Obesity prevention and obesogenic behavior interventions in child care: A systematic review

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Abstract

Objective. Review peer-reviewed interventions designed to reduce obesity and improve obesogenic behaviors, including physical activity, diet, and screen time, at child care centers. Interventions components and outcomes, study design, duration, use of behavioral theory, and level of social ecological influence are detailed.

Methods. Article searches were conducted from March 2014, October 2014, March 2015, January 2016 across three databases. Eligible interventions were conducted in child care settings, included 3-to-5-year-old children, included an outcome measure of obesity or obesogenic behavior, and published in English. Study design quality was assessed using Stetler’s Level of Quantitative Evidence.

Results. All unique records were screened (n = 4589); 237 articles were assessed for eligibility. Of these, 97 articles describing 71 interventions met inclusion criteria. Forty-four articles included multi-level interventions. Twenty-nine interventions included an outcome measure of obesity. Forty-one interventions included physical activity. Forty-five included diet. Eight included screen time. Fifty-five percent of interventions were Level II (randomized controlled trials), while 37% were Level III (quasi-experimental or pre-post only study design), and 8% were Level IV (non-experimental or natural experiments). Most interventions had the intended effect on the target: obesity 48% (n = 14), physical activity 73% (n = 30), diet 87% (n = 39), and screen time 63% (n = 5).

Conclusion. Summarizing intervention strategies and assessing their effectiveness contributes to the existing literature and may provide direction for practitioners and researchers working with young children in child care. Most interventions produced the targeted changes in obesity and obesity-associated behaviors, supporting current and future efforts to collaborate with early-care centers and professionals for obesity prevention.

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Keywords: Obesity, Day care, Preschool, Young children, Screen time, Physical activity, Diet

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Abbreviations: RCT, Randomized controlled trial; HBM, Health belief model; CMT, Competence motivational theory; SEM, Social Ecological Model; SCT, Social Cognitive Theory; F/V, Fruits and vegetables; [I], Intervention; [C], Control; N/C, No change; MVPA, Moderate-to-vigorous physical activity; SES, Socio-economic status; CCC, Child care center; OR, Odds ratio; 95% CI, 95% confidence interval; CACFP, Child and Adult Care Food Program; LDC, Long day care.

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1. Introduction

In the U.S., 23% of 2-to-5-year-old children are overweight or obese (Ogden et al., 2014). Although the prevalence of obesity appears to have reached a plateau and may be on a decline (Ogden et al., 2014), the early development of excess adiposity (hereafter, obesity) is associated with a high likelihood of overweight classification tracking as a child grows throughout childhood, adolescence, and into adulthood (Singh et al., 2008; Freedman et al., 2005). Moreover, childhood overweight and obesity are associated with elevated disease risk factors, such as high blood pressure and cholesterol (Messiah et al., 2014; Lambert et al., 2008), which persist into adulthood (Janssen et al., 2005). In 2012, five million 3-to-5-year-old U.S. children received regular care in a child care center, Head Start program, preschool, prekindergarten, or other early childhood program (Mamedova and Redford, 2013). These programs provide an ideal environment for obesity prevention interventions (Story et al., 2006). Furthermore, recent national organizations have addressed the importance of obesity prevention in the early childhood environment (Hoelscher et al., 2013; Move! LS, 2014; American Association of Pediatrics, American Public Health Association, National Resources Center for Health and Safety in Child Care and Early Education, 2012; Larson et al., 2011a; Buscemi et al., 2015; Physical Activity Guidelines for Americans Midcourse Report Subcommittee on the President’s Council on Fitness’s, 2012).

Researchers and practitioners need up-to-date and thorough evidence from previous obesity prevention interventions. Building an evidence-base in this growing area will serve as a foundation as investigators develop and tailor interventions in the early childhood setting. Other recent reviews have exclusively examined physical activity (Mehtala et al., 2014; Temple and Robinson, 2014; Ward et al., 2010) or healthy eating (Mikkelsen et al., 2014) interventions in child care centers, with many studies showing healthful results (Mehtala et al., 2014; Temple and Robinson, 2014; Ward et al., 2010). However, due to the complexity of obesity development, a multifaceted approach targeting multiple behaviors and/or levels of influence has been recommended for obesity prevention (Hoelscher et al., 2013; Larson et al., 2011a; Summerbell et al., 2012). Reviews have also examined obesity prevention interventions. However, these reviews targeted children older than age four (Cole et al., 2006; Zenzen and Kridli, 2009; Sharma, 2007), included only randomized controlled trials (Monasta et al., 2010; Kamath et al., 2008), or included only interventions with parental components (Morris et al., 2014). These strategies eliminated interventions using less-rigorous study design and did not examine the preschool age-range of 3–5 years.

Obesity prevention interventions that focused on child care centers and were published before 2010 have also been reviewed (Campbell and Hesketh, 2007; Hesketh and Campbell, 2010; Larson et al., 2011b). Most of these studies included intervention strategies at multiple levels of the ecological model; many were effective at eliciting behavior change, yet less successful at improving weight status (Campbell and Hesketh, 2007; Hesketh and Campbell, 2010; Larson et al., 2011b). However, given the interest in early obesity prevention and the growing accessibility of commercially available curriculums and interventions for this population, an update is warranted.

Given the exponential increase in studies addressing this population, this systematic review is needed to update the literature and provide a resource for those who are interested in improving child health. The purpose of this review is to determine the effectiveness of obesogenic behavioral interventions (physical activity, diet, screen time) at child care centers serving preschool-age children across social ecological levels (environment, parent/family, child), and to understand the inclusion of behavioral theory in intervention development. We also aim to describe the strategies used in weight and obesogenic behavioral interventions, and provide a resource to investigators seeking to advance this body of literature and improve the health of young children.

1.1. Objectives

We examined published data to:

- Identify interventions that target obesogenic behaviors in child care centers;
- Examine the duration, use of behavioral theory, and intervention targets, including the child care environment, teacher, parents, and children;
- Describe the intervention strategies and their effectiveness.

2. Methods

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). We used Stetler’s Level of Quantitative Evidence to assess the quality of the studies, based on study the design that met inclusion criteria (Stetler et al., 1998). We operationally defined “child care center” as “facilities that provide care to children during the daytime hours, typically for the duration of the work day.” These facilities may include preschools and programs focused on lower income children, such as Head Start. All facilities, regardless of for-profit/non-profit status or private or public operation, were included.

2.1. Search strategy

We searched PubMed, PsychInfo, and Ovid using combinations of specific search terms shown in Fig. 1. Searches were conducted March through October 2014, and were repeated in March–April 2015, and January 2016. Manual searches of personal records were also conducted, along with screening of previous review articles and reference lists of identified articles. Papers published up to January 2016 were included.

2.2. Inclusion and exclusion criteria

To optimize retrieval of studies that could include relevant factors, systematic review criteria were not wholly applied. In order for an article to be considered for inclusion, the intervention met the following criteria: 1) performed in center-based child care settings and included preschool age 3-to-5-year-old children, and 2) influenced body weight and/or obesogenic behaviors, such as diet, physical activity, or screen use. All experimental designs were eligible. Ineligibility criteria included studies conducted in a family child care home or school setting, process or methodological papers detailing an intervention with no subsequent outcomes.
papers, articles that were not published in English, and those that were not peer-reviewed. No authors were contacted to provide additional data.

2.3. Identification and review of relevant studies

Articles were identified by two authors (MK and SS and confirmed by KA). Initial screening was conducted by MK. Two authors (MK and SS) determined whether studies met the inclusion criteria. Of these, 71 distinct interventions described and evaluated in 97 manuscripts met inclusion criteria. The number of manuscripts is larger than the number of interventions due to our inclusion strategy: 1) retaining and including methodological papers to provide the necessary detail on the intervention, if outcomes papers had been published subsequently.

Search Terms:
Child care center OR preschool OR childcare OR daycare OR day care
AND nutrition, diet
AND physical activity
AND obesity, weight
AND obesity prevention

Electronic Databases:
PubMed, PsychInfo, Ovid

Fig. 1. Search strategy.

3. Results and discussion

3.1. Summarizing the articles

Initial searches yielded 4859 unique articles parsed to 97 papers selected for inclusion, representing 71 distinct interventions (Fig. 2). The duration of the interventions ranged from ≤3 weeks to 2 school years (Table 1), and focused on different levels of the Social Ecological Model. Eleven interventions focused exclusively on children. Thirteen interventions focused exclusively on the environment. Most (48 of 71) interventions were multilevel. Forty-two interventions included children, 37 included parents, 19 included teachers, and 31 included the facility environment.

Earlier studies included more dietary outcomes and fewer physical activity and screen time outcomes. Fitzgibbon et al. (Fitzgibbon et al., 2002, 2005, 2006, 2011) published the first intervention to include outcomes for all three obesogenic behaviors, as well as obesity. Of the 71 interventions, 58% (n = 41) included a physical activity outcome measure. 63% (n = 45) included a dietary outcome measure. 11% (n = 8) included a screen time outcome measure, and 11% (n = 29) included a measure of obesity as an outcome. Since many studies included multiple behavioral outcomes, the sum exceeds 100%. The most frequently occurring outcomes measured were physical activity alone (n = 14) and diet alone (n = 18). Six studies included all three obesogenic behaviors as outcomes; five of these also included obesity as an outcome measure. Overall, the quality of the studies was fairly strong. Most interventions (55%; 39 of 71 interventions) were classified as quality Level II (randomized controlled trials). Thirty-seven percent (26 of 71 interventions) were classified as level IV (non-experimental or pre-post study design). The remaining 8% (6 interventions) were classified as level V (non-experimental or natural experiments). Theoretical framework, study quality, and effectiveness by outcome are summarized in Table 2.

3.2. Summarizing the outcome findings

3.2.1. Obesity

Twenty-nine interventions included obesity as an outcome (Fitzgibbon et al., 2002, 2005, 2006, 2011; Adams et al., 2009; Bayer et al., 2009; Bell et al., 2008; de Silva-Sanigorski et al., 2010; Dennison et al., 2004; Eliakim et al., 2007; Reilly et al., 2006; Stratton and Mullan, 2005; de Silva-Sanigorski et al., 2012; Barnett et al., 2014; Jouret et al., 2009; Niederer et al., 2009, 2013; Puder et al., 2011; Zask et al., 2012a, teachers, childcare classroom) and ability to elicit change, and study design. Study findings are reported in the format presented in the manuscript. A desired outcome (positive change in behavior or obesity) or undesirable outcome (no change or unhealthful change in behavior or obesity) was determined. A liberal application of effectiveness was used for interventions in which some of the outcomes were undesirable, while others showed a change in the desired direction. This was determined given the variety in measures to assess each outcome (i.e., weight classification, BMI-z, and waist circumference) as well as the multiple levels of intervention. For example, if physical activity was assessed post intervention using accelerometer and parental reports, but only one of these measures showed a desirable change, the intervention was determined to be effective.

Study quality and design was assessed using Steckler’s Level of Quantitative Evidence (Steckler et al., 1998), which classifies studies based on the type of design, as follows: Level I: systematic review, Level II: randomized controlled trials (RCTs), Level III: quasi-experimental or pre-post only study, Level IV: non-experimental or natural experiments, Level V: case reports, and Level VI: opinions of respected authorities (Steckler et al., 1998). Two authors (MK and SS) independently assessed study quality, and consensus was reached (Supplementary Table 1).
Obesity was determined by a variety of metrics, including BMI, BMI-z score, waist circumference, skin folds, percent body fat, muscle mass, weight status, and waist-to-hip ratio. Almost half (n = 14) of the interventions demonstrated favorable results (Fitzgibbon et al., 2005; de Silva-Sanigorski et al., 2010; Eliakim et al., 2007; Niederer et al., 2013a; De Coen et al., 2012; Herman et al., 2012; Kunkel et al., 2013; Yin et al., 2012; Natale et al., 2014a; Alkon et al., 2014a; Zhou et al., 2014; Bonis et al., 2014; Salazar et al., 2014). Over 2/3 of those interventions deemed effective (71%) at reducing obesity were developed using behavioral theory (n = 10). Nine of the 14 (64%) studies yielding favorable results were Level II quality (RCT), with the remaining studies at Level III (quasi-experimental or pre-post design). A greater number of effective studies utilized behavioral theory and were higher quality study design (Level II) which indicates the desirability of using these design characteristics to develop interventions to influence obesity outcomes.

While 14 interventions were determined to be effective, enthusiasm was mildly tempered for two of these fourteen since success was short-term. Only one (Fitzgibbon et al., 2005) of the three Hip Hop to Health Jr. implementations showed a reduction in obesity, and Tooty Fruity Vegie reached short-term obesity goals that were not sustained at three-year follow-up. However, Cespedes et al. (Cespedes et al., 2013a, 2013b) demonstrated that the intervention was not effective short-term (Cespedes et al., 2013b), at 36-months follow-up (Cespedes et al., 2013a), the prevalence of children classified as normal weight had increased. Interestingly, 17% of overweight children and 12% of

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**PRISMA 2009 Flow Diagram**


For more information, visit [www.prisma-statement.org](http://www.prisma-statement.org).

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2012b; De Bock et al., 2010, 2013; Annesi et al., 2013a; Bellows and Anderson, 2013; Bellows et al., 2013; Bonvin et al., 2013; Cespedes et al., 2013a, 2013b; De Coen et al., 2012; Herman et al., 2012; Krombholz, 2012; Kunkel et al., 2013; Yin et al., 2012; Natale et al., 2014a; Alkon et al., 2014a; Zhou et al., 2014; Bonis et al., 2014; Salazar et al., 2014). Obesity was determined by a variety of metrics, including BMI, BMI-z score, waist circumference, skin folds, percent body fat, muscle mass, weight status, and waist-to-hip ratio. Almost half (n = 14) of the interventions demonstrated favorable results (Fitzgibbon et al., 2005; de Silva-Sanigorski et al., 2010; Eliakim et al., 2007; Niederer et al., 2013a; Puder et al., 2011; Zask et al., 2012a; Annesi et al., 2013a; De Coen et al., 2012; Herman et al., 2012; Kunkel et al., 2013; Yin et al., 2012; Alkon et al., 2014a; Zhou et al., 2014; Salazar et al., 2014). No intervention resulted in an increase in obesity, which would support the benefit of weight maintenance. However, the control sites in those studies did not increase in obesity (Fitzgibbon et al., 2006; Bayer et al., 2009; Dennison et al., 2004; Reilly et al., 2006; De Bock et al., 2013; Bellows et al., 2013; Bonvin et al., 2013; Natale et al., 2014a; Baskale and Bahar, 2011). Over 2/3 of those interventions deemed effective (71%) at reducing obesity were developed using behavioral theory (n = 10). Nine of the 14 (64%) studies yielding favorable results were Level II quality (RCT), with the remaining studies at Level III (quasi-experimental or pre-post design). A greater number of effective studies utilized behavioral theory and were higher quality study design (Level II) which indicates the desirability of using these design characteristics to develop interventions to influence obesity outcomes.

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 targeting children at greater risk, such as those in higher weight categories, interventions to prevent excess weight gain may be most effective when based on school year are grouped into separate categories. (Brown et al., 2009; Hannon and Brown, 2008; Harnack et al., 2012; Hendy, 2002; Joseph et al., 2015; Schwartz et al., 2015).

Based on these studies, it seems that interventions demonstrated greater effectiveness in improving waist circumference, percent fat, and BMI in the overall and high economic groups, yet demonstrated that parent-proxy reported time in activity was initially higher after intervention, but the effects diminished at follow-up 3–12 months later (de Silva-Sanigorski et al., 2010). Interestingly, Cespedes et al. (Cespedes et al., 2013a) showed a parent-reported improvement in children’s physical activity habits at 36-months follow-up, but no change at post-test or 12-month follow-up. Given the three-year delay in demonstration of effectiveness, caution must be used when interpreting these findings.

In sum, obesity was favorably affected in at least half of the reviewed interventions; those focusing on children at greatest risk may demonstrate higher efficacy. Given the contradictions in follow-up effectiveness, booster interventions may be needed to maintain healthy weight trajectories.

3.2.2. Physical activity

Forty-one interventions included at least one measure of physical activity as an outcome; most included multiple physical activity measures (Fitzgibbon et al., 2002, 2005, 2006, 2011; Adams et al., 2009; Bell et al., 2008; de Silva-Sanigorski et al., 2010; Eliakim et al., 2007; Reilly et al., 2006; Stratton and Mullan, 2005; de Silva-Sanigorski et al., 2012; Barnett et al., 2014; Niederer et al., 2009, 2013; Puder et al., 2011; Zask et al., 2012a, 2012b; De Bock et al., 2010, 2013; Annesi et al., 2013a; Bellows and Anderson, 2013; Bellows et al., 2013; Bonvin et al., 2013; Cespedes et al., 2013a, 2013b; De Coen et al., 2012; Herman et al., 2012; Yin et al., 2012; Natale et al., 2014a; Alkon et al., 2014a; Zhou et al., 2014; Bonis et al., 2014; Salazar et al., 2014; Agrawal et al., 2012; Alhassan et al., 2012; Ammerman et al., 2007; Annesi et al., 2013b; Battista et al., 2014; Brown et al., 2009; Bruhn and Parcel, 1982; Cardon et al., 2009; Cespedes et al., 2014; De Marco et al., 2015; Drummond et al., 2009a; Finch et al., 2010, 2014; Hannon and Brown, 2008; Hardy et al., 2010; Jones et al., 2011; Nicaise et al., 2012; Nonas et al., 2014; O’Dwyer et al., 2013; Parcel et al., 1983; Sharma et al., 2011; Stephens et al., 2014; Trost et al., 2008; Ward et al., 2008; Williams et al., 2009; Breck et al., 2014). Of those, 73% (n = 30) elicited a desired change in physical activity outcomes. Measurement techniques and outcomes greatly varied across interventions. This may present challenges in direct comparisons of study effectiveness. Objective measurement using a pedometer or accelerometer (Eliakim et al., 2007; Reilly et al., 2006; Barnett et al., 2014; De Bock et al., 2013; Annesi et al., 2013a; Bellows and Anderson, 2013; Bonvin et al., 2013; Yin et al., 2012; Bonis et al., 2014; Salazar et al., 2014; Alhassan et al., 2012; Annesi et al., 2013b; Cardon et al., 2009; Finch et al., 2010; Hannon and Brown, 2008; Jones et al., 2011; Nonas et al., 2014; O’Dwyer et al., 2013; Trost et al., 2008) was the most frequent outcome measure. However, methods included direct observation (Alkon et al., 2014a; Brown et al., 2009; Cosco et al., 2014; De Marco et al., 2015; Sharma et al., 2011), proxy report of children’s behaviors by parents (de Silva-Sanigorski et al., 2010; Cespedes et al., 2013b; De Coen et al., 2012; Natale et al., 2014a; Williams et al., 2009), heart rate (Stratton and Mullan, 2005; Zhou et al., 2014), cardiorespiratory fitness (Puder et al., 2011), or any combination of these. Differences and rigor in outcome measures may also have precluded the demonstration of an intervention’s effectiveness at changing behavior. Parental report of physical activity behaviors or habits, participation in activities of different intensities, or sports involvement may not be sensitive enough to demonstrate behavior change. Hip Hop to Health Jr. (Fitzgibbon et al., 2005, 2006) used parent reports and did not observe behavior change but did with use of accelerometer (Fitzgibbon et al., 2011). However, the opposite has also been reported (Puder et al., 2011). Romp and Chomp demonstrated that parent-proxy reported time in activity was initially higher after intervention, but the effects diminished at follow-up 3–12 months later (de Silva-Sanigorski et al., 2010). Interestingly, Cespedes et al. (Cespedes et al., 2013a) showed a parent-reported improvement in children’s physical activity habits at 36-months follow-up, but no change at post-test or 12-month follow-up. Given the three-year delay in demonstration of effectiveness, caution must be used when interpreting these findings.

The majority (n = 23) utilized behavior change theory as a foundation, most commonly the Social Ecological Model (n = 10) (Bell et al., 2008; Niederer et al., 2009; Bonvin et al., 2013; De Coen et al., 2012; Natale et al., 2014a; Zhou et al., 2014; Salazar et al., 2014; Drummond et al., 2009a; Finch et al., 2010; O’Dwyer et al., 2013) and Social Cognitive Theory (n = 9) (Fitzgibbon et al., 2002; Annesi et al., 2013a; Cespedes et al., 2013b; Herman et al., 2012; Salazar et al., 2014; Agrawal et al., 2012; Ammerman et al., 2007; Bruhn and Parcel, 1982; Parcel et al., 1983; Sharma et al., 2011). Of those interventions not based on behavioral theory (n = 17), 13 were effective to some degree (Eliakim et al., 2007; Yin et al., 2012; Alkon et al., 2014a; Alhassan et al., 2012; Battista et al., 2014; Brown et al., 2009; Cosco et al., 2014; De Marco et al., 2015; Hannon and Brown, 2008; Jones et al., 2011; Stephens et al., 2014; Trost et al., 2008; Williams et al., 2009). Similarly, 16 of the 23 interventions based on behavioral theory were determined to result in desired physical activity behavior changes (Fitzgibbon et al., 2011; de Silva-Sanigorski et al., 2010; Stratton and Mullan, 2005; Puder et al., 2011; De Bock et al., 2013; Annesi et al., 2013a; Cespedes et al.,

### Table 1

<table>
<thead>
<tr>
<th>Study duration</th>
<th>Number of studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤3 weeks</td>
<td>4</td>
</tr>
<tr>
<td>1–3 months</td>
<td>14</td>
</tr>
<tr>
<td>3–6 months</td>
<td>17</td>
</tr>
<tr>
<td>7–9 months</td>
<td>5</td>
</tr>
<tr>
<td>≥10 months</td>
<td>5</td>
</tr>
<tr>
<td>1 school year</td>
<td>5</td>
</tr>
<tr>
<td>2 school years</td>
<td>5</td>
</tr>
<tr>
<td>Unreported</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
</tr>
</tbody>
</table>

Durations that were reported in weeks were converted into months, by calculating four weeks into one month. Durations that are based on school year are grouped into separate categories. (Brown et al., 2009; Hannon and Brown, 2008; Harnack et al., 2012; Hendy, 2002; Joseph et al., 2015; Schwartz et al., 2015).
## Table 2

Theoretical framework, quality, and effectiveness of child care center interventions addressing physical activity, diet, TV viewing, and adiposity.

<table>
<thead>
<tr>
<th>Name</th>
<th>Theoretical framework</th>
<th>Study Quality (I–VI) (Stetler et al., 1998)</th>
<th>PA</th>
<th>Diet</th>
<th>TVV</th>
<th>Adiposity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bruhn 1982 (Bruhn and Parcel, 1982), Parcel 1983 (Parcel et al., 1983)</td>
<td>SCT</td>
<td>II</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.L. Williams 1998 (Williams et al., 1998), C.L. Williams 2002 (Williams et al., 2002)</td>
<td>SCT</td>
<td>III</td>
<td>*</td>
<td>+/+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Johnson 2000 (Johnson, 2000)</td>
<td></td>
<td>III</td>
<td>*</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollard 2001 (Pollard et al., 2001)</td>
<td>Other</td>
<td>IV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fitzgibbon 2002 (Fitzgibbon et al., 2002), Fitzgibbon 2005 (Fitzgibbon et al., 2005), Fitzgibbon 2006 (Fitzgibbon et al., 2006), Fitzgibbon 2011 (Fitzgibbon et al., 2011)</td>
<td>Other</td>
<td>II</td>
<td>+/-/-</td>
<td>-/+/-</td>
<td>+/-/-</td>
<td>+/-/+</td>
</tr>
<tr>
<td>Hendy 2002 (Hendy, 2002)</td>
<td>SCT</td>
<td>III</td>
<td>*</td>
<td>-</td>
<td></td>
<td></td>
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<tr>
<td>Young 2003 (Young et al., 2003), Young 2004 (Young et al., 2004), Johnson 2007 (Johnson et al., 2007)</td>
<td>SCT</td>
<td>III</td>
<td>*</td>
<td>+/-</td>
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<td>Dennison 2004 (Dennison et al., 2004)</td>
<td>Other</td>
<td>IV</td>
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<tr>
<td>Stratton 2005 (Stratton and Mullan, 2005)</td>
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<td></td>
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<tr>
<td>Mier 2005 (Mier et al., 2005), Pizziak 2012 (Pizziak, 2012)</td>
<td>Other</td>
<td>III</td>
<td>*</td>
<td>+</td>
<td></td>
<td></td>
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<tr>
<td>Dunn 2006 (Dunn et al., 2006), Witt 2012 (Witt and Dunn, 2012)</td>
<td>SCT</td>
<td>II</td>
<td>*</td>
<td>+/+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reilly 2006 (Reilly et al., 2006)</td>
<td>SEM</td>
<td>III</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ammerman 2007 (Ammerman et al., 2007), Benjamin 2007 (Benjamin et al., 2007), Ward 2008 (Ward et al., 2008), Elaiakim 2007 (Elaiakim et al., 2007)</td>
<td>SCT</td>
<td>II</td>
<td></td>
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<tr>
<td>Matwiejczuk 2007 (Matwiejczuk et al., 2007)</td>
<td>Other</td>
<td>IV</td>
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<td>Trost 2008 (Trost et al., 2008)</td>
<td>SEM</td>
<td>I</td>
<td></td>
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<tr>
<td>Hannon 2008 (Hannon and Brown, 2008)</td>
<td>Other</td>
<td>III</td>
<td></td>
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<tr>
<td>Bell 2008 (Bell et al., 2008), de Silva-Sanigorski 2010 (de Silva-Sanigorski et al., 2010), de Silva-Sanigorski 2012 (de Silva-Sanigorski et al., 2012)</td>
<td>Other</td>
<td>III</td>
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Studies are organized by publication date of the first publication regarding the intervention. Quality level of studies assessed using Stetler’s Level of Quantitative Evidence (Stetler et al., 1998).

PA = physical activity; D = diet; TVV = TV viewing; SCT = intervention based on Social Cognitive Theory; SEM = intervention based on Social Ecological Model; Other = intervention based in any other theoretical model; unmarked indicates that no theoretical framework was used.

*, Any desirable change; −, undesirable outcome; *+, not measured; multiple symbols separated by/indicates multiple follow-up time periods. If multiple measures were used to measure a change, the intervention was considered effective (+) if any of the measures reported a desirable change.

2013a; Herman et al., 2012; Zhou et al., 2014; Salazar et al., 2014; Agrawal et al., 2012;ammerman et al., 2007; Annesi et al., 2013b; Bruhn and Parcel, 1982; Cosco et al., 2014; Hannon and Brown, 2008; Parcel et al., 1983; Trost et al., 2008). Struktured physical activity integrated into academic lessons was effective in one intervention (Trost et al., 2008) but not the other (Hartdy et al., 2010). Twenty interventions included parents (Fitzgibbon et al., 2002; Adams et al., 2009; Bell et al., 2008; Reilly et al., 2006; Niederer et al., 2009; De Bock et al., 2010; Annesi et al., 2013a; Bellows et al., 2013; Bonvin et al., 2013; Cespedes et al., 2013b; de Coen et al., 2012; Natale et al., 2014a; Alkon et al., 2014a; Bonis et al., 2014; Salazar et al., 2014; Alhassan et al., 2012; Ammerman et al., 2007; Bruhn and Parcel, 1982; Cosco et al., 2014; Hannon and Brown, 2008; Parcel et al., 1983; Trost et al., 2008). Strukured physical activity integrated into academic lessons was effective in one intervention (Trost et al., 2008) but not the other (Hardy et al., 2010). Twenty interventions included parents (Fitzgibbon et al., 2002; Adams et al., 2009; Bell et al., 2008; Reilly et al., 2006; Niederer et al., 2009; De Bock et al., 2010; Annesi et al., 2013a; Bellows et al., 2013; Bonvin et al., 2013; Cespedes et al., 2013b; de Coen et al., 2012; Natale et al., 2014a; Alkon et al., 2014a; Zhou et al., 2014; Bonis et al., 2014; Salazar et al., 2014; Agrawal et al., 2012; Bruhn and Parcel, 1982; Parcel et al., 1983; Sharma et al., 2011). Those with more comprehensive engagement strategies included interactive homework, family activities, websites, workshops and sessions, and use of a family advocate for outreach (Adams et al., 2009; De Bock et al., 2010; Boniv et al., 2013; Cespedes et al., 2013b; Herman et al., 2012; Zhou et al., 2014; Agrawal et al., 2012; Bruhn and Parcel, 1982; Parcel et al., 1983). More than half (65%; n = 13) of the interventions that included parents were effective. However, 85% of those that did not involve parents were also effective. This should not be interpreted as a rationale to overlook parental involvement in furtue interventions given the complexity of multi-level interventions. Few interventions included staff and teacher training regarding physical activity and physical education (Bell et al., 2008; Herman et al., 2012; Zhou et al., 2014; Salazar et al., 2014; Agrawal et al., 2012; De Marco et al., 2015) or staff personal health and wellness (Yin et al., 2012; Alkon et al., 2014a; Agrawal et al., 2012; Drummond et al., 2009a; Williams et al., 2009). All of the interventions that included staff training demonstrated the desired effects regarding physical activity.

Some interventions incorporated environmental changes that addressed play space (Stratton and Mullan, 2005; Niederer et al., 2009; Bonvin et al., 2013; Zhou et al., 2014; Cardon et al., 2009; Cosco et al., 2014; Hannon and Brown, 2008; Nicaise et al., 2012), practices, and policies (De Coen et al., 2012; Natale et al., 2014a; Alkon et al., 2014a; Bonis et al., 2014; Agrawal et al., 2012; Ammerman et al., 2007; Battista et al., 2014; Drummond et al., 2009a; Finch et al., 2010; Hardy et al., 2010; Nonas et al., 2014). Of the studies that included a child care environment intervention component and aimed to improve the physical activity practices and/or policies, 88% (8 out of 9) elicited a desired change in the center outcome measures. Several were based on the Nutrition and Physical Activity Self-Assessment in Child Care (NAP SAC), which includes the provision of technical assistance to the centers by consultants working to improve policies and practices (Ammerman et al., 2007). Of
the two interventions that did not demonstrate an improvement in physical activity policies, one did not provide technical assistance and only provided suggestions (Hardy et al., 2010), and the other had such high use of best practices that a post-test was not included (Agrawal et al., 2012). These findings demonstrate that the child care center environment can be enhanced, although increasing opportunities for a successful collaboration with the center and provision of technical support are crucial. However, incorporation of these center-level improvements did not translate to sustained increases in child-level physical activity (de Silva-Sanigorski et al., 2010; Alkon et al., 2014a; Finch et al., 2014). Adherence and consistency in the implementation of the physical activity policies and practices in a multi-pronged intervention may be essential for translating the policy change to child-level behavior change. This was demonstrated in the New York City regulation changes regarding obesogenic behaviors (Nonas et al., 2014). Stephens et al. (Stephens et al., 2014) reported that children who attended centers with greater adherence and consistent implementation of the policies had higher accelerometer-determined moderate-to-vigorous physical activity levels.

In summary, the majority of reviewed interventions had a favorable effect on physical activity outcomes. Interventions focusing on the child care center environment and that include structured physical activity during the day, parental engagement, staff training and wellness, and technical support and training, seemed to facilitate positive changes.

Since the translation of practices, policies, and playgrounds into actual increases in child movement was limited, inclusion of structured physical activity curriculums while children are at the center is needed. All five interventions that included addressing child care staff personal health demonstrated desirable outcomes, indicating that this may be a worthwhile component. Most interventions were high quality levels and were based on behavioral theory. Therefore, these characteristics were determined not to influence intervention effectiveness. However, it is worth noting that the Stetler’s Levels of Quantitative Evidence, the method used to classify study design and quality, predominantly assesses study design and that quality of the execution of the intervention and rigor in measurement is likely more important in determining effectiveness.

### 3.2.3. Dietary behaviors

Forty-five interventions included at least one measure of dietary behavior as an outcome; many included multiple dietary measures, which limits direct comparison across studies (Fitzgibbon et al., 2002, 2005, 2006, 2011; Adams et al., 2009; Bayer et al., 2009; Bell et al., 2008; de Silva-Sanigorski et al., 2010, 2012; Barnett et al., 2014; Niederer et al., 2009, 2013; Puder et al., 2011; Sharma et al., 2015; Sigman-Grant et al., 2014). Twenty-nine of the forty-three interventions based on behavioral theory were of the 29 interventions (n = 13) (Fitzgibbon et al., 2002; Cespedes et al., 2013b; Herman et al., 2012; Salazar et al., 2014; Agrawal et al., 2012; Ammerman et al., 2007; Bruhn and Parcel, 1982; Parcel et al., 1983; Sharma et al., 2011; De Bock et al., 2012; Harnack et al., 2012; Niederer et al., 2009; Williams et al., 2014; Bell et al., 2015; Natale et al., 2013, 2014b; Sweitzer et al., 2010). Twenty-nine of the forty-three interventions utilized behavior change theory; most commonly the Social Cognitive Theory (n = 13) (Fitzgibbon et al., 2002; Cespedes et al., 2013b; Herman et al., 2012; Salazar et al., 2014; Agrawal et al., 2012; Ammerman et al., 2007; Bruhn and Parcel, 1982; Parcel et al., 1983; Sharma et al., 2011; De Bock et al., 2012; Harnack et al., 2012; Niederer et al., 2009; Williams et al., 2014; Bell et al., 2015; Natale et al., 2013, 2014b; Sweitzer et al., 2010). Some included measuring intake at both child care centers and at home (Fitzgibbon et al., 2005, 2006, 2011; Salazar et al., 2014; Bruhn and Parcel, 1982; Parcel et al., 1983; Vereecken et al., 2009; Williams et al., 2002). Some examined changes in menus and policies (de Silva-Sanigorski et al., 2010; Alkon et al., 2014a; Zhou et al., 2014; Agrawal et al., 2012; Battista et al., 2014; Drummond et al., 2009a; Hardy et al., 2010; Ward et al., 2008; Miatwiejczyk et al., 2007; Pollard et al., 2001; Williams et al., 2002; Bell et al., 2015; Ritchie et al., 2015), staff or parent behaviors (Cespedes et al., 2013b; Herman et al., 2012; Yin et al., 2012; Agraval et al., 2012; Gripshover and Markman, 2013; Hendy, 2002; Johnson, 2000; Johnson et al., 2007; O’Connell et al., 2012; Joseph et al., 2015; Schwartz et al., 2015; Sigman-Grant et al., 2014). Foods were often categorized into fruits and vegetables, but also included fast food, poor or healthy dietary quality or snack intake, water, milk, and juice (Bayer et al., 2009; Puder et al., 2011; Zask et al., 2012a; Cespedes et al., 2013b; De Coen et al., 2012; Kunkel et al., 2013; Yin et al., 2012; Natale et al., 2014a; Baskale and Bahar, 2011; Bruhn and Parcel, 1982; Hardy et al., 2010; Parcel et al., 1983; Sharma et al., 2011; De Bock et al., 2012; Harnack et al., 2012; Namenek Brouwer and Benjamin Neelon, 2013; Vereecken et al., 2009; Williams et al., 2014; Bell et al., 2015; Natale et al., 2013, 2014b; Sweitzer et al., 2010).
2014; Agrawal et al., 2012; Battista et al., 2014; Drummond et al., 2009a; Sharma et al., 2011; Farfan-Ramirez et al., 2011; Hendy, 2002; Johnson, 2000; Mier et al., 2005; Williams et al., 1998; Young et al., 2003; Bell et al., 2015; Joseph et al., 2015; Natale et al., 2013, 2014b; Schwartz et al., 2015; Sigman-Grant et al., 2014), and three were Level IV (Matwiejczyk et al., 2007; Pollard et al., 2001; Ritchie et al., 2015). Quality of study design does not appear to predict study effectiveness; of the 5 interventions that did not alter dietary outcomes, three were Level II (Cespedes et al., 2013b; De Coen et al., 2012; Bruhn and Parcel, 1982; Parcel et al., 1983) and two were Level III studies (Sharma et al., 2011; Hendy, 2002). Variability in sample sizes and intervention duration could not clearly explain why these five interventions did not produce desired changes in nutrition outcomes. Each implemented strategies similar to other interventions, such as tasting new foods, parent workshops and tailored advice, interactive games, and learning for children.

Two interventions reported an initial desirable response that diminished over time (Fitzgibbon et al., 2005; Johnson et al., 2007). Hip Hop to Health Jr. (Fitzgibbon et al., 2005) demonstrated a decrease in percent saturated fat intake at 1-year follow-up, but not at 2 years post-intervention. Food Friends (Johnson et al., 2007) showed that immediately following the intervention, children rated novel foods more highly. That effect diminished at follow up 10 days later. However, five other interventions that included a follow-up demonstrated a sustained improvement in nutrition outcome (de Silva-Sanigorski et al., 2010; Natale et al., 2014a; Baskale and Bahar, 2011; Williams et al., 2002; Witt and Dunn, 2012). In addition, as we defined effectiveness, any desired change in nutrition outcomes was considered effective. This could potentially inflate the number of effective nutrition interventions, since some interventions demonstrated a desired change in child care center menu or policy, but this did not translate into a change in children’s dietary intake (Alkon et al., 2014a; Zhou et al., 2014; Williams et al., 2002). It is worth noting, that while the Healthy Caregivers-Healthy Children (HC2) intervention (Natale et al., 2013, 2014b) did not favorably alter dietary behavior in the invention group, pre to post, the control group demonstrated undesirable changes over time. Thus curbing potential undesirable changes in dietary behavior could be considered beneficial. Moreover, seven interventions only examined child care center, environment, or menu changes, and did not examine children’s dietary intake or nutrition behaviors (Battista et al., 2014; Drummond et al., 2009a; Ward et al., 2008; Matwiejczyk et al., 2007; Pollard et al., 2001; Bell et al., 2015; Ritchie et al., 2015). Three interventions measured and effectively demonstrated a desired change at the child care center and with the children (de Silva-Sanigorski et al., 2010; Agrawal et al., 2012; Schwartz et al., 2015). Intervention characteristics of two of the successful programs included a long duration (2–4 years), multi-level intervention focusing on children, substantial parental engagement, provision of staff training and resources, and modifications to policies and menus (de Silva-Sanigorski et al., 2010; Agrawal et al., 2012). The third included alterations in the timing of food components within the meal (Dunn et al., 2006).

Intervention strategies focused primarily on the child and included educational lessons with supporting activities, books, puppets, games, music and songs, as well as trying and tasting novel foods (Fitzgibbon et al., 2002; Adams et al., 2009; Bayer et al., 2009; Bell et al., 2008; Niederer et al., 2009; Cespedes et al., 2013b; De Coen et al., 2012; Herman et al., 2012; Kunkel et al., 2013; Yin et al., 2012; Salazar et al., 2014; Baskale and Bahar, 2011; Bruhn and Parcel, 1982; Hardy et al., 2010; Parcel et al., 1983; Sharma et al., 2011; De Bock et al., 2012; Dunn et al., 2006; Farfan-Ramirez et al., 2011; Gripshover and Markman, 2013; Harnack et al., 2012; Hendy, 2002; Johnson, 2000; Mier et al., 2005; Nameken Brouwer and Benjamin Neelon, 2013; O’Connell et al., 2012; Vereecken et al., 2008; Williams et al., 1998, 2014; Young et al., 2003; Joseph et al., 2015; Natale et al., 2013, 2014b; Sharma et al., 2015; Sigman-Grant et al., 2014; Sweitzer et al., 2010). Gardens (Adams et al., 2009; Farfan-Ramirez et al., 2011; Nameken Brouwer and Benjamin Neelon, 2013) and child cooking classes (Adams et al., 2009) were used less frequently. The majority of interventions that included parents substantially engaged parents with interest groups, hands-on educational sessions, and technical assistance from health professionals (n = 18 of 23) (Adams et al., 2009; Niederer et al., 2009; Cespedes et al., 2013b; De Coen et al., 2012; Herman et al., 2012; Yin et al., 2012; Natale et al., 2014a; Zhou et al., 2014; Salazar et al., 2014; Bruhn and Parcel, 1982; Parcel et al., 1983; De Bock et al., 2012; Vereecken et al., 2009; Williams et al., 2014; Young et al., 2003; Natale et al., 2013, 2014b) versus take-home materials (Bayer et al., 2009; Kunkel et al., 2013; Baskale and Bahar, 2011; Sharma et al., 2011; Farfan-Ramirez et al., 2011; Williams et al., 1998; Joseph et al., 2015; Sharma et al., 2015; Sweitzer et al., 2010). Fewer interventions included staff training and technical assistance regarding program implementation (Bell et al., 2008; Salazar et al., 2014; Agrawal et al., 2012; Dunn et al., 2006; Bell et al., 2015; Natale et al., 2013, 2014b; Sharma et al., 2015; Sweitzer et al., 2010) or personal health and wellness (Yin et al., 2012; Alkon et al., 2014a). However, all but five of the interventions that included any parent component were considered effective. One recent intervention, demonstrated improvements in teacher-parent communication regarding healthy food (Sharma et al., 2015) in addition to dietary changes in the children (Sweitzer et al., 2010). Center environment, training of food preparers, enhancing nutrition policy and practices, timing of lunch food components, and menu modification were targets in several interventions (Adams et al., 2009; Bell et al., 2008; De Coen et al., 2012; Natale et al., 2014a; Alkon et al., 2014a; Zhou et al., 2014; Agrawal et al., 2012; Ammerman et al., 2007; Battista et al., 2014; Hardy et al., 2010; Matwiejczyk et al., 2007; Pollard et al., 2001; Vereecken et al., 2009; Williams et al., 1998; Williams et al., 2014; Bell et al., 2015; Natale et al., 2013, 2014b; Ritchie et al., 2015; Schwartz et al., 2015) Several (n = 4) of these environment-focused interventions (Alkon et al., 2014a; Agrawal et al., 2012; Battista et al., 2014; Drummond et al., 2009a) were based on NAP SACC (Ammerman et al., 2007) and one included a change in state law regarding beverages served in CCC (Ritchie et al., 2015). Classroom support materials, such as posters and books, were provided in four additional interventions (Niederer et al., 2009; Dunn et al., 2006; Nameken Brouwer and Benjamin Neelon, 2013; Young et al., 2003).

In summary, the majority of interventions reviewed demonstrated a favorable effect on nutrition outcomes. Interventions that focused on the child care center environment and included technical support and training seemed to facilitate positive changes. However, the translation into child dietary behaviors was not consistently observed. Interventions included creative and fun curriculums for children and also focused on enhancing the child care center environment, policies, practices, menus, and food preparation procedures, with less emphasis on parental engagement. However, sustaining an improvement in young children’s dietary intake will likely need to include parental involvement. Addressing the personal health of child care staff was only included in two interventions and both demonstrated desirable outcomes. Most interventions were higher quality, as based on study design, and were based on sound behavioral theory. Therefore, these characteristics were determined not to influence intervention effectiveness.

### 3.2.4. Screen time

Eight studies included at least one measure of screen time as an outcome, although no two studies measured it in the same manner (Fitzgibbon et al., 2006, 2011; de Silva-Sanigorski et al., 2010; Dennison et al., 2004; Puder et al., 2011; De Coen et al., 2012; Battista et al., 2014; Natale et al., 2013, 2014a, 2014b). Five (71%) reported a favorable change in screen time (Fitzgibbon et al., 2011; de Silva-Sanigorski et al., 2010; Dennison et al., 2004; Puder et al., 2011; Natale et al., 2014a). Hip Hop to Health Jr. (Fitzgibbon et al., 2006, 2011) included a measure of screen time in two different populations, with varying results. The 2006 (Fitzgibbon et al., 2006) study in a Latino population showed no difference between intervention and control sites. However,
a subsequent rendition of the intervention with a sample of black children reported that overall screen time, which can include media other than TV, decreased at intervention sites and increased at control sites (Fitzgibbon et al., 2011). Most (n = 5) interventions utilized behavior change theory (Fitzgibbon et al., 2002; Bell et al., 2008; Niederer et al., 2009; De Coen et al., 2012; Natale et al., 2014a), most commonly the Social Ecological Model. Eighty percent (n = 4) of those using behavioral theory demonstrated effective changes, at least at one time point (Fitzgibbon et al., 2006, 2011; de Silva-Sanigorski et al., 2010; Puder et al., 2011; Natale et al., 2014a). Most (n = 6) were Level II (Fitzgibbon et al., 2002; Dennison et al., 2004; Puder et al., 2011; De Coen et al., 2012; Natale et al., 2013, 2014a, 2014b), with two interventions at Level III (Bell et al., 2008; Battista et al., 2014). The majority (n = 4) of Level II (Fitzgibbon et al., 2006, 2011; Dennison et al., 2004; Puder et al., 2011; Natale et al., 2014a) and half (n = 1) of Level III interventions demonstrated favorable outcomes.

Intervention strategies focused on the child, parent, and the child care environment. Only one study exclusively examined center practices and policies. While screen time did not decrease, this was likely due to a high percent of centers engaging in best practices prior to the intervention, leaving no room for improvement (Battista et al., 2014). De Coen et al. (De Coen et al., 2012) did not demonstrate a desirable change in screen time behaviors; this may be due to the relatively low volume of screen time for this Belgian population (1.4 h/day). However, Ballabeina in Switzerland showed similarly low overall screen time (just over 1 h/day) and demonstrated that, while media use was unchanged in the intervention group, use increased in controls (Puder et al., 2011). No changes in the intervention group and increased in screen use in controls were also recently demonstrated in the HC2 intervention (Natale et al., 2013, 2014b).

In summary, most interventions reviewed demonstrated a favorable effect on screen time, although this effect seemed to result from preventing an increase in screen use over time. Since media use increases as children age (Sisson et al., 2009), preventing increases in screen time is a successful outcome. Studies that did not demonstrate the desired effects fell into three categories: 1) no decrease, likely due to low baseline screen time use (De Coen et al., 2012), 2) child care center best practice of no TV at the majority of sites (Battista et al., 2014), and 3) only assessing TV viewing, not all types of screen use (Fitzgibbon et al., 2006). Almost all interventions were higher design quality and it was therefore not determined to influence intervention effectiveness.

4. Conclusion

Seventy-one unique projects were included in this review of literature examining interventions aimed to improve obesogenic behaviors at child care centers and reduce obesity in young children. The content of this review is relevant for health and nutrition practitioners, child care workers, researchers and policy makers, and updates and expands previous reviews (Mehtala et al., 2014; Temple and Robinson, 2014; Ward et al., 2010; Mikkelsen et al., 2014; Campbell and Hesketh, 2007; Hesketh and Campbell, 2010; Larson et al., 2011b). These findings can be utilized in an evidence-based manner to inform future obesity prevention interventions targeting child care centers, workers, and young children. Most studies demonstrated a desired change in obesity or obesity-associated behaviors. Overall, the findings indicate that obesity and obesogenic behaviors, including physical activity, dietary behaviors, and screen time, can be impacted by health behavior interventions. While physical activity and nutrition behaviors were more positively impacted by intervention, it seems that the intervention effect on screen time behaviors may be prevention of increases in viewing time, which is a desirable outcome and can likely be included in child care settings by eliminating TV from the center. Child care center policies and practices can also be improved by intervention, demonstrating the environment is amendable to change, although environment-level only interventions had less impact on child health behavior outcomes than those that specifically included child-level interventions.

Interventions included strategies to change and measure physical activity (n = 41), dietary behaviors (n = 45), screen time (n = 8), and obesity (n = 29). Multiple behavioral outcomes were included in several interventions (n = 13) (Adams et al., 2009; Cespedes et al., 2013b; Herman et al., 2012; Yip et al., 2012; Alkon et al., 2014a; Zhou et al., 2014; Salazar et al., 2014; Agrawal et al., 2012; Ammerman et al., 2007; Bruhn and Parcel, 1982; Drummond et al., 2009a; Hardy et al., 2010; Parcel et al., 1983; Sharma et al., 2011). Six interventions included all three obesogenic behaviors (Fitzgibbon et al., 2002; Bell et al., 2008; Niederer et al., 2009; De Coen et al., 2012; Natale et al., 2014a; Battista et al., 2014). Behavior change theory appears to be more predominantly used in interventions targeting screen time (63%) and diet (67%) than PA (56%) and adiposity (55%). This may be due to the number of physical activity interventions that included environment-only play space modifications. Social Cognitive Theory and the Social Ecological Model were the most prevalently utilized behavior theories. A multi-level intervention focusing on the child care center environment, policies and practices, staff training, and personal health in addition to child engagement and parental support and outreach would be a goal for future obesity-prevention interventions, and is consistent with obesity prevention recommendations (Hoelscher et al., 2013; Larson et al., 2011a; Summerbell et al., 2012). Future interventions should also build on existing materials, evidence-based effectiveness, and focus on ways to involve parents and staff to maintain healthy changes for children and their families over the life-course.

Strengths and limitations of this review should be considered. A primary strength is the broad inclusion criterion to assess three obesogenic behaviors and obesity outcomes. Had this review been only limited to obesity outcomes, many interventions effective in improving obesogenic behaviors would have been omitted. Another strength is the rigorous methodology, including the repeated search of multiple databases, reference review list, and detailed abstraction. The prime limitation is the lack of consistent outcome measures, which limited direct comparisons and precluded a more sophisticated meta-analysis. The liberal determination of intervention effectiveness may have introduced positivity bias. In attempts to be more inclusive and review a greater number of studies with multiple behavioral outcomes, intervention effectiveness was determined by examining the main effects for each outcome rather than examining effect size and confidence intervals. Although including only peer-reviewed papers is a strength, this also presents a limitation in that there may be other existing interventions that have not been published in a peer-reviewed journal. It is also likely there are several ongoing interventions without published outcomes that were not included.

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As this was a review of existing literature, no approval was needed.

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