

Treating Obesity in Latino Children: A Systematic Review of Current Interventions

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Abstract: Childhood obesity remains a significant public health issue in the U.S. and globally. Rates are disproportionately higher in Latinos than other ethnic groups. This review provides a qualitative synthesis of the current evidence for childhood obesity treatment interventions among Latino children. A systematic search was performed in PubMed, Web of Science and Google Scholar for articles published from September 2010 to December 2015. Randomized controlled trials treating childhood overweight/obesity in Latino children ages 5-19 focused on diet and/or physical activity (PA) behaviors were included. Of the records initially identified (n=1,592), 11 studies met the inclusion criteria. The majority included a family-based component (n=8; 73%). Nearly half (n=5) focused on children ages 5-12, with three specifically developed for the pre-adolescence stage (ages 8-12). Nine studies acknowledged cultural tailoring, most frequently by seeking input from their intended population and utilizing bilingual delivery staff. Improvements in anthropometric measures (e.g. body mass index (BMI) z-score) were observed in 55% of the studies (n=6). Many interventions with a combined focus of diet and PA, in the form of nutrition education in a group setting and in-person activity/exercise sessions and incorporated a parent/family component reported positive anthropometric results. Three (27%) studies included a follow-up period, all of which observed a sustained decrease in BMI over time. Overall, family-based interventions focusing on both diet and PA demonstrated promising results. However, additional research incorporating a follow-up period is warranted to assess sustainability of these outcomes. Additionally, more interventions could be developed specifically for the critical developmental stage of pre-adolescence.

Keywords: Childhood obesity, body mass index, treatment, Latino, intervention.

INTRODUCTION

While recent data have shown that childhood obesity rates may be stabilizing in certain countries [1, 2] this epidemic still remains a significant public health problem in the United States (U.S.) and globally [3-5]. Prevalence rates have remained high in the U.S. as about one-third of six to 19 year olds are overweight or obese. Other countries across the different continents have observed significant increases in prevalence rates. In particular, Mexico and Brazil have reported some of the highest rates of childhood overweight and obesity, internationally, at rates of up to 37.2% and 34.8%, respectively [6].

In the U.S., rates are disproportionately higher in Latinos as 38.9% of its children are either overweight or obese compared to the overall national prevalence of 31.8% [7]. This increased prevalence poses a greater risk for the development of short- and long-term consequences. Early consequences of childhood obesity include asthma, hypertension, type 2 diabetes mellitus, and diminished quality of life [8, 9]. In addition, childhood obesity has been shown to follow into adulthood and may lead to cardiovascular disease,

cancer, and an increased chance of mortality after the age of 30 years [8, 10-12].

Many Latino children reside in lower income communities, which face multiple barriers to promoting healthy lifestyles and behaviors. For example, such neighborhoods are more likely to be characterized as food 'swamps' (areas with greater availability of energy-dense foods) as small grocery stores (or bodegas) with limited healthy options and fast food establishments have a greater presence [13]. Additionally, outdoor activity can be challenging in these neighborhoods, whether it be due to the limited opportunities to be physically active or the higher crime rates that deter such activity [14-16]. Furthermore, Latino families tend to have cultural perceptions that increase obesity risks, such as perceiving overweight children as healthy and using culturally acceptable parenting strategies, like offering unhealthy foods (e.g. sugary drinks) and television use, as rewards for desired behaviors [17-19].

As one of the fastest growing ethnic minority groups, particularly in the U.S., developing interventions to improve the health of Latino children is vital as such initiatives could impact the overall health of countries. While multiple reviews have been conducted on obesity prevention and treatment in children and adolescents [20-23], this review focuses

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specifically on treatment interventions that have a primary aim of improving weight-related outcomes and obesity-related behaviors in Latino children ages five to 19 years. Limited knowledge exists as to the effectiveness of interventions focused on this at-risk population. Thus, the aim of this paper is to systematically review the current evidence and provide a qualitative synthesis of intervention approaches related to obesity treatment, specifically among Latino children.

METHODS

Eligibility Criteria

Inclusionary and exclusionary criteria have been defined using the relevant PICOS elements [24]. Identified studies included those that used an intervention aimed at treating childhood overweight and/or obesity. Specifically, interventions:

- targeting children and adolescents from five to 19 years with a body mass index (BMI) \geq 85th percentile for age and gender, with at least 50% of the study population being Latino (Population),
- focusing on diet and/or physical activity (PA) (Intervention),
- including a primary anthropometric-related measure (Outcome), and
- utilizing a randomized trial design (Study Design)

were included in our review. As the terms “Hispanic” and “Latino” are often used interchangeably in the literature, articles that used either term were considered. However, for the purpose of this review, we are interested in the Latino population, defined as people of Latin American origin. Thus, this term will be used throughout the paper. Articles were excluded if the target population was not within the five to 19 year age range, the majority of the study population was not Latino, the article did not focus on treatment interventions for childhood overweight and/or obesity, or if the articles were not in English.

Database Sources and Search Terms

A literature search was performed in PubMed, Web of Science and Google Scholar. The search terms were: “youth”, “children”, “adolescents”, “nutrition”, “diet”, “physical activity”, “hispanic”, “latino”, “latina”, “minority”, “obesity”, “overweight”, “BMI”, “inactivity”,

“sedentary”, “intervention”, and “program”. The search was limited to articles published between September 2010 and December 2015 that focused on the treatment of childhood obesity. Thus, the articles had to have a primary focus of weight management or obesity-related behaviors.

Variable Extraction

A data extraction form with all the variables of interest was initially created by the lead author (MML) and then pre-tested by the two reviewers (AED and OBC) responsible for the data extraction stage, using three randomly selected studies from the sample. Agreement among reviews in this pilot testing was discussed to clarify any possible confusion, discrepancy, and to improve subsequent reliability. Variables for the data extraction form were also finalized through this pilot process. At the end of this pilot process, inter-rater agreement was 87%. Data extraction was then performed independently by the two reviewers. Any questions or clarifications were discussed and resolved with the participation of the lead author.

The following variables were extracted from the articles:

Study Characteristics

- a) Study country: information was gathered to document in which country each study was conducted.
- b) Study location: information was gathered about the setting(s) where each study was conducted.
- c) Sample size: the size of the population recruited for each study was collected, as documented at baseline.

Study Participants

Extensive information about the targeted audience of each study was collected, which included age, gender, socioeconomic status (SES), weight status, and ethnicity of recruited participants. Additionally, percentage of the study population that was Latino was specifically recorded.

Intervention Characteristics

- a) Intervention focus: information on whether the intervention focused on the child, family and/or other population groups was gathered.

- b) Theoretical framework: the theory or approach that was used to design the intervention was documented, if available.
- c) Intervention and follow-up duration: duration of each intervention and of its follow-up, if relevant, was recorded.
- d) Intervention components: the different components (education, counseling, and activities) that comprised each intervention were documented in the areas of diet, PA, sedentary behavior (SB), and health and wellness.
- e) Intervention delivery: for every intervention, the person(s), such as a dietitian, health educator, or volunteer, designated to deliver the program was recorded. Additionally, the chosen delivery mode, either face to face and/or via technology was also collected.

Study Outcomes

- a) Child anthropometric measures which included weight, BMI, BMI z-score, waist circumference, body fat percentage, and/or skinfold were documented.
- b) Child behavioral and related psycho-social measures associated with diet, PA, and SB were also gathered.
- c) Any parental/family measures that were collected were also documented.

Health Equity

Information related to ways in which health equity, such as SES, was addressed in the different interventions was collected.

Statistical Analysis

Descriptive analyses were performed to report means for the continuous variables and frequency analysis for the categorical variables. All statistical data analyses were performed using Excel 14.5.0.

RESULTS

A total of 1,592 records were identified through the initial search process. Upon review of the abstracts, 61 articles were retrieved for further review by two investigators. Of those 61 articles, 10 met the inclusion criteria. Two additional articles were identified from the reference lists of the initial 10, which resulted in 12

articles. While a total of 12 articles were found, upon further review, it was determined that two of them presented findings from the same study [25, 26]. For analysis and interpretation purposes, these two articles have been combined into a single study, thus a final total of 11 studies were analyzed and will be referred to in the Results and Discussion sections. Figure 1 outlines the flow of the search process using the PRISMA guidelines [27] and the number of articles/studies that were identified at each stage of the process.

Study Characteristics

- a) *Study country:* 10 (91%) of the studies were conducted in the U.S., while one (9%) was based in Mexico [28].
- b) *Study location:* The studies reviewed were conducted in different settings: five [28-32] out of 11 (45%) took place in clinics or health centers that were primarily based in the community, two [25, 26, 33] (18%) interventions were conducted in a school setting, one [34] (9%) at a research site, one [35] (9%) in multiple sites including a community-based clinic and recreation center, and two [36, 37] (18%) studies did not report or had limited details about their intervention setting.
- c) *Study Sample size:* Seven [25, 26, 28, 31, 33, 34, 36, 37] (64%) studies had a sample population of only children while the remaining [29, 30, 32, 35] (n=4, 36%) included parents or families, as well.

Study Participants

Of the child participants, almost half of the studies [25, 26, 29, 30, 32, 35] (n=5, 46%) focused on children age five to 12 years, three [34, 36, 37] (27%) studies targeted adolescents (defined as being between 12 and 18 years) and three [28, 31, 33] (27%) studies had a mixed age population ranging from two to 19 years. Three studies [25, 26, 30, 35] (27%) focused specifically on the pre-adolescence stage of eight to 12 years. As per the inclusionary criteria, study participants of all the reviewed interventions comprised at least 50% Latino youth; the average percentage of Latino participants across all interventions was 96% and nine [25, 26, 28, 30-32, 34-36] (82%) studies recruited a population that was 100% Latino. In eight [25,26,29,30,32-35,37] (73%) of the studies,

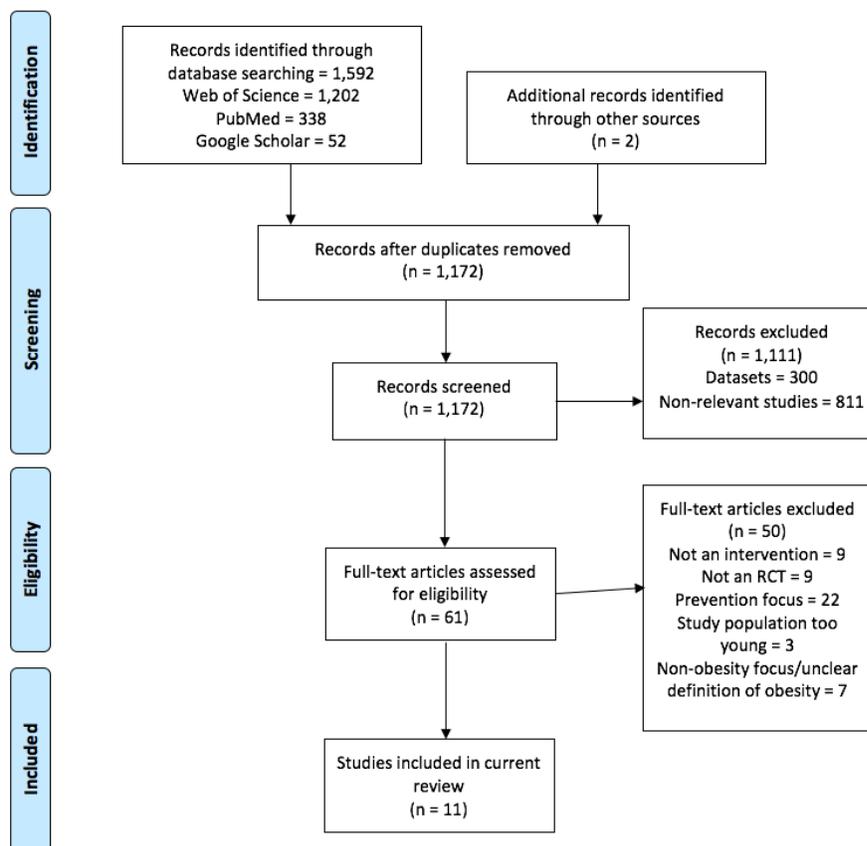


Figure 1: A PRISMA diagram detailing the review process.

inclusionary criteria consisted of participants with a BMI at the 85th percentile or higher, while the remaining studies [28, 31, 36] (n=3, 27%), participant BMI was at the 95th percentile or higher.

Intervention Characteristics

- a) *Intervention focus:* The majority of the reviewed interventions (n=8, 73%) targeted both children and their parents/families [28-33, 35, 37], whereas only two (18%) focused on the child alone [34, 36] and one [25, 26] (9%) was most comprehensive by targeting not only the children and family, but also the social and environmental level.
- b) *Theoretical Framework:* Nine [25, 26, 28-32, 34, 35, 37] (82%) of the assessed studies reported having a specific theoretical framework and/or an approach that guided the intervention. Out of these nine studies, three [32, 35, 37] (33%) used elements of the Transtheoretical Model, four [28, 29, 31, 37] (44%) used other behavioral theoretical models such as the Social Cognitive Theory and Health Belief Model. Additional models and approaches were used as well (n=3, 33%), including the ESFT model (Emphasizes cultural sensitivity and relationship building to reveal patients' Explanatory model, Social barriers, Fears and understanding of Treatment) [30], motivational interviewing (MI) [34], or a community-based participatory approach [25, 26].
- c) *Intervention tailoring:* Nine [25, 26, 28-33, 35, 37] out of the 11 (82%) studies reported tailoring of their interventions to be culturally appropriate for the intended population. The most common approaches to tailoring included bi-lingual and/or native staff who delivered the interventions (n=5, 56%) [25, 26, 29, 32, 33, 35], input from the intended population during intervention development (n=3, 33%) [25, 26, 35, 37], and incorporation of cultural foods and recipes into intervention sessions (n=3, 33%) [28, 32, 33].
- d) *Intervention and follow-up duration:* Two [25, 26, 32] out of the 11 (18%) interventions reviewed lasted less than 12 weeks, three [31, 34, 36] (27%) lasted between three and six months, four

[29, 30, 33, 35] (36%) lasted between six and 12 months, and two [28, 37] (18%) extended beyond a 12-month period. The majority of the studies [28-30, 32, 34-37] (n=8, 73%) did not have a follow-up period after the intervention ended, while one [25, 26] (9%) study had a follow-up period of two months and two [31, 33] (18%) studies included a follow-up time of 18 months or more.

- e) *Intervention components:* The interventions addressed childhood obesity through the following topics: diet, PA, SB, and health/wellness. Ten [25, 26, 28, 30-37] (91%) studies addressed PA in their interventions, eight [25, 26, 28, 30-33, 36, 37] (73%) addressed diet, four [28, 30, 32, 37] (36%) included SB, and three [30, 32, 36] (27%) interventions addressed the topic of health/wellness. Most studies addressed more than one topic in their intervention. Six [25, 26, 28, 31, 33, 36, 37] (55%) interventions focused on two or three topics (predominantly comprising of diet, PA, and/or SB). Two [30, 32] out of the 11 studies (18%) addressed all four topics of diet, PA, SB, and health/wellness. Three [29, 34, 35] (27%) studies focused on only one topic. Specifically, two [34, 35] focused on PA and one intervention [29] offered participants the choice to select one topic/behavior to focus on.

Of all the ten interventions focusing on PA, five [25, 26, 30, 33-35] (50%) used in-person activities ranging between five to 32 sessions, while seven [25, 26, 28, 30-32, 36, 37] (70%) addressed the topic through education and one [35] incorporated counseling in the form of behavior modification as well. All of the studies that targeted diet as a topic (n=8) used education sessions to convey their messages, which ranged between six to 51 sessions. Majority of the education sessions were conducted in a group setting, while one [37] was web-based. Additionally, three [28, 31, 37] (37.5%) utilized counseling, and one [25, 26] (12.5%) included school wellness activities. Out of the interventions that targeted SB, all (n=4) used education sessions. Finally, all the studies that focused on health and wellness (n=3, 27%), implemented educational sessions while one [30] utilized counseling and another one [36] incorporated a guided imagery activity.

- f) *Intervention delivery:* All reviewed interventions had a face-to-face component (n=11), and one

[37] (9%) also included delivery through technology via computer and text messaging. Most of the interventions (n=8, 73%) were delivered by a multidisciplinary team, which included such staff as health paraprofessionals (*promotoras*), primary healthcare/allied health professionals (predominantly physicians and nurses), PA specialists (e.g. personal trainer), and dietitians. The remaining three (27%) interventions were delivered exclusively by either allied health professionals [29, 37] (n=2) or a dietitian (n=1) [31].

Study Outcomes

- a) *Anthropometric measures:* All reviewed interventions assessed anthropometric outcomes in different combinations. Specifically, all the studies measured BMI and/or a derivative, such as BMI z-score or BMI percentile. Half of the studies [25, 26, 28, 34, 36, 37] (n=5, 45%) measured waist circumference and body fat percentage and only two [28, 34] (10%) measured weight as an outcome. Six out of the 11 [25, 26, 28, 31-34] (55%) studies reported positive anthropometric results, such as decreases in BMI z-score and/or waist circumference. Four out of the five [25, 26, 31, 32, 34] shorter interventions (defined as less than six months) (80%) reported significant anthropometric findings compared to two out of the six [28, 33] (33%) longer ones (defined as six months or more), respectively. When comparing intervention focus, four out of eight [28, 31-33] (50%) family-focused interventions reported significant anthropometric findings compared to one out of the two [34] (50%) that only focused on the child. Overall, interventions that demonstrated favorable anthropometric results addressed diet and PA, in the form of nutrition education in a group setting and in-person activity/exercise sessions, and also incorporated a parent/family component.
- b) *Behavioral and related psycho-social measures:* Seven [25, 26, 29-31, 34, 36, 37] (64%) studies measured diet as an outcome. Of these studies, all measured dietary intake, in various forms, while psychosocial outcomes were also measured in two of the studies [25, 26, 36]. Among the studies that had diet as an outcome, the tools used to measure intake included 24-hour dietary recall (n=2, 25%) [29, 31], three-day

diet record (n=2, 25%) [34, 36], food frequency questionnaire (FFQ) (n=2, 25%) [31, 37] and a survey (n=2, 25%) [25, 26, 30].

All of the six [25, 26, 29, 30, 34, 36, 37] (55%) studies that measured PA assessed moderate to vigorous physical activity (MVPA), one [34] also measured fitness and strength as an outcome. The tools that were used to collect the MVPA data included the accelerometer (n=3, 50%) [29, 30, 34] and different types of self-reported tools (three-day recall, seven-day recall, or CATCH SPAN) (n=3, 50%) [25, 26, 36, 37].

Finally, five [25, 26, 29, 34, 36, 37] (45%) studies also measured SB as an outcome, such as screen time and leisure SB (e.g. talking on the phone). Of the studies that measured SB, the majority used a self-reported tool like the three-day activity recall [25, 26, 36, 37] (n=3, 60%), while one utilized parental report on child's habits [29] and another study [34] measured SB with an accelerometer. All of these interventions reported significant decreases in SB.

c) *Parental/Family Measures*: Four out of the 11 studies [25, 26, 29, 32, 35] (36%) collected measures at the parental/family level. Of these measures, two studies [32, 35] collected parental BMI or weight, while two others [25, 26, 29] measured parenting practices or engagement. While the studies that collected parental weight or BMI reported no significant findings, the two that assessed practices or engagement did. O'Connor *et al.* (2013) [29] measured effective (responsiveness, structure, and non-directive control) and ineffective (external control) parenting practices to promote fruit and vegetable intake and PA practices, such as logistical support and role modeling. As part of their process evaluation, Wright *et al.* [25, 26] captured parental involvement related to the school wellness advisory committee.

Health Equity

Seven [25, 26, 30, 32, 34-37] of the 11 (63.6%) studies addressed health equity in some manner. Specifically, five [25, 26, 30, 32, 36, 37] out of these seven (71.4%) studies targeted low SES children and/or families or had a study population that was primarily of low SES (although it was not specifically stated in the intervention objectives), two [34, 35] (28.6%) targeted health equity by designing the study to reach all SES groups or focused on participants with

limited acculturation. To specifically address the low SES Latino study populations, several of the interventions were culturally tailored, which often included such approaches as bi-lingual or native delivery staff [25, 26, 29, 32, 33, 35] and incorporation of cultural foods and recipes into the sessions [28, 32, 33].

Table 1 summarizes the study design and duration and intervention characteristics noting if tailoring occurred, while Table 2 summarizes the outcome measurements and findings related to anthropometrics, diet, PA, SB, and also parental/family measures for each study.

DISCUSSION

Reviews of childhood obesity interventions among the Latino population have been limited and, to the best of our knowledge, a review, specifically focused on childhood obesity treatment interventions for Latino children, has not been conducted. Results of our systematic review yielded 11 randomized trials, which focused on treating childhood obesity in Latino children.

Intervention Characteristics

One key characteristic of the interventions that emerged from the review was the involvement of the parent/family. Majority of interventions actually targeted the parent/family, in addition to the child. This was not necessarily surprising, as prior reviews have highlighted the success of incorporating parents into both obesity prevention and treatment interventions [38-40]. Of the studies that were reviewed, a few engaged parents separately from the children, such as parent-only education sessions. However, most of the family-focused interventions incorporated parents through family-based education classes and/or counseling sessions. Parents play an important role in developing a home environment that could foster positive dietary behaviors and development of lifelong habits contributing to weight status [41, 42] and the engagement of the family within interventions to promote an overall healthy lifestyle is recommended by the Expert Committee (2007) [43]. Parental encouragement has been shown to be positively correlated with child fruit and vegetable consumption and negatively correlated with child BMI z-score [44]. Furthermore, children whose parents are overweight are more likely to be overweight themselves [45] and are at an increased risk of developing obesity as adults

Table 1: Summary Description of Interventions to Treat Childhood Obesity in Latino Children

Reference	Setting	Theory	Study Duration	Intervention focus	Participants	Intervention
Barkin <i>et al.</i> , 2011 [35]	Community primary care clinic; Community recreation center	Transtheoretical Model	I: 6 months F/U: 0	Child; Parent	N=212 (106 parent-child dyads)	5 PA and behavior modification counseling sessions · Developed with input from Latino children and families · Delivered by bilingual staff
Boudreau <i>et al.</i> , 2013 [30]	Community health center	ESFT model	I: 7.5 months F/U: 0	Child; Family	N= 82 (41 parent-child dyads)	6 interactive healthy lifestyle education sessions; 6 monthly coaching sessions · Coaching sessions modeled on Latino adult diabetes program (ESFT Model)
Davis <i>et al.</i> , 2011 [34]	Research site	Motivational Interviewing (Client-centered counseling approach)	I: 16 weeks F/U: 0	Child	N=45 (child)	32 PA sessions with and without 8 motivational intervention sessions · No cultural tailoring noted
Diaz <i>et al.</i> , 2010 [28]	Primary care clinic	Health Belief Model	I: 12 months F/U: 0	Child; Parent	N=76 (child)	21 2-hour nutrition and PA education sessions; 21 2-hour nutrition counseling sessions; 12 15-minute physician consultations · Informed by the workbook, <i>Programa Cambia</i> · Used Mexican exchange list for meal planning
Falbe <i>et al.</i> , 2015 [32]	Federally-qualified health center	Transtheoretical Model	I: 10 weeks F/U: 0	Child; Family	N=110 (55 parent-child dyads)	5 2-hour healthy lifestyle education sessions · Addressed Latino cultural perceptions/practices and immigration · Included culturally appropriate foods · Focused on family and parenting · Delivered by bilingual, native staff, including <i>promotoras</i>
Johnston <i>et al.</i> , 2013 [33]	School	No detail reported	I: 6 months F/U: 18 months	Child; Parent	N=71 (child)	24 nutrition education sessions; 96 PA sessions · Modified traditional Mexican recipes · Included extended family members · Parental sessions delivered by bilingual staff
Mirza <i>et al.</i> , 2013 [31]	Community clinic	Behavior change tools (e.g., self-monitoring, social reinforcement)	I: 12 weeks F/U: 21 months	Child; Parent	N=113 (child)	12 nutrition education, PA and counseling sessions (for child and parent separately and additionally as a family) · Tailored for Latino culture, but no detail reported

(Table 1). Continued.

Reference	Setting	Theory	Study Duration	Intervention focus	Participants	Intervention
O'Connor <i>et al.</i> , 2013 [29]	Community pediatric clinic	Social Cognitive Theory; Parenting Theory	I: 6 months F/U: 0	Child; Parent	N=80 (40 parent-child dyads)	6 2-hour nutrition counseling sessions with F/U calls every 2 weeks · Delivered by bilingual staff
Patrick <i>et al.</i> , 2013 [37]	No detail reported	Behavioral Determinants Model; Transtheoretical Model	I: 12 months F/U: 0	Child; Parent	N=101 (child)	51 computer-based nutrition and PA education sessions; and weekly 'check-in' emails, monthly group counseling sessions, or text messages 3 times/week reinforcing health messages (dependent on group assignment) · Developed and pretested with input from target population
Weigensberg <i>et al.</i> , 2014 [36]	No detail reported	No detail reported	I: 12 weeks F/U: 0	Child	N=35 (child)	12 healthy lifestyle education sessions; 12 interactive guided imagery classes · No cultural tailoring noted
Wright <i>et al.</i> , 2012 & 2013 [25, 26]	School	Community-academic partnered participatory research	I: 6 weeks F/U: 2.5 months	Child; Parent	N=305 (child)	6 90-minute healthy lifestyle education sessions; School Wellness Policy; partnerships with community health clinics · Developed with CPPR approach (community advisory board advised on all phases of research) · Delivered by bilingual and bicultural <i>promotoras</i>

CPPR: community-academic partnered participatory research; ESFT: Emphasizes cultural sensitivity and relationship building to reveal patients' Explanatory model, Social barriers, Fears and understanding of Treatment; F/U: follow-up period after end of intervention; I: intervention; PA: physical activity.

Table 2: Summary of Anthropometric and Diet, Physical Activity and Sedentary Behavioral Outcome Measures and Findings for Child and Parent^{a,b}

Reference	Child Measures				Parental/Family	Health Equity	Study Limitations
	Anthropometric	Diet	PA	Sedentary Behavior			
Barkin <i>et al.</i> , 2011 [35]	BMI: NS	N/A	N/A	N/A	Parent BMI: NS	Target population Latinos with limited acculturation	Limited by measures; High attrition or loss to follow-up
Boudreau <i>et al.</i> , 2013 [30]	BMI z-score: NS	N/A	MVPA: NS	N/A	N/A	Target population low-income Latino community	Small sample size; Homogenous or specific sample
Davis <i>et al.</i> , 2011 [34]	BMI: NS WC: ↓ AT: ↓	N/A	Fitness: ↑ Strength: ↑	N/A	N/A	Target population adolescents and families of all income levels	Small sample size; Homogenous or specific sample

(Table 2). Continued.

Reference	Child Measures				Parental/Family	Health Equity	Study Limitations
	Anthropometric	Diet	PA	Sedentary Behavior			
Diaz <i>et al.</i> , 2010 [28]	BMI: ↓ BMI z-score: ↓ WC: ↓ BF (kg): ↓ % BF: NS	N/A	N/A	N/A	N/A	N/A	High attrition or loss to follow-up
Falbe <i>et al.</i> , 2015 [32]	BMI: ↓ BMI z-score: ↓	N/A	N/A	N/A	Weight: NS	Target population low-income Latino families	Homogenous or specific sample; Missing data; Long-term impact unknown
Johnston <i>et al.</i> , 2013 [33]	BMI z-score: -24-mth F/U: ↓	N/A	N/A	N/A	N/A	N/A	Limited by measures
Mirza <i>et al.</i> , 2013 [31]	BMI z-score: ↓ -24-mth F/U: ↓	GL per kcals: ↓ -24-mth F/U: NS Energy: NS -24-mth F/U: NS % kcals from fat: ↓ -24-mth F/U: NS	N/A	N/A	N/A	Study population Latino children and adolescents	No control group; Limited by measures
O'Connor <i>et al.</i> , 2013 [29]	BMI z-score: NS	Energy: NS F/V servings: NS Sugary drink: NS Water: NS	MVPA: NS	TV viewing: ↓	Parenting practices re: (1) F/V control and (2) PA logistical support: ↑	N/A	Small pilot study; Homogenous or specific sample; Non-blinded data collection
Patrick <i>et al.</i> , 2013 [37]	BMI z-score: NS BMI %-ile: NS % BF: NS	% kcals from fat: NS F/V servings: NS	MVPA: NS	Sedentary activity: ↓	N/A	Target population primarily low-income and ethnically diverse	Small pilot study; Homogenous or specific sample; Self-reported data; High attrition or loss to follow-up
Weigensberg <i>et al.</i> , 2014 [36]	BMI: NS BMI z-score: NS % BF: NS WC: NS	Energy: ↓ CHO: NS FAT: NS PRO: NS Total sugars: NS Total fiber: NS	Moderate PA: ↑ MVPA: NS Vigorous PA: NS	Sedentary activity: ↓	N/A	Target population Latina adolescents	Small pilot study; No control group; Homogenous or specific sample; Self-reported data; Short duration

(Table 2). Continued.

Reference	Child Measures				Parental/Family	Health Equity	Study Limitations
	Anthropometric	Diet	PA	Sedentary Behavior			
Wright <i>et al.</i> , 2012 & 2013 [25, 26]	BMI: ↓ -12-mth F/U: ↓ BMI z-score: ↓ - 12-mth: ↓ WC: ↓ - 12-mth: NS	For 12-mth F/U: Vegetables: ↑ F/V and 100% fruit juice: ↑ French fries/chips: NS Sweets: NS	For 12-mth F/U Daily PA: ↑ Daily PE class attendance: ↑ Team sports participation: NS	TV viewing: ↓ (for males only) Computer/video game use: NS	Parent involvement in Health Advisory Committee: ↑	Target population urban, low-income children	Homogenous or specific sample; Convenience sampling; Limited by measures; High attrition or loss to follow-up; Long-term impact unknown

AT: adipose tissue; BF: body fat; BMI: body mass index, CHO: carbohydrates; GL: Glycemic Load; kcals: kilocalories; F/V: fruits and vegetables; F/U: follow-up period after end of intervention; MVPA: moderate to vigorous physical activity; PA: physical activity; PRO: protein; WC: waist circumference; SES: socioeconomic status; %BF: body fat percentage; %-ile: percentile.

^aAnthropometric, diet, PA, and SB are all child measures.

^bOutcome Results: ↑= increase significantly, ↓= decrease significantly, NS = non-significant increase or decrease (between intervention and control group at end of intervention, unless otherwise noted).

[11]. Thus, addressing childhood obesity requires engaging the family, in addition to the child. Family-based approaches have been successful in supporting healthy eating and PA in children [46, 47]. Additionally, such approaches may be particularly relevant to Latino communities, given the Latino cultural value of *familismo*, which is valuing the family as central to behaviors and decisions [48].

While the focus of most interventions included both parents and children, data were mainly collected on the children. However, four studies [25, 26, 29, 32, 35] did collect parental measures, which included BMI, weight, and parenting practices or engagement level during the intervention. Recent recommendations [49] related to evidence-based childhood obesity treatment suggest the incorporation of family-level metrics, such as parent/caregiver and sibling weight changes during the intervention, in addition to family readiness and retention, to properly monitor treatment process/success and assess systemic impact.

Intervention Tailoring

To enhance potential effectiveness, it is important that health behavioral interventions are responsive to the cultural practices and values of the intended population. The majority of studies did tailor their interventions, often using bi-lingual intervention delivery staff and incorporating cultural foods and recipes into the curriculum. In addition to using such approaches, the Falbe *et al.* (2015) intervention [32] expanded its

tailoring to specifically focus on obesogenic behaviors for which Latino youth are at greater risk, which included sugary drink consumption and screen time. Furthermore, this intervention was designed with a focus on the family and addressed distinct cultural perceptions and practices, such as perceiving overweight youth as healthy and using food as a reward. Additionally, a module on immigration was included. This intervention's tailoring was informed by interviews and focus groups with Latino parents and field visits to local food markets, conducted by the researchers [32].

Two of the studies that observed significant anthropometric changes [25, 26, 32] also included *promotoras* (health paraprofessionals) as part of their intervention delivery team. In these studies, the *promotoras* were responsible for helping to engage the families and deliver health education sessions. A growing body of evidence supports the implementation of *promotora*-delivered interventions in health-related programs as a culturally and linguistically appropriate strategy [50]. Also known as community health workers, they are trusted, trained, and respected members of the community, who provide informal community-based health-related services such as health education, referral and follow up, basic preventive health care, and home visiting services [51]. *Promotoras* can create vital links between health care professionals in local public health departments and people in hard to reach communities.

Intervention Components

The reviewed interventions focused on various health behaviors, which included diet, PA, SB, and overall health/wellness. Of the interventions that observed anthropometric improvements, all but one incorporated in-person PA/exercise activities and nutrition education sessions, conducted in a group setting. As childhood obesity is a complex epidemic with multiple influences, it is not surprising that multi-component interventions addressing multiple behaviors appear to be more successful, which has also been reported in prior reviews [38, 40]. Several of the interventions reviewed also included a counseling component, in the form of MI (a client-centered approach), which was conducted by trained research staff [34], or in the form of consultations with a physician, registered dietitian [28], or interventionist [31]. While the consultation approaches in the Diaz *et al.* [28] and Mirza *et al.* [31] interventions were not specified, the MI approach utilized in the Davis *et al.* study [34] is a well-accepted counseling strategy recommended for childhood obesity treatment [43]. The technique uses nonjudgmental questions and reflective listening to better understand the beliefs and values of the participant. Through this process, the counselor is able to encourage motivation, thus allowing the participant to play a key role in developing a care plan aligned with their own values and stage of readiness [52].

In addition to incorporating various approaches to address multiple behaviors, recent reviews and recommendations have highlighted the value of incorporating multiple settings, including the community, into interventions [40, 49] as this could improve an intervention's sustainability. Of the studies from the current review, one [25, 26] had utilized a more comprehensive, multi-sectoral approach. Wright *et al.* incorporated school and community-level components, along with engaging the child and parents [25, 26]. In this intervention, a School Wellness Policy was implemented, which involved dietary changes in the school and professional development related to health for staff. Additionally, at the community-level, partnerships were established with local clinics to provide health and mental health services. Such comprehensive initiatives, particularly focused on treatment of childhood obesity, is a relatively new but expanding area [53, 54], which could help promote the adoption of sustainable healthy behaviors in this at-risk population.

Study Outcomes

Anthropometric

All studies did collect objective anthropometric measures. Specifically, the main anthropometric outcomes included BMI and/or a derivative, followed by waist circumference, and percent body fat. One of the major challenges of making comparisons and conclusions regarding the effectiveness of such interventions is the lack of consensus for what is considered to be the most appropriate, reliable and valid assessment of childhood obesity, which has resulted in the variation of measures across studies [55]. A systematic review by Bryant *et al.* [55] concluded that BMI (or a derivative of BMI) and dual-energy X-ray absorptiometry (DXA) were the most recommended primary outcome measures. While there are limitations to BMI, as it does not provide information related to fat distribution or body composition, such a measurement is considered feasible to conduct, particularly in a community-based setting, while also limiting the burden of the participants. On the other hand, DXA provides detailed information related to fat distribution and other critical data; however, the equipment is costly, participant burden is an issue, and accessibility in community-based settings is limited. According to the Childhood obesity treatment evaluation Outcomes Review (CoOR) framework [55], it is suggested that ideally, BMI should be measured in combination with DXA, which would allow for comparisons to be conducted between intervention evaluation.

Dietary

Most of the studies collected some form of dietary measures, primarily intake. However, intake was defined in a variety of ways, such as the number of fruit and vegetable servings, energy intake, and dietary fat consumption. Given the complexity of the dietary behaviors that are associated with childhood obesity, it was not surprising to observe that intake was measured in multiple ways as well, ranging from FFQ's to dietary food records and 24-hour recalls. The Bryant *et al.* [55] systematic review concluded that FFQ's were the most recommended dietary assessment tools for childhood obesity treatment interventions, however, the validity and reliability often differ across such questionnaires based upon the nutrients and foods measured. Thus, this should be closely examined when determining which FFQ may be most appropriate for each study.

One diet-related measure that has not been explored extensively is emotion regulation associated with eating behaviors [56, 57]. Such measures were not collected in the studies reviewed for this paper, aside from one [36] which assessed emotional and physical associations to eating via an Intuitive Eating Scale [58]. Stress and negative emotions increase the risk of obesity, and it has been hypothesized that emotion regulation (defined as strategies to maintain positive affect or improve negative affect) is associated with obesity-related eating behaviors, and thus childhood obesity risk [59]. This presents another potential pathway in the development of obesity. Therefore, future interventions may want to consider addressing this topic and including measures related to emotion and affect associated with food consumption.

Physical Activity

Over half of the reviewed studies measured PA as an outcome, with the most common measure being MVPA. One study [34] also measured fitness, as VO_2 max, and strength as an outcome. Half of the PA measures were collected objectively with the recommended devices of accelerometers and monitors, which further strengthens those study designs. One study [37] did utilize pedometers as a measure. Such a device is not as valid and reliable as other objective tools like accelerometers, however, it has been recommended as a less-expensive measure when feasibility and cost concerns are considered [55]. While objective measures are becoming more common, self-report measures may also be warranted or could be the only option, if only for reasons due to costs. Recalls were most frequently used in the reviewed studies, however, the Physical Activity Questionnaire for Children/Adolescents (PAQ-C/PAQ-A), Youth Risk Behaviour Surveillance Survey (YRBSS), and the Teen Health Survey have been recommended, particularly for tracking child PA over time [60].

It is important to acknowledge that there are several limitations to this study. Similar to other papers, this systematic review is limited by the quantity and quality of the studies that were identified. Additionally, the search included only those studies that were indexed in PubMed, Web of Science, and Google Scholar, thus studies that might not have been published in these scientific databases could have been excluded. Another possible limitation is the use of keywords that may not be sufficient to retrieve all the possible relevant articles. However, a secondary search by reviewing the references of the final articles included in this analysis was conducted. Generalizability to other

countries, where cultural values and dietary and PA patterns may differ, is limited as the majority of the studies were conducted in the U.S.

CONCLUSIONS

Interventions that focused on both diet and PA, while also including a parent/family component, have presented some promising results. Childhood obesity in the Latino population is a complex epidemic with various contributing factors at multiple levels. A combined effort of strategies that address multiple determinants related to diet, PA, and SB across multiple settings, including the school, community, and clinic, appear to be warranted, while also considering the cultural needs and influences of this at-risk population.

Implications for Future Research

Additional research is needed to further explore culturally-appropriate interventions to treat childhood obesity in the Latino population. More comprehensive study designs, which include post-intervention follow-up periods, are suggested to better understand the impact and potential sustainability of different strategies on outcomes measures related to diet, PA, SB, and anthropometry. Data should be collected with parents/families to better understand systemic impact of interventions, which could have implications related to sustainability of behaviors and practices. Furthermore, additional studies should be conducted in the understudied but critical developmental stage of preadolescence. Children at this age are gaining autonomy and developing decision-making skills related to dietary behaviors [42], which highlight the importance of intervening at this critical period [61-63]. Although only one study utilized technology [37], as smartphones and technology use increases in popularity amongst all minority populations, including Latino youth [64], this medium should be further explored as a potentially effective medium to engage with this often hard to reach population. Small sample sizes and high attrition rates and/or lost to follow-up were frequently acknowledged as limitations by authors of the reviewed studies, thus future study designs should take these issues into consideration.

All authors of this article declare they have no conflicts of interest.

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