most important thing is that each intervention sector keeps its prerogative. Nevertheless, to reach an effective obesity prevention the different settings need more transparency without leaving aside the 3 different aspects of prevention (primary secondary = school/community; secondary tertiary = clinical). Another interesting aspect is the use of new technologies in prevention. On this point, further studies are needed to evaluate the potential added value of these tools in obesity prevention.

Insert Figure 2 here

4.3 Limits

Many studies use BMI as measurement or other variables related to it. However, if it is easy to use, alone it is not a representative indicator of the benefits of a program. Morano et al.⁷⁹ showed that the use of multiple body composition measurements provide better indications of change in body fat, which is more representative of expected changes. Furthermore, weight

related measurements can skew the results ⁶⁸. In the PA-oriented programs, which lead to positive body composition change (e.g., lean mass gain and body fat loss), the participant weight can increase (lean mass heavier); which can induce an increase of BMI measures. This lack of precision, relative to these measurements can also distort the results of the studies which only use BMI as measurements or variables relative to the weight of the participants.

A second limitation could be the lack of information about programs in some studies to assess the quality of the study. This sometimes makes it difficult to identify: the equipment uses, the staff involved and their skills/knowledge. The duration of the program is another limitation. Indeed, all the identified studies do not last the same time (e.g., more than 1 year; less than 6 months; few weeks). Furthermore, they do not use the same evaluation time (e.g., pre-post; pre-post + follow-up). It is therefore difficult to evaluate the effectiveness of an IS compared to another over a shorter time. Moreover, to assess the efficacy of an IS, these ones need time to embed ⁵⁶. The number of participants in each study is also very variable and can make the generalization or the comparison with other studies impossible. The last limitation we notice is the number of studies selected for each setting. Indeed, the number of studies being relatively low in the mixed setting can lead to a sur/under-estimation of the results. Nevertheless, this work seems to have promising results and it is important that future studies continue to move to mixed setting, to nested IS.

5. Conclusion

Future studies should focus on establishing a prevention program in a given geographical area (e.g., town, county), involving all stakeholders with their respective skills/knowledge, in decision making and in the development of the IS (e.g., parents association, professors, doctors, local representatives, sport association); so that it be the most efficient and best adapted to its environment.

6. References

1. Haute Autorité de Santé. Surpoids et obésité de l'enfant et de l'adolescent—Actualisation des recommandations 2003. *France (english version available)*. 2011.
2. Faucher P, Poitou C. Physiopathologie de l'obésité. *Revue du rhumatisme monographies*. 2016;83(1):6-12.
3. Abarca-Gómez L, Abdeen ZA, Hamid ZA, et al. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128· 9 million children, adolescents, and adults. *The Lancet*. 2017;390(10113):2627-2642.

- 495 4. Matta J, Carette C, Lange CR, Czernichow S. Épidémiologie de l'obésité en France et dans le
496 monde. *La Presse Médicale*. 2018;47(5):434-438.
- 497 5. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness
498 in school-aged children and youth. *International journal of behavioral nutrition and physical*
499 *activity*. 2010;7(1):40.
- 500 6. Organisation Mondiale de la Santé. Recommandations mondiales en matière d'activité physique
501 pour la santé,[En ligne]. 2010.
- 502 7. Duclos M, Duché P, Guezennec C-Y, Richard R, Rivière D, Vidalin H. Position de consensus:
503 activité physique et obésité chez l'enfant et chez l'adulte. *Science & Sports*. 2010;25(4):207-
504 225.
- 505 8. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress,
506 pitfalls, and prospects. *The lancet*. 2012;380(9838):247-257.
- 507 9. Cooper AR, Goodman A, Page AS, et al. Objectively measured physical activity and sedentary
508 time in youth: the International children's accelerometry database (ICAD). *International*
509 *journal of behavioral nutrition and physical activity*. 2015;12(1):113.
- 510 10. Ekelund U, Luan Ja, Sherar LB, et al. Moderate to vigorous physical activity and sedentary time
511 and cardiometabolic risk factors in children and adolescents. *Jama*. 2012;307(7):704-712.
- 512 11. Gadais T. Les stratégies d'intervention pour aider les jeunes à gérer leur pratique d'activité
513 physique. Une revue de la littérature. *Staps*. 2015(3):57-77.
- 514 12. Lydecker JA, Cotter E, Gow RW, Kelly NR, Mazzeo SE. Preventing childhood obesity. *Eating*
515 *Disorders and Obesity: A Counselor's Guide to Prevention and Treatment*. 2015:167-199.
- 516 13. Daniels SR, Arnett DK, Eckel RH, et al. Overweight in children and adolescents:
517 pathophysiology, consequences, prevention, and treatment. *Circulation*. 2005;111(15):1999-
518 2012.
- 519 14. Garvey WT. The Diagnosis and Evaluation of Patients with Obesity. *Current Opinion in*
520 *Endocrine and Metabolic Research*. 2018.
- 521 15. Staiano AE, Abraham AA, Calvert SL. Adolescent exergame play for weight loss and
522 psychosocial improvement: a controlled physical activity intervention. *Obesity (Silver Spring)*.
523 2013;21(3):598-601.
- 524 16. Stettler N, Wrotniak BH, Hill DL, et al. Prevention of excess weight gain in paediatric primary
525 care: beverages only or multiple lifestyle factors. The Smart Step Study, a cluster-randomized
526 clinical trial. *Pediatr Obes*. 2015;10(4):267-274.
- 527 17. Most SW, Højgaard B, Teilmann G, et al. Adoption of the children's obesity clinic's treatment
528 (TCOCT) protocol into another Danish pediatric obesity treatment clinic. *BMC pediatrics*.
529 2015;15(1):13.
- 530 18. Walsh AD, Lioret S, Cameron AJ, et al. The effect of an early childhood obesity intervention
531 on father's obesity risk behaviors: the Melbourne InFANT Program. *Int J Behav Nutr Phys Act*.
532 2014;11:18.
- 533 19. Sacchetti R, Ceciliani A, Garulli A, Dallolio L, Beltrami P, Leoni E. Effects of a 2-year school-
534 based intervention of enhanced physical education in the primary school. *J Sch Health*.
535 2013;83(9):639-646.

- 536 20. Santos RG, Durksen A, Rabbanni R, et al. Effectiveness of peer-based healthy living lesson
537 plans on anthropometric measures and physical activity in elementary school students: a cluster
538 randomized trial. *JAMA Pediatr.* 2014;168(4):330-337.
- 539 21. Wright K, Giger JN, Norris K, Suro Z. Impact of a nurse-directed, coordinated school health
540 program to enhance physical activity behaviors and reduce body mass index among minority
541 children: a parallel-group, randomized control trial. *Int J Nurs Stud.* 2013;50(6):727-737.
- 542 22. Kriemler S, Meyer U, Martin E, van Sluijs EM, Andersen LB, Martin BW. Effect of school-
543 based interventions on physical activity and fitness in children and adolescents: a review of
544 reviews and systematic update. *Br J Sports Med.* 2011;45(11):923-930.
- 545 23. Cogérino G. *Apprendre à gérer sa vie physique.* FeniXX; 1999.
- 546 24. Hung L-S, Tidwell DK, Hall ME, Lee ML, Briley CA, Hunt BP. A meta-analysis of school-
547 based obesity prevention programs demonstrates limited efficacy of decreasing childhood
548 obesity. *Nutrition Research.* 2015;35(3):229-240.
- 549 25. Kain J, Concha F, Moreno L, Leyton B. School-based obesity prevention intervention in Chilean
550 children: effective in controlling, but not reducing obesity. *Journal of obesity.* 2014;2014.
- 551 26. Moher D, Shamseer L, Clarke M, et al. Preferred reporting items for systematic review and
552 meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic reviews.* 2015;4(1):1.
- 553 27. Bai Y, Saint-Maurice PF, Welk GJ, Russell DW, Allums-Featherston K, Candelaria N. The
554 Longitudinal Impact of NFL PLAY 60 Programming on Youth Aerobic Capacity and BMI.
555 *American Journal of Preventive Medicine.* 2017;52(3):311-323.
- 556 28. Grao-Cruces A, Ruiz-López R, Moral-García J-E, Ruiz-Ariza A, Martínez-López EJ. Effects of
557 a steps/day programme with evaluation in physical education on body mass index in School
558 Children 11-12 years of age. *Kinesiology.* 2016;48(1):132-141.
- 559 29. Grydeland M, Bjelland M, Anderssen SA, et al. Effects of a 20-month cluster randomised
560 controlled school-based intervention trial on BMI of school-aged boys and girls: the HEIA
561 study. *Br J Sports Med.* 2014;48(9):768-773.
- 562 30. Melnyk BM, Jacobson D, Kelly SA, et al. Twelve-Month Effects of the COPE Healthy
563 Lifestyles TEEN Program on Overweight and Depressive Symptoms in High School
564 Adolescents. *J Sch Health.* 2015;85(12):861-870.
- 565 31. Smith JJ, Morgan PJ, Plotnikoff RC, Stodden DF, Lubans DR. Mediating effects of resistance
566 training skill competency on health-related fitness and physical activity: the ATLAS cluster
567 randomised controlled trial. *J Sports Sci.* 2016;34(8):772-779.
- 568 32. Madsen K, Thompson H, Adkins A, Crawford Y. School-community partnerships: a cluster-
569 randomized trial of an after-school soccer program. *JAMA Pediatr.* 2013;167(4):321-326.
- 570 33. Ning Y, Yang S, Evans RK, et al. Changes in body anthropometry and composition in obese
571 adolescents in a lifestyle intervention program. *Eur J Nutr.* 2014;53(4):1093-1102.
- 572 34. Trost SG, Sundal D, Foster GD, Lent MR, Vojta D. Effects of a pediatric weight management
573 program with and without active video games a randomized trial. *JAMA Pediatr.*
574 2014;168(5):407-413.
- 575 35. Bonsergent E, Agrinier N, Thilly N, et al. Overweight and Obesity Prevention for Adolescents:
576 A Cluster Randomized Controlled Trial in a School Setting. *American Journal of Preventive
577 Medicine.* 2013;44(1):30-39.

578 36. Dubuy V, De Cocker K, De Bourdeaudhuij I, et al. Evaluation of a real world intervention using
579 professional football players to promote a healthy diet and physical activity in children and
580 adolescents from a lower socio-economic background: a controlled pretest-posttest design.
581 *BMC Public Health*. 2014;14:457.

582 37. Elder JP, Crespo NC, Corder K, et al. Childhood obesity prevention and control in city
583 recreation centres and family homes: the MOVE/me Muevo Project. *Pediatr Obes*.
584 2014;9(3):218-231.

585 38. Erfle SE, Gamble A. Effects of daily physical education on physical fitness and weight status
586 in middle school adolescents. *J Sch Health*. 2015;85(1):27-35.

587 39. Foltz SC, Kuder JF, Goldberg JP, et al. Changes in diet and physical activity resulting from the
588 Shape Up Somerville community intervention. *BMC Pediatr*. 2013;13:157.

589 40. Gesell SB, Sommer EC, Lambert EW, et al. Comparative effectiveness of after-school programs
590 to increase physical activity. *J Obes*. 2013;2013:576821.

591 41. Guo H, Zeng X, Zhuang Q, Zheng Y, Chen S. Intervention of childhood and adolescents obesity
592 in Shantou city. *Obes Res Clin Pract*. 2015;9(4):357-364.

593 42. Herbert PC, Lohrmann DK, Seo DC, Stright AD, Kolbe LJ. Effectiveness of the energize
594 elementary school program to improve diet and exercise. *J Sch Health*. 2013;83(11):780-786.

595 43. Johnston CA, Moreno JP, Gallagher MR, et al. Achieving long-term weight maintenance in
596 Mexican-American adolescents with a school-based intervention. *J Adolesc Health*.
597 2013;53(3):335-341.

598 44. Larsen KT, Huang T, Ried-Larsen M, Andersen LB, Heidemann M, Moller NC. A Multi-
599 Component Day-Camp Weight-Loss Program Is Effective in Reducing BMI in Children after
600 One Year: A Randomized Controlled Trial. *PLoS One*. 2016;11(6):e0157182.

601 45. Lau C, Stevens D, Jia J. Effects of an occupation-based obesity prevention program for children
602 at risk. *Occup Ther Health Care*. 2013;27(2):163-175.

603 46. Lubans DR, Smith JJ, Plotnikoff RC, et al. Assessing the sustained impact of a school-based
604 obesity prevention program for adolescent boys: the ATLAS cluster randomized controlled trial.
605 *Int J Behav Nutr Phys Act*. 2016;13:92.

606 47. Madsen KA, Cotterman C, Crawford P, Stevelos J, Archibald A. Effect of the Healthy Schools
607 Program on prevalence of overweight and obesity in California schools, 2006-2012. *Prev*
608 *Chronic Dis*. 2015;12:E77.

609 48. Messiah SE, Diego A, Kardys J, et al. Effect of a park-based after-school program on participant
610 obesity-related health outcomes. *Am J Health Promot*. 2015;29(4):217-225.

611 49. Parra-Medina D, Liang Y, Yin Z, Esparza L, Lopez L. Weight Outcomes of Latino Adults and
612 Children Participating in the Y Living Program, a Family-Focused Lifestyle Intervention, San
613 Antonio, 2012-2013. *Prev Chronic Dis*. 2015;12:E219.

614 50. Safdie M, Jennings-Aburto N, Levesque L, et al. Impact of a school-based intervention program
615 on obesity risk factors in Mexican children. *Salud Publica Mex*. 2013;55 Suppl 3:374-387.

616 51. Siegrist M, Lammel C, Haller B, Christle J, Halle M. Effects of a physical education program
617 on physical activity, fitness, and health in children: the JuvenTUM project. *Scand J Med Sci*
618 *Sports*. 2013;23(3):323-330.

- 619 52. Sigmund E, Sigmundova D. Longitudinal 2-year follow-up on the effect of a non-randomised
620 school-based physical activity intervention on reducing overweight and obesity of Czech
621 children aged 10-12 years. *Int J Environ Res Public Health*. 2013;10(8):3667-3683.
- 622 53. Smith JJ, Morgan PJ, Plotnikoff RC, et al. Smart-phone obesity prevention trial for adolescent
623 boys in low-income communities: the ATLAS RCT. *Pediatrics*. 2014;134(3):e723-731.
- 624 54. Vander Ploeg KA, McGavock J, Maximova K, Veugelers PJ. School-based health promotion
625 and physical activity during and after school hours. *Pediatrics*. 2014;133(2):e371-378.
- 626 55. Wang JJ, Lau WC, Wang HJ, Ma J. Evaluation of a comprehensive intervention with a
627 behavioural modification strategy for childhood obesity prevention: a nonrandomized cluster
628 controlled trial. *BMC Public Health*. 2015;15:1206.
- 629 56. Watson PM, Dugdill L, Pickering K, et al. Service evaluation of the GOALS family-based
630 childhood obesity treatment intervention during the first 3 years of implementation. *BMJ Open*.
631 2015;5(2):e006519.
- 632 57. Tarro L, Llauro E, Albaladejo R, et al. A primary-school-based study to reduce the prevalence
633 of childhood obesity--the EdAl (Educacio en Alimentacio) study: a randomized controlled trial.
634 *Trials*. 2014;15:58.
- 635 58. Tarro L, Llauro E, Moria D, Solà R, Giralt M. Follow-up of a Healthy Lifestyle Education
636 Program (the Educació en Alimentació Study): 2 Years After Cessation of Intervention. *Journal*
637 *of Adolescent Health*. 2014;55(6):782-789.
- 638 59. Brennan L, Walkley J, Wilks R, Fraser SF, Greenway K. Physiological and behavioural
639 outcomes of a randomised controlled trial of a cognitive behavioural lifestyle intervention for
640 overweight and obese adolescents. *Obesity Research & Clinical Practice*. 2013;7(1):e23-e41.
- 641 60. Davis AM, Sampilo M, Gallagher KS, Landrum Y, Malone B. Treating rural pediatric obesity
642 through telemedicine: outcomes from a small randomized controlled trial. *J Pediatr Psychol*.
643 2013;38(9):932-943.
- 644 61. Altman M, Cahill Holland J, Lundeen D, et al. Reduction in food away from home is associated
645 with improved child relative weight and body composition outcomes and this relation is
646 mediated by changes in diet quality. *J Acad Nutr Diet*. 2015;115(9):1400-1407.
- 647 62. Arauz Boudreau AD, Kurowski DS, Gonzalez WI, Dimond MA, Oreskovic NM. Latino
648 families, primary care, and childhood obesity: a randomized controlled trial. *Am J Prev Med*.
649 2013;44(3 Suppl 3):S247-257.
- 650 63. Boodai SA, McColl JH, Reilly JJ. National Adolescent Treatment Trial for Obesity in Kuwait
651 (NATTO): project design and results of a randomised controlled trial of a good practice
652 approach to treatment of adolescent obesity in Kuwait. *Trials*. 2014;15:234.
- 653 64. Endevelt R, Elkayam O, Cohen R, et al. An intensive family intervention clinic for reducing
654 childhood obesity. *J Am Board Fam Med*. 2014;27(3):321-328.
- 655 65. Gerards SM, Dagnelie PC, Gubbels JS, et al. The effectiveness of lifestyle triple P in the
656 Netherlands: a randomized controlled trial. *PLoS One*. 2015;10(4):e0122240.
- 657 66. Luca P, Dettmer E, Khoury M, et al. Adolescents with severe obesity: outcomes of participation
658 in an intensive obesity management programme. *Pediatr Obes*. 2015;10(4):275-282.
- 659 67. Marild S, Gronowitz E, Forsell C, Dahlgren J, Friberg P. A controlled study of lifestyle
660 treatment in primary care for children with obesity. *Pediatr Obes*. 2013;8(3):207-217.

- 661 68. Martín-García M, Alegre Durán LM, García-Cuartero B, Bryant EJ, Gutin B, Royo IA. Effects
662 of a 3-month vigorous physical activity intervention on eating behaviors and body composition
663 in overweight and obese boys and girls. *Journal of Sport and Health Science*. 2017.
- 664 69. Nemet D, Ben-Haim I, Pantanowits M, Eliakim A. Effects of a combined intervention for
665 treating severely obese prepubertal children. *J Pediatr Endocrinol Metab*. 2013;26(1-2):91-96.
- 666 70. Nemet D, Oren S, Pantanowitz M, Eliakim A. Effects of a multidisciplinary childhood obesity
667 treatment intervention on adipocytokines, inflammatory and growth mediators. *Horm Res*
668 *Paediatr*. 2013;79(6):325-332.
- 669 71. Rank M, Wilks DC, Foley L, et al. Health-Related Quality of Life and Physical Activity in
670 Children and Adolescents 2 Years after an Inpatient Weight-Loss Program. *The Journal of*
671 *Pediatrics*. 2014;165(4):732-737.e732.
- 672 72. Serra-Paya N, Ensenyat A, Castro-Vinuales I, et al. Effectiveness of a Multi-Component
673 Intervention for Overweight and Obese Children (Nereu Program): A Randomized Controlled
674 Trial. *PLoS One*. 2015;10(12):e0144502.
- 675 73. Siwik V, Kutob R, Ritenbaugh C, et al. Intervention in overweight children improves body mass
676 index (BMI) and physical activity. *J Am Board Fam Med*. 2013;26(2):126-137.
- 677 74. Staiano AE, Beyl RA, Hsia DS, Katzmarzyk PT, Newton Jr RL. Twelve weeks of dance
678 exergaming in overweight and obese adolescent girls: Transfer effects on physical activity,
679 screen time, and self-efficacy. *Journal of Sport and Health Science*. 2017;6(1):4-10.
- 680 75. Staiano AE, Marker AM, Beyl RA, Hsia DS, Katzmarzyk PT, Newton RL. A randomized
681 controlled trial of dance exergaming for exercise training in overweight and obese adolescent
682 girls. *Pediatr Obes*. 2017;12(2):120-128.
- 683 76. Taveras EM, Marshall R, Kleinman KP, et al. Comparative effectiveness of childhood obesity
684 interventions in pediatric primary care: a cluster-randomized clinical trial. *JAMA Pediatr*.
685 2015;169(6):535-542.
- 686 77. Rito AI, Carvalho MA, Ramos C, Breda J. Program Obesity Zero (POZ)--a community-based
687 intervention to address overweight primary-school children from five Portuguese
688 municipalities. *Public Health Nutr*. 2013;16(6):1043-1051.
- 689 78. Maatoug J, Fredj SB, Msakni Z, et al. Challenges and results of a school-based intervention to
690 manage excess weight among school children in Tunisia 2012-2014. *Int J Adolesc Med Health*.
691 2017;29(2).
- 692 79. Morano M, Rutigliano I, Rago A, Pettoello-Mantovani M, Campanozzi A. A multicomponent,
693 school-initiated obesity intervention to promote healthy lifestyles in children. *Nutrition*.
694 2016;32(10):1075-1080.
- 695 80. Sanders K, Bariield JP, Hodge K, Phillips I, Pino A. Effects of the Get Youth Moving (GYM)
696 Intervention on Health-Related Fitness and Behaviors. *Journal of Park & Recreation*
697 *Administration*. 2014;32(3):106-117.
- 698 81. Kokkvoll A, Grimsgaard S, Steinsbekk S, Flaegstad T, Njolstad I. Health in overweight
699 children: 2-year follow-up of Finnmark Activity School--a randomised trial. *Arch Dis Child*.
700 2015;100(5):441-448.
- 701 82. Rieder J, Khan UI, Heo M, et al. Evaluation of a community-based weight management program
702 for predominantly severely obese, difficult-to-reach, inner-city minority adolescents. *Childhood*
703 *obesity*. 2013;9(4):292-304.

83. Morgan PJ, Collins CE, Plotnikoff RC, et al. The 'Healthy Dads, Healthy Kids' community randomized controlled trial: a community-based healthy lifestyle program for fathers and their children. *Prev Med.* 2014;61:90-99.

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713 **Figure 1. PRISMA Flow Chart**

714

Figure 2. Modelisation of Physical activity IS

Table 1. Illustrations of studies for School / Community IS

Authors, year	Participants, Prevention Type	Material and variables	Program / IS summary	Results summary	Town (country)
Safdie, M. and al. (2013).	RCT, young aged 9 to 11 years old (n: 886) primary/secondary prevention (Impact on obesity risk factors) Collaboration between the Physical education general direction, The National institute of public health, The Federal Administration of Educational Services	Food and beverage availability, food intake PA levels and quality of PE lessons BMI SD	The Basic program: Focused on: Nutrition, physical activity, communication and education. The Plus program: Focused on Nutrition, Physical education, communication and education but with workshop and not just with booklets.	- The availability of recommended foods increased significantly ($p < 0.05$) - ($p = 0.06$) children in basic schools and ($p = 0.03$) in plus schools maintained a status of reaching cut off for steps in school relative to students in the control group - The intervention had no significant effect on the prevalence of overweight and obesity or children's BMI	Mexico City (MEXICO)
Wright, K. and al., (2013).	RCT, Young aged 8-12 years (n: 251) Secondary prevention (BMI > 85 th percentile) Community collaboration and University partnership with school	BMI BMI z-score Health behaviors knowledge	Phase n°1 (KNF© intervention): Focused on youth PA (practice) and nutrition (group sessions with parents) Parents involvement (sessions on obesity consequences and healthy lifestyle) Phase n°2 (« Environmental » Activities): Health care offered to participating children Establishment of a school health advisory council (establishment of health policy, providing newsletter to parents, offer seminar to school staff and parents on health promotion)	-Significant decrease in BMI z-for girls ($p < 0.005$) stays at 4 and 12 months. -Boys and girls fit with the recommendations of 60 min of daily PA ($p = 0.002$ et $P = 0.005$) at 12 months. -Boys and girls increased their attendance to PE classes ($p = 0.003$ et $p = 0.002$) -Boys and girls decrease their TV use at 4 months but it is maintained only by boys at 12 months ($p = 0.03$)	Los Angeles (USA)
Staiano and al., (2013)	RCT, Young aged 15-19 years (n :54) Secondary / tertiary prevention (BMI percentile ≥ 75 th)	Anthropometric BMI z-score Psychosocial variables (e.g. Rosenberg self-esteem scale)	Competitive exergaming 30-60 min of exergaming per school day during 7 months - 1 coordinator -> encourage daily exergaming + ensures the maintenance of the social environment of the classes Goal = Earn more points than his/her opponent Cooperative Exergaming: 30-60 min of exergaming per school day during 7 months - 1 coordinator -> encourage daily exergaming + ensures the maintenance of the social environment of the classes Goal = Earn the most points with his/her partner Control : Usual activities	-Cooperative group lost significantly more weight than control group ($p = 0.021$) -Competitive group did not experiment significant weight variation, compared to others. -Both cooperative and competitive groups experiment a significant increase in "pair support" ($p : 0.010$ and $p = 0.001$ respectively)	Georgetown (USA)

Table 2. Illustrations of studies for Clinical IS

Authors, year	Participants, Prevention Type	Material and variables	Program / IS summary	Results summary	Town (country)
Martín-García, M. and al. (2017)	Young aged 7-16 years old (n: 61) Secondary/Tertiary prevention (BMI > 85 th percentile)	Anthropometric (height, weight, BMI z-score) Body composition (DXA) Eating behaviors PA Intensity and enjoyment Health related quality of life	Focused on recreational PA games (mainly aerobic games, at least 10 min per game) at a high intensity; 75,5% of child's maximal HR (mean 151 ± 13 bpm)	-Significant decrease in whole body fat mass and % Body fat mass for boys (p<0,05 and p<0,001 respectively) -Significant increase in (p=0,003). Lean mass (whole body) -VPA reduce overeating behaviors especially linked to negative mood state (reduction of emotional eating traits)	Madrid (SPAIN)
Noemi Serra- Paya and al. (2015)	Young (B/G) 6-12 years old (n: 113) Secondary/tertiary prevention (BMI > 85 th percentile)	Anthropometric (height, weight, BMI z-score) Dietary habits PA and sedentary time	Supervised PA for the child (3x1h/sem) Practical and theoretical Sessions for parents (1x1H/sem) Weekends of activities offered outside the family (3x) Session on good behavior to adopt	Decrease BMI: -If attendance ratio = 0,547 (P<0,001) -Improve LPA et MVPA (p<0,001) -Improve MVPA by 2.5h/day -Increase MVPA in all the sub-groups of analysis (puberty vs not; Boys vs girls) -Increase fruit consumption (3/day and decrease in sugar sweetened juices/soft drinks).	Leida (SPAIN)
Staiano, A. E. and al. (2017)	Young girls, 14-18 years old (n: 41) Secondary/tertiary prevention (BMI > 85 th percentile)	Anthropometric (height, weight, BMI z-score) Body composition (DXA) Cardiovascular risk factors (Blood sample, blood pressure, resting electrocardiogram)	Supervised ("gaming coaches") dance exergaming sessions with a self-selected intensity, dance partner, game. (60 minutes, 3 x per week for 12 weeks)	-Per protocole analysis (attendance >75%): significant improvement in bone mass density (BMD) for trunk and spine (p=0,03 and p=0,008 respectively) -Per protocole analysis (step per session >2600): significant decrease in leg fat % (p=0,049), Subcutaneous adipose tissue (p=0,02) and total adipose tissue (p=0,03)	Bâton-Rouge (USA)
Marild, S. and al. (2013)	Young, 9-13 years old (n:64) Tertiary prevention (BMI-SD > IOTF-30)	Anthropometric (height, weight, BMI z- score, WHtR) Cardiovascular risk factors (Blood sample) Pubertal stage (Tanner stages)	Nurse-Dietician management treatment (NDT): 8 x 1h nurse visits though 1 year (monitor weight development, reinforce diet messages and try to reduce inactivity) 4 x 1h dietician visits though 1 year (dietary habits) Nurse-Dietician-physiotherapist management treatment (NDPT): 4 x 1h nurse visits though 1 year (monitor weight development and reinforce diet messages) 4 x 1h dietician visits though 1 year (dietary habits) 4 x 1h physiotherapist visits though 1 year (reduce inactivity, change transportation, use pedometer for motivation and diary to register steps, reduce inactivity, stimulate child to participate in PE lessons at school and talk about PA recommendations)	-No significant differences were observed between NDPT and NDT intervention -Significant decrease in BMI for NDPT and NDT (p=0,0007 and p=0,002 respectively) compared to the non-intervention group -Significant decrease in BMI-SD for NDPT and NDT (p=0,0005 and p=0,002 respectively) compared to the non-intervention group	Alingsås, Göteborg, Trollhättan and Skövde (SWEDEN)

Table 3. Illustrations of studies for mixed IS

Authors, year	Participants, Prevention Type	Material and variables	Program / IS summary	Results summary	Town (country)
Morano, M and al. (2016).	Young (B/G) 11,3 ± 0,4 years (n=18) Secondary/tertiary prevention (BMI ≥ 85th percentile; CDC)	BMI SD / percentile Anthropometric Physical fitness (Eurofit, Fitnessgram) Dietary habits PA enjoyment and perceived PA abilities; HRQoL	Exercise training and fun type PA 2x2h/week PA diary review 1x30min/week in group Nutrition counselling sessions 3 time during the 6-month intervention + 1 time at the beginning to give the recommendations Parent monitor their child at the completion of the PA diary	-Significant decrease in BMI variables (e.g BMI z-score p=0,001; BMI percentile p=0,001) and % body fat (p<0,001) -Skinfold thickness reduction (e.g. Biceps, p<0,001; Subscapular p=0,008) except for Triceps skinfold (p=0,363) -Physical performance significantly improves (e.g. 10m sprint, p<0,001) as Perceived PA (p=0,026) and Enjoyment of PA (p=0,035) -Psychosocial health improve significantly (p=0,048) but there is no significant effect on Physical health -Better Dietary habits are showed (e.g. reduction in caloric intake (Kcal/day) p<0,001) -BMI SD decrease pre-post (p<0,001) and after follow up 4-months (P<0,001) -BMI SD decrease pre-post (p<0,001) and after follow up 4-months (P=0,230) in Control Group -Decrease in calories intake (p<0,001) pre-post in CG and IG -No PA drop in IG (p=0,690) contrary to CG (p=0,001)	Parisi-De-Sanctis, Foggia (ITALY)
Maatoug, J. and al. (2015).	Young (B/G) 13.1±0.96 years (n: 317) Secondary/tertiary prevention (BMI SD >1; WHO) Transfer of a clinical strategy to a school-based intervention	BMI SD Anthropometric PA expenditure Dietary intake	2 arms: collective intervention: PA group sessions on -healthy eating -Self-esteem -Snacking PA sessions proposed by teachers Individual intervention: Only Obese meeting on: -self-esteem and depression screening -dietician consultation -causes of obesity -educate and motivate participant on healthy eating and PA habits	-Significant decrease in BMI variables (e.g BMI percentile, CI 95% -2,2 ; -1,3; p<0,001) -No significant effect on dietary variables, except for fibre consumption (p=0,005) -VPA improvement (CI 95% 0,1 ; 0,5 ; p=0,008) Nutrition knowledge and attitude improvement (Knowledge, CI 95% 4,6; 7,1; p<0,001 and attitude CI 95% 0,9; 1,6; p<0,001)	Sousse (TUNISIA)
Rito, A. I. and al. (2013).	Young (B/G) 6-10 years (n: 266) Secondary/tertiary prevention (BMI ≥ 85th percentile; CDC)	BMI percentile Anthropometric PA and sedentary Dietary intake Nutritional and physical activity knowledge, attitudes and behavior	Health center (individual) 4x1h nutrition counselling sessions Family “healthy cooking” workshop 1x3h cooking practice for skills development and knowledge (e.g. food preservation and storage) + POZ recipes book School intervention <i>Child</i> 6h of intervention focusing on healthy eating and PA <i>Parents</i> 3h of intervention focusing on healthy eating an PA (improve knowledge + support their child) + Brochures <i>Teachers</i> “Nutrition and physical activity sheets” given to facilitate additional initiatives in classrooms	-Significant decrease in BMI variables (e.g BMI percentile, CI 95% -2,2 ; -1,3; p<0,001) -No significant effect on dietary variables, except for fibre consumption (p=0,005) -VPA improvement (CI 95% 0,1 ; 0,5 ; p=0,008) Nutrition knowledge and attitude improvement (Knowledge, CI 95% 4,6; 7,1; p<0,001 and attitude CI 95% 0,9; 1,6; p<0,001)	Melgaço, Cascais, Mealhada, Beja and Silves (PORTUGAL)

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Table 4. Results Summary

	School / Community	Clinical	Mixed
Intervention Team	Rarely multi-disciplinary	Widely multidisciplinary	Totally multidisciplinary
Prevention Goal	Primary / secondary (Preventive)	Secondary / Tertiary (Curative)	Secondary / Tertiary (Curative)
Duration	Variable (53% more than a year; 39% less than 6 months)	Short (84% less than a year)	Relatively short (2/3 less than a year)
Material	Reliable	Reliable ++	Reliable +
Efficacy	Anthropometric measurements (72%) and health factors (90%)	Anthropometric measurements (74%) and health factors (83%)	Anthropometric measurements (83%) and health factors (100%)

Table 5. Recommendations for future IS

	Recommendations	Ideas for optimization	
		Clinical	School/community
Team	Multidisciplinary / specialized -Each contributor is specialized in his field, or have the skills / knowledge to intervene (e.g. formation) -IS must be multi-disciplinary and intervene on essential fields (i.e. PA, Nutrition, Psychology)	-Doctor -PA specialist -Psychologist -Dietician	-PE teacher: -Other teachers -School nurses
Prevention objective	Primary/ Secondary/ Tertiary (global prevention) -IS should focus on the whole young population with the possibility to identify young people at risk (material and skills / knowledge) in order to intervene and/or guide as well as possible. -Possibility of further control examination not requiring the personal initiative of young people (examination by medical staff with more objective measuring equipment, to confirm or deny the presence of overweight or obesity).	Individual IS Secondary prevention: -Additional individual consultation with a dietician every 3 months ⁷³ . Tertiary prevention: -start a clinical lose weight management program (after a “ability to change” assessment)	Collective IS Primary prevention: -control consultation with the school nurse every year -availability of free water -availability of fruits and vegetables -posters -flyers Secondary prevention: -courses on obesity -workshops on “how to eat healthy” with a dietician -additional PA classes (new activities or tailored PA) Extensive duration focusing on: -Information -Environment
Duration	-Various -« Daily » integrated primary prevention -« Extended » primary / secondary prevention (≥ 1 year) renewable -« Shorter » tertiary prevention (<6 months) after needs assessment and with a follow-up. In addition to the two other axes mentioned above.	Shorter interventions duration focusing on: -Life habits (enjoyable PA, gradual increase in difficulty, reduce sedentary time) -Nutrition (tailored diet to avoid the feeling of frustration, deprivation) -Psychology (climate free from judgment; behavioral therapy) At least a 3 month follow up (Canadian recommendations)	
Material	-« Classic » measurement, estimated Measures in first resort + possibility of further control if deemed necessary, with objective measurement	Playful ⁴⁷ , cooperative ¹² (if possible), varied theoretical and practical activities ⁶⁷	
		Impedance DXA Blood samples Interview Monitored stress test	BMI BMI for age and sex WtHR WC Questionnaires Field Tests

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APPENDIX A: Key words and Meshterms

Theme 1	Theme 2	Theme 3	Theme 4
Program	Obese	“Physical activity”	Child
Protocol	Obesity	Sport	Childhood
Plan	Overweight		Young
“Intervention strategy”	“Obesity Management”		Youth
method			“Elementary school”
recommendation			Children
Treatment			Adolescence
Prevention			Adolescent
			“under 18”
			Student
			Pediatric

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APPENDIX B: Equations of research

733 (((program[Title/Abstract] OR "intervention strategy"[Title/Abstract] OR
 734 protocol[Title/Abstract] OR method[Title/Abstract] OR plan[Title/Abstract] OR
 735 recommendation[Title/Abstract] OR treatment[Title/Abstract] OR prevention[Title/Abstract]))
 736 AND (obese[Title/Abstract] OR obesity[Title/Abstract] OR overweight[Title/Abstract] OR
 737 "obesity management"[Title/Abstract])) AND ("physical activity"[Title/Abstract] OR
 738 sport[Title/Abstract])) AND (Child[Title/Abstract] OR childhood[Title/Abstract] OR
 739 young[Title/Abstract] OR youth[Title/Abstract] OR "elementary school"[Title/Abstract] OR
 740 children[Title/Abstract] OR adolescent[Title/Abstract] OR adolescence[Title/Abstract] OR
 741 under 18[Title/Abstract] OR student[Title/Abstract] OR pediatric[Title/Abstract]) AND ((
 742 Observational Study[ptyp] OR Multicenter Study[ptyp] OR Clinical Study[ptyp] OR Clinical
 743 Trial[ptyp] OR Comparative Study[ptyp] OR Evaluation Studies[ptyp] OR Government
 744 Publications[ptyp] OR Letter[ptyp] OR Meta-Analysis[ptyp] OR Randomized Controlled
 745 Trial[ptyp] OR Validation Studies[ptyp]) AND full text[sb] AND "last 5 years"[PDat] AND
 746 Humans[Mesh] AND (English[lang] OR French[lang]) AND (child[MeSH:noexp] OR
 747 adolescent[MeSH]))

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