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Environmental characteristics of early childhood education and care centres and young children's weight status: A systematic review

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Abstract

The aim of this systematic review was to summarize ECEC environmental correlates of weight status in children under the age of 6. years. Six databases (PubMed, PsycINFO, CINAHL, SPORTDiscus, Scopus, and Web of Science) were searched until March 2017. Observational studies examining the relationship between ECEC environmental characteristics and weight status in children aged 0-6. years were included. Data was extracted using a predesigned form. Eight studies, representing 4862 children, met the inclusion criteria. Twenty-two environmental characteristics were identified and classified into four domains (physical, political, economic, and sociocultural); of these, six correlates were found. 'Active environment' 'sedentary opportunities', 'active play time', 'high sugar and high fat served', 'educators' weight' and 'educators' habitual physical activity level' were associated with weight status in young children. However, for most environmental characteristics examined, strong evidence is not available yet, due to variations across studies on the measures of environmental characteristics and analytical methodologies. Stronger empirical evidence in greater quantity is needed. Future studies in this area are recommended to investigate the environmental influence using an ecological approach and to examine the potential mediators, with a focus on the settings of family-based centres and samples representing toddlers and/or infants.

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Environmental Characteristics of Early Childhood Education and Care Centres and Young Children's Weight Status: A Systematic Review

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Abstract

The aim of this systematic review was to summarize ECEC environmental correlates of weight status in children under the age of 6 years. Six databases (PubMed, PsycINFO, CINAHL, SPORTDiscus, Scopus, and Web of Science) were searched until March 2017. Observational studies examining the relationship between ECEC environmental characteristics and weight status in children aged 0-6 years were included. Data was extracted using a predesigned form. Eight studies, representing 4,862 children, met the inclusion criteria. Twenty-two environmental characteristics were identified and classified into four domains (physical, political, economic, and sociocultural); of these, six correlates were found. 'Active environment' 'sedentary opportunities', 'active play time', 'high sugar and high fat served', 'educators' weight' and 'educators' habitual physical activity level' were associated with weight status in young children. However, for most environmental characteristics examined, strong evidence is not available yet, due to variations across studies on the measures of environmental characteristics and analytical methodologies. Stronger empirical evidence in greater quantity is needed. Future studies in this area are recommended to investigate the environmental influence using an ecological approach and to examine the potential mediators, with a focus on the settings of family-based centres and samples representing toddlers and/or infants.

Abbreviations:

ECEC: Early Childhood Education and Care

ANGELO: Analysis Grid for Environments Links to Obesity

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

BMI: body mass index

CACCP: Child and Adult Care Food Program

1. Introduction

During the last 20 years, the global prevalence of overweight and obesity among children under the age of 5 years has increased from 4.2% to 6.9%[2]. In 2014 alone, 41 million children in that age group were overweight or obese, worldwide[1]. This is a global public health challenge; because the first five years of life are considered a critical period for the development of obesity, due to the occurrence of the adiposity rebound [3] and the establishment of dietary and physical activity habits that are likely to track through the life course[4-7].

Excessive weight in early childhood can be associated to several disadvantageous health outcomes[8]. For example, accelerated weight gain during early childhood is associated with elevated inflammatory markers and blood pressure, which in turn are linked to long-term vascular damage[9-11], increased adiposity later in life[12] and coronary events in adulthood[13]. These indicate the importance of identifying the factors influencing young children's weight status.

Although the interaction between the environmental and genetic factors could determine individual's weight status[14], researchers have increasingly concurred that not genetic, but environment factors, drive today's obesity epidemic, primarily because the prevalence of obesity has increased rapidly, whereas genes have remained relatively unchanged[14-17]. An obesogenic environment, i.e. an environment that provides inexpensive energy-dense foods, discourages physical activity and promotes sedentariness[18], is more likely to influence young children's weight status, who cannot make informed health-related choices for themselves[15,19,20]. In order to help

young children maintain a healthy weight and reduce the risk of overweight and obesity, it is important to optimise the environments of settings frequented by them.

As the number of women in the workforce increases, Early Childhood Education and Care (ECEC) centres have become major settings of childcare. In 2011, approximately 60% of U.S. children under five attended some form of ECEC centres[21] and 54% of Australian children aged 2-3 years attended care in 2014[22]. In most European countries, ECEC centre attendance rate is higher than 80% in children aged 3-6 years[23] and around 35% in children under the age of 3[24] . Given the high proportion of children who attend ECEC centres, these settings might have the potential capacity to help prevent early childhood overweight and obesity.

ECEC centre attendance has been associated with young children's weight status[25-28] as well as weight-related behaviours, such as dietary intake [29,30], physical activity [31,32], and sleep[33]. Overweight and obesity prevention programmes in ECEC settings that had incorporated environmental changes were more sustainable and effective than those that had not in changing adiposity and weight-related behaviours[34]. However, inconsistent associations between ECEC centre attendances and weight status in preschool-aged children reported across studies may suggest that not attendance, but environmental differences (e.g. food access and quality, outdoor play time and television exposure) among ECEC centres influence young children's weigh status[35]. In that light, understanding which ECEC environmental characteristic(s) are associated with young children's weight status could be vital. Such a review could guide future early childhood overweight and obesity prevention programmes in incorporating environmental interventions in ECEC centres. Accordingly, this

systematic review aims to examine the ECEC environmental characteristics associated with young children's weight status.

Although the term "environment" generally refers to the physical and sociocultural surroundings with which individuals interact[36,37], various ecological models have proposed a range of classifications for environmental aspects[37]. In the present systematic review, the Analysis Grid for Environments Linked to Obesity (ANGELO) framework[18], specifically designed for the conceptualising obesogenic environments, is used to classify the environmental characteristics. The framework identifies micro and macro environments; whereas micro-environments directly interact with individuals, including schools, workplaces, families and neighbourhoods — ECEC settings are micro-environments — macro-environments are the broader environments, such as governments, education systems and the food industry. Within both categories, environments can be further classified into four domains: the physical environment, which refers to the availability; the economic environment, which refers to the cost; the political environment, which refers to rules; and the sociocultural environment, which refers to the attitudes, beliefs, and values[18]. For example, in an ECEC centre, the physical environment could include the availability of healthy food and play equipment; the economic environment could include the expense of childcare; the political environment could include the care centre's policies; and the sociocultural environment could include educators' attitudes and behaviours related to lifestyles.

2.Methods

2.1 Protocol

The present systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines[38].

2.2 Data Sources and Search Strategy

Six electronic databases (PubMed, PsycINFO, CINAHL, SPORTDiscus, Scopus, and Web of Science) were searched from the inception until March 22 2017. Table1 presents the search strategy.

Insert Table 1 here. Table 1. Search strategy

2.3 Study Selection

Studies were screened and selected according to the following criteria:

Type of study. Observational studies (cross-sectional and longitudinal) and intervention studies reporting cross-sectional results from baseline data were considered, whereas studies reporting intervention results were not considered, nor were reviews, editorials, commentaries, methods papers, and conference proceedings. Eligible studies were limited to publications in the following languages: English, Chinese, Portuguese, French, Spanish, Polish, Dutch, and Germany. Reference lists of the articles included and relevant reviews were also checked to identify other relevant studies.

Participants. Eligible participants were healthy children aged from birth to 6 years old (for longitudinal studies, the criterion had to be met at the beginning of the study). Studies focusing on children with illness other than obesity or overweight were excluded.

Settings. Eligible studies were performed at formal institutions that provide ECEC, including childcare centres, preschools, day care centres, nursery schools, and family care homes; informal care (i.e. relatives, friends, and neighbours) and primary/elementary schools were excluded.

Exposure variable(s). Exposure variables were required to be environmental characteristics and could be measured either objectively (e.g. by direct observations) or subjectively (e.g. by surveys).

Outcome measures. Eligible studies were required to report participants' weight status as primary outcomes, i.e. body mass index (BMI), BMI percentile, BMI z-scores, the prevalence of overweight and/or obesity, overweight likelihood, waist circumference, percentage of body fat, skinfold thickness or weight-height (length) ratio.

2.4 Data Extraction

Studies retrieved from the search were imported into reference manager software (EndNote X7), which was used to remove duplicates. Three authors (ZZ, JP, and ES) screened the titles and abstracts independently against the criteria described above, and when necessary, the full text of the study was evaluated to determine its eligibility. Disagreements were resolved by discussion and consultation with a fourth author (RS). Figure 1 presents a summary of the study selection process.

Insert Figure 1 here. Figure 1. Flow chart of studies selection process

2.5 Risk of Bias Assessment

The risk of bias was assessed independently by three authors (ZZ, JP, ES), and any differences were resolved by discussion with the fourth author (RS). The criteria for bias appraisal were adapted from the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) statement[39], which has been applied in previous systematic reviews[40-43]. These criteria were: (i) Did the study specify the eligibility criteria? (ii) Was the selection of participants random? (iii) Did these participants represent a certain population (i.e. country or region level)? (iv) Did the study have sample size more than 100? (v) Did the study have an acceptable proportion of participants with completed data regarding the variables of interest (at least 70% for cross-sectional studies and 60% for longitudinal studies[44])? (vi) Did the study report the source and details of adiposity assessment? (vii) Were the measurements valid and reliable for the age group of children from birth to 6 years? (viii) Did the study report the source and detail of environmental correlates assessment? (ix) Did assessment instruments have acceptable validity or reliability? A value of 1 (*yes*) or 0 (*no or unsure*) was assigned to the answer to each of the above questions, which allowed a maximum possible score of 9 points, and a quality score was assigned to each study. Studies that scored 0-4 points were classified as having a high risk of bias.

2.6 Data Analysis and Synthesis

Given the large variety of environmental characteristics in the studies reviewed, inconsistency in measurement methodology and heterogeneity in samples and study outcomes prevented their synthesis into a meta-analysis. Instead, a narrative summary of the findings was performed.

Categorisation of variables. Environmental factors were categorised into four types: physical, economic, political, and sociocultural, following the ANGELO framework[18].

Coding associations. Associations between environmental characteristics and weight status in studies were summarised as positive or negative association ($p<0.05$) or non-significant association ($p\geq0.05$).

3. Results

3.1 Overview of Studies

Eight studies[45-52], representing 4862 children aged under 6 years, met the pre-specified inclusion criteria and were included in this review. Table 2 presents characteristics of the studies. All studies were published between 2011 and 2016. Four studies were conducted in United States; whereas the rest were conducted in Germany, Sweden, Israel, or Vietnam. The sample sizes ranged from 82 to 2810. Five studies were cross-sectional, and three were longitudinal. Six studies focused on pre-schoolers (i.e.36-60 months olds), only one study[48] focused on infants (i.e. < 12 months olds), and one study[48] included a combination of toddlers (i.e. 12-35 months olds) and pre-schoolers. ECEC settings investigated in the eight studies included kindergartens, day care centres, preschools and Head Start programmes, while no study focused on family-based ECEC centres. Seven studies assessed adiposity using objective measures and one study[52] used the data of children's weight and height from records of a maternal and child healthcare centre. Weight outcomes were presented in the reviewed studies as BMI, BMI z-score, BMI dichotomised, overweight likelihood, weight, weight-height ratio, waist circumference, and skinfold thickness. Most of the

studies assessed environmental characteristics via surveys (e.g. parents' and educators' reports), although two studies[50,51] used direct observations.

Insert Table 2 here. Table 2. Summary of included studies

3.2 Risk of Bias

Table 3 presents results regarding risk of bias. Five studies imposed specific eligibility criteria. Two studies selected participants randomly and three had a representative sample of participants. Seven studies had samples with more than 100 participants, whereas one [50] had a sample of 82 participants. Most studies had an adequate proportion of participants with completed data (at least 70% for cross-sectional studies and 60% for longitudinal studies). All studies presented detailed reports of adiposity assessment; seven used valid and reliable measurements to assess adiposity in children aged 0-6 years. Six studies reported the sources and details of environmental characteristics assessments; three used valid and reliable instruments to assess environments. Of the eight studies, five have a low risk of bias.

Insert Table 3 here. Table 3. Risk of bias results

3.3 ECEC Environmental Characteristics

Twenty-two ECEC environmental characteristics were identified and classified as belonging to the physical, political or sociocultural environment; none of the characteristics was identified as representing the economic environment. Table 4 presents a complete list of the environmental characteristics.

Insert Table 4 here. Table 4. Summary of ECEC environmental correlates of weight status

Physical Environment

Six environmental characteristics were classified as representing the physical environment, with the potential correlate 'active environment' identified. A higher quality of active environment, consisting of the elements 'the presence of portable and fixed play equipment' and 'the suitability of indoor space for active play', was less likely to be associated with overweight in pre-schoolers[50]. Mixed results emerged regarding 'the availability of unhealthy food around ECEC settings'[47], which tended to depend on gender and the measure of adiposity. Null results were reported regarding 'outdoor environment quality', 'the amount of play equipment', 'sedentary environment', and 'food environment'[50,51].

Political Environment

Eleven characteristics were categorised as representing the political environment, with 'active play time', 'sedentary opportunities', and 'servings of high sugar and high fat" identified as potential correlates. 'Active play time', 'sedentary time', 'structured physical activity time' and 'outdoor play time' referred to the durations of these activities at ECEC centres in which most children engaged, not the durations of individuals' activities[45,50,51]. Such characteristics were categorised as representing the political environment because they tended to depend on the schedules of ECEC programmes. 'Active play time', defined as the total time of free play outdoor and indoor, was negatively associated with overweight likelihoods[50], whereas 'sedentary time', defined as the duration of seated activities in ECEC centres lasting more than

30 minutes, and 'structured physical activity time', defined as the duration of teacher-led physical activities, were null. 'Outdoor play time', defined as the total time of outdoor activity periods, was inconsistently related to children's weight status across the studies[45,50,51]. Far more consistent results emerged regarding 'sedentary opportunities', which incorporated the elements of 'seated activities', 'TV viewing', and 'video game playing in ECECs' [49,50]. More specifically, children who attended the ECEC centres offering frequent seated activities in the ECEC schedules were more likely to become overweight. 'Active opportunities', combining the elements of 'active play time', 'structured physical activity', and 'outdoor play in ECECs', was reported to be unrelated to overweight likelihood in pre-schoolers[49]. 'Servings of fruits and vegetable', 'servings of high sugar and high fat', and 'servings of beverage and water' were measured considering relevant documented policies and practices in ECEC centres in the reviewed study[49] and therefore categorised as representing the political environment. No association was detected between 'the servings of fruits and vegetables' or 'servings of beverage and water' and overweight likelihood in pre-schoolers, whereas frequent servings of high sugar and high fat food might increase young children's likelihood of being overweight. Neither 'the type of ECEC nutrition policy' (i.e. Child and Adult Care Food Program (CACCP), Non-CACFP, or Head start) nor 'the number of educators caring children' were related to children's weight outcomes[48,52].

Sociocultural Environment

Five potential environmental characteristics were classified as representing the sociocultural environment, with 'educators' weight status (i.e. normal weight or overweight)' and 'educators' habitual physical activity status' identified as potential

correlates. For pre-schoolers, having overweight educators tended to increase their likelihood of being overweight, whereas children cared by active educators were less likely to be overweight[46]. Null results were found regarding 'physical activity educators' behaviours', 'nutrition training and education for children', and 'nutrition educator's behaviours'[50].

4.Discussion

4.1 Overview of Findings

The aim of this systematic review was to identify ECEC environmental correlates of children's weight status. Twenty-two environmental characteristics were identified from eight studies and classified using the ANGELO framework, and six potential correlates were found.

Regarding the physical environment, "active environment", measured with Environment and Policy Assessment and Observation (EPAO) instrument, was associated with pre-schoolers' reduced likelihood of being overweight[50], which physical activity might mediate. Having more play equipment, both portable and fixed, and more suitable indoor active play environment might encourage children to become more active, which in turn might increase their energy expenditure and help them to maintain a healthy weight. However, in other studies using the same environment rating scale to assess ECEC environments, portable play equipment and fixed play equipment had opposite associations with children's moderate-to-vigorous physical activity[31,53]. In that case, an environmental characteristic incorporating both 'portable play equipment' and 'fixed play equipment' might show a null result

regarding the association with physical activity in children as well as with their weight outcomes in the observations. For example, in the study conducted by Huynh et al[47], the environmental characteristic 'the amount of equipment in ECEC', including both portable and fixed equipment, was not related to children's BMI changes. Moreover, as reported by Sission et al[50], the association between "active environment" and children's weight status ceased to be significant after controlling for confounders. In response, future studies is recommended to subdivide 'active environment' into detailed elements in order to clarify the influence of different types of play equipment on young children's physical activity and weight status.

Regarding the political environment, 'sedentary opportunities', 'active play time', and 'servings of high sugar and high fat' were associated with children's weight status, which obesity-related behaviours might mediate. For example, children enrolled in ECEC programmes that offer more seated activities might have extended sedentary time. Likewise, a longer 'active play time' in ECEC programmes might promote the time that children spend being active. ECECs' policies and practices that allow more frequent provisions of high sugar and high fat foods might encourage children to consume larger amount of those foods. Such obesity-related behaviours might contribute to a high likelihood of being overweight[54-56]. However, 'active play time', and "high sugar and high fat served" were identified in a study with a small sample dominated by Native Americans, which limits the generalisability of the findings.

The findings of two sociocultural environmental correlates (i.e. 'educators' weight' and 'educators' habitual physical activity level') suggest the influence of educators on young children's weight status. Evidence has shown that educators' characteristics,

beliefs and behaviours may influence children's weight-related attitudes and behaviours[57,58]. Accordingly, physical activity levels in children could have been influence by their inactive educators and thus decreased. Similarly, overweight educators might exhibit obesity-related behaviours that children are liable to emulate. Overweight educators could also lack the knowledge regarding healthy diet and physical activity and therefore enact care practices that encourage children, even if inadvertently, to adopt unhealthy dietary habits and inactive lifestyles, that could, in turn, those behaviours may influence their weight status. With the increase population of children who attend ECEC centres, educators play an increasingly important in children's lives; however, educators' influences on young children's health remain poorly understood[46].

At the same time, the associations described above should be interpreted with cautions given the lack of repetition and methodological limitations evident in the reviewed studies.

4.2 Limitations of Reviewed Studies

Some methodological challenges emerged in the reviewed studies that limit their contributions to the evidence base and could prompt the inconsistent results across studies.

First, the definitions and measures of environmental characteristics varied across studies, which reduced the comparability of the findings. For instance, 'outdoor play time' was defined by Soderstrom et al[51] to mean relative time children spent outdoor at the ECEC but referred to the absolute time children spend in outdoor play by

Sisson et al[50]. Moreover, the subjective measures of environmental characteristics used in most reviewed studies were likely to cause inaccuracy since unmeasured confounders might have been introduced that unduly inflated the proportion of variance for which a variable could account in the outcome[40]. For example, on the questionnaire used by *Ansari et al*[45],"outdoor play time" was scaled into a 5- to 10-min intervals (e.g. 15, 20, and 25 minutes) and reported by the educators. That measure is less precise and tends to be biased compared with the objective measures (e.g. using a stopwatch) in two other studies[50,51].

Since obesity is multifactorial in origin[59], it is important in statistical analyses to adjust for potential confounders such as demographic factors in order to understand the "independent" influence of ECEC environmental characteristics on young children's weight status. For example, the association between 'active environment' and children's weight status was determined by using an unadjusted regression model in a study with an ethnically diverse sample; however, that association ceased to be significant after controlling for ethnicity[50], which suggests that it might be the confounder rather than 'active environment' that explained the variation in those children's weight status. At the same time, confounders were adjusted in a few studies only, which complicated ascertaining results.

4.3 Gaps in Research

Several gaps might need to be addressed in current research in this area. First, there is a lack of repetition in the ECEC environmental characteristics examined with children's weight status. This may be due to the broad spectrum of environmental characteristics of ECEC settings and the limited number of relevant studies. Future

research is therefore recommended to adopt ecological approached, in order to capture a more complete picture of the ECEC environmental influence on children's weight status.

From another angle, evidence of how regarding obesity-related behaviours mediate the association between ECEC environmental characteristics and young children's weight status remains scarce. Most associations investigated in the studies reviewed were likely to be mediated by diet or physical activity, although the mediation effects of food intake and physical activity in the associations have not been investigated as extensively. Moreover, some risk factors for early childhood overweight and obesity are seldom considered to be potential mediators. For example, there is a consistent evidence of the association between sleep duration and pre-schoolers' weight status[60-63], and sleep duration, especially nap duration, is likely influenced by environmental cues[64-66]. Therefore, some ECEC environmental characteristics, such as the quality of nap rooms, could influence children's weight status, mediated through nap. However, those relationships remain not fully understood[67].

Another gap in available research is that no economic environmental characteristic has been examined with young children's weight status. Evidence has shown that school-level economic disadvantage was associated with greater prevalence of obesity in children [68] as well as adolescents[69,70], regardless of household economic status or ethnicity, which indicates that the economic inequality in educational settings might influence children's weight outcomes. In response, future research is needed to focus on younger children who are more likely to be influenced by environmental cues[71]. It should also be noted that all four environmental domains interact with each other to

some extent, especially with economic environment. For example, 'play equipment in ECEC' is classified into the physical environmental domain, while the availability of such equipment depends on the cost of purchase and maintenance, which belongs to the economic environmental domain. That sort of interaction and its influence on young children's weight status warrants consideration in further research.

No environmental characteristics of family-based ECEC centres were investigated in the studies reviewed. Moreover, inconsistent associations between family-based ECEC centre attendance and children's weight status were reported in a recent systematic review[35], in which such inconsistency was suggested to stem from the discrepancy across the environments of family-based ECEC centres[35]. Since this type of ECEC centre is common in many countries[25,72,73], it is pivotal to understand its environmental influence on young children's weight status.

Lastly, few studies have focused on infants and toddlers. Since many infants and toddler now receive care in ECEC centres and because their rapid weight gain tends predict their overweight and obesity in later life[74-77], it is additionally important to study ECEC environmental influences on their weight status.

4.3 Strengths and Limitations

To the authors' knowledge, the present systematic review marks the first to report ECEC environmental correlates of young children's weight status. It followed an ecological framework (i.e. ANGELO), which provided a clear organisation of the reporting. Most studies reviewed had adequate sample sizes, minimal missing data and reliable measures of weight status. However, since the scarcity of studies and the

variation in measurement precluded meta-analysis, a narrative summary of the findings was used to describe the results instead. Results should be interpreted with caution, given the various measures of environmental characteristics, cross-sectional designs and unadjusted analytical models in most studies reviewed.

5. Conclusions

Altogether, twenty-two ECEC environmental characteristics were identified in this systematic review, among which six correlates of children's weight status were determined. To promote healthy weight in young children, ECEC settings are recommended to improve their active environments, reduce opportunities for sedentary behaviours and limit servings of high sugar and high fat food, while educators could maintain normal weight and high physical activity levels. At the same time, the strength of evidence from studies reviewed is currently limited. More studies with stronger study designs, objective measures of environmental characteristics, and adjustments for confounders are needed to confirm and elucidate the relationship between ECEC environmental characteristics and young children's weight status. Future research is also recommended to investigate those relationships using ecological approaches to examine the potential mediators, as well as to focus on family-based ECEC centres, toddlers, and infants.

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Table 1. The search strategy

S1	"childcare" OR "child care" OR "preschool*" OR "pre-school*" OR "daycare" OR "day care" OR "head start" OR "kindergarten*" OR "nurser*" OR "education centre" OR "early childhood education and care"
S2	"child*" OR "toddler*" OR "pre-schooler*" OR "preschooler*" OR "infant*" OR "newborn*" OR "p?ediatric"
S3	"environment*" OR "equipment" OR "facilities" OR "space" OR "polic*" OR "guide*" OR "programme structure" OR "program structure" OR "class size" OR "practice*" OR "care routine" OR "cultur*" OR "teacher*" OR "educator*" OR "staff" OR "attitude" OR "belief"
S4	"obes*" OR "adipos*" OR "weight" OR "overweight" OR "BMI" OR "body mass index" OR "waist circumference" OR "skinfold thickness"
S5	Combine S1 to S4 with "OR"

Table 2. Summary of included studies

Author & date	Study design	Location	Sample size	Age	Sex	Ethnicity	Setting	Assessment of weight status	Primary outcome	Assessment of independent variable	Environmental characteristics	Analysis	Findings
Hoffmann, 2014[46]	Cross-sectional	Germany	N=434	3~6 years	Girls and boys (56%) combined	-	Kindergarten	Objective	Overweight likelihood	Surveys (educators' reports)	Educators' weight status (overweight, normal weight); Educators' habitual physical activity scores;	Logistic regression analysis (controlling for covariates)	Positive association between educators' weight status and children's odds of being overweight (OR: 1.97; 95% CI: 1.01, 3.83; p = 0.047). Negative association between educators' habitual physical activity score and children's odds of overweight (OR: 2.32; 95% CI: 1.10, 4.92; p = 0.028).
McBride, 2013[48]	Cross-sectional	US	N=329	2~5 years	Girls and boys combined	68.7% black and 31.3% white.	Head Start	Objective	BMI dichotomized (healthy weight, overweight/obese)	Surveys (parents/primary caregivers' report)	Nutrition policies (Non-CACFP, CACFP, Head Start)	Logistic regression	No association between nutrition policies and children's BMI categories.
Ross, 2013[49]	Cross-sectional	US	N=339	4.5± 0.3 years	Girls and boys (52.2%) combined	46.3% black, 38.9% white, and 14.8% other race group.	Preschool	Objective	BMI□; BMI z scores Waist circumference	Surveys (directors' reports)	TV viewing (High-TV, Low-TV)	t-test (unadjusted model); Mixed model ANOVA (controlling for gender, race/ethnicity, SES and length of school day)	In unadjusted model, children in High-TV preschool group had significantly higher BMI (high TV: 16.5 ± 1.9, low TV: 16.1 ± 1.8; P = 0.04), and BMI-z score (high TV: 0.6 ± 1.1, low TV: 0.4 ± 1.1; P = 0.02). In adjusted model, children in High-TV preschool group had insignificantly higher BMI (high TV: 16.5 ± 0.2, low TV: 16.2 ± 0.2; P = 0.20), and BMI-z score (high TV: 0.6 ± 0.1, low TV: 0.4 ± 0.1; P = 0.18)
Soderstrom, 2013[51]	Cross-sectional	Sweden	N=172	3.0~ 5.9 years	Girls and boys combined	-	Day care centres	Objective	BMI dichotomized (over weight, normal weight)□; Waist circumference	Objective (observation)	Quality of outdoor environment; The percent of time spent outdoor	ANOVA (controlling for age, sex, birth weight and mothers socioeconomic status)	No association between the quality of outdoor environment and BMI dichotomized (P = 0.32), and waist circumference (p = 0.44). No association between the percent of time spent outdoor and BMI categories (P = 0.07), and waist circumference (p = 0.25).

Sisson, 2016[50]	Cross-sectional	US	N=82	3~5 years	Girls and boys (55%) combined	67% American Indian, 28% white, and 5% other.	Head Start	Objective	Overweight likelihood	Objective (observation)	Sedentary environment; physical activity environment Fruits & vegetables served; high sugar & high fat served; access to beverages & water; opportunities for physical activity; opportunities for sedentary activity; sedentary time; TV viewing time; active play time; outdoor play time; time of structured physical activity Nutrition environment Nutrition training and education; nutrition staff behaviors; Physical activity staff behaviors	Logistic regression (controlling for % American Indian children, years of operation, program size, direction education, teacher education, respectively)	In unadjusted model, only sedentary opportunities was significantly associated with overweight likelihood (OR: 0.95, 95%CI: 0.90, 1.00; p = 0.031). In model adjusted for % American Indian children, activity environment (OR: 0.94, 95%CI: 0.90, 0.98; p≤ 0.05) and active play (OR: 1.00, 95%CI: 0.99, 1.00; p≤ 0.05) was significantly associated with overweight likelihood. In model adjusted for years of operation, high sugar and high fat served (OR: 0.72, 95%CI: 0.6, 0.87; p≤ 0.05) was significantly associated with overweight likelihood. In model adjusted for program size, high sugar and high fat served (OR: 0.74, 95%CI: 0.56, 0.97; p≤ 0.05) and active play (OR: 1.00, 95%CI: 0.99, 1.00; p≤ 0.05) was significantly associated with overweight likelihood. In model adjusted for director education, high sugar and high fat served (OR: 0.69, 95%CI: 0.56, 0.86; p≤ 0.05) and active play (OR: 0.99, 95%CI: 0.99, 1.00; p≤ 0.05) was significantly associated with overweight likelihood. In model adjusted for teacher education, high sugar and high fat served (OR: 0.74, 95%CI: 0.62, 0.88; p≤ 0.05) was significantly associated with overweight likelihood.
Ansari, 2015[45]	Longitudinal (1 Head start year)	US	N=2810	3~4 years	Girls and boys (51.3%) combined	22.4% white, 33.5% black, 35.4% Hispanic, and 8.7% Asian/other	Head Start	Objective	Change in BMI Obesity likelihood	Surveys (educators' reports)	Outdoor play time	Linear regression	Outdoor play time was significantly associated with the reduction in BMI (β = -0.05, 95% CI: -0.09, -0.01; p≤ 0.05). The difference between high levels and low levels of outdoor play correspondent to 0.18 BMI kg/m^2. Outdoor play time was significantly associated with obesity likelihood (OR: 0.99, 95% CI: 0.98, 0.99; p≤ 0.05). The difference between high levels and low levels of outdoor play correspondent to 42% reduction in obesity likelihood.

Huynh, 2011[47]	Longitudinal (1 year)	Vietnam	N=526	4~5 years	Girls and boys (49%) assessed separately	Vietnamese	Preschool	Objective	Change in BMI; Change in SSFs	Surveys	Amount of play equipment; Food environment	Hierarchical generalized estimating equation	Amount of play equipment was not significantly associated with girls' or boys' change in BMI. Food environment was not significantly associated with girls' or boys' change in BMI. Amount of play equipment was not significantly associated with girls' or boys' change in SSFs. Food environment was not significantly associated with boys' change in SSFs in but positively associated with girls' change in SSFs (smallest score: adjusted coefficient =0.00; medium score: adjusted coefficient=3.22, 95%CI: 0.02, 6.42, p=0.048; largest score: adjusted coefficient =4.19, 95%CI: 1.25, 7.13, p= 0.005)
Zmiri, 2011[52]	Longitudinal Study (6 months)	Israel	N=170	Research group: 38.9 weeks on average; Control group: 39.4 weeks on average	Girls and boys combined	-	Day care centers	Proxy report (maternal and child health care centre charts)	Change in weight (percentiles, z-score); Change in weight/height ratio (percentiles, z-score)	Surveys (parents' reports)	The number of caretakers per children	Not clear	No association between the number of caretaker per child and weight change or weight/height ratio.

BMI – body mass index, SSFs - the sum of skinfold thickness
ANOVA – analysis of variance,

Table 3. Risk of bias results

Reference	Did the study specify the eligibility criteria?	Was the selection of participants random?	Did these participants represent a certain population (i.e. country or region level)?	Is the sample size more than 100?	Did the study have an acceptable proportion of participants with completed data for the outcome?	Did the study report the source and detail of adiposity assessment?	Were the measurements reliable for age group from birth to 6 years?	Did the study report the source and detail of environmental correlates assessment?	Did the assessing instruments have acceptable validity or reliability?	Scores for the study (higher scores denote lower risk of bias)
Ansari, 2015[45]	✓	?	✓	✓	✓	✓	✓	✓	Outdoor play time (✓)	8 / 9
Hoffmann, 2014[46]	✓	✗	?	✓	✓	✓	✓	✓	Educators BMI (✗); Educators' habitual physical activity status (✓)	6 / 9
Huynh, 2011[47]	✗	✓	✓	✓	✓	✓	✓	✓	The number of items of play environment (✗); The size of the preschool (✗); The quality of the food environment (✗); The time allocated for physical education (✗); The number and type of activities permitted during break times per school day (✗)	7 / 9
McBride, 2013[48]	✓	✗	?	✓	✓	✓	✓	✗	Nutrition policies (✓)	5 / 9
Ross, 2013[49]	✓	✓	✓	✓	✓	✓	✓	✓	TV viewing (?)	8 / 9
Soderstrom, 2013[51]	✗	✗	?	✓	✓	✓	✓	✓	Quality of outdoor environment (✓); The percent of time spent outdoor (✓)	6 / 9
Sisson, 2016[50]	✗	✗	?	✗	✗	✓	✓	✓	Sedentary environment (✓); Physical activity environment (✓); Fruits & vegetables served (✓); High sugar & high fat served (✓); Access to beverages & water (✓); Opportunities for physical activity (✓); Opportunities for sedentary activity (✓); Sedentary time (✗); TV viewing time (✗); Active play time (✗); Outdoor play time (✗); The number of activity bouts (✗); Time of structured physical activity (✗); Nutrition environment (✓); Nutrition training and education; nutrition staff behaviors (✓); Physical activity staff behaviors (✓);	3 / 9

Reference	Did the study specify the eligibility criteria?	Was the selection of participants random?	Did these participants represent a certain population (i.e. country or region level)?	Is the sample size more than 100?	Did the study have an acceptable proportion of participants with completed data for the outcome?	Did the study report the source and detail of adiposity assessment?	Were the measurements reliable for age group from birth to 6 years?	Did the study report the source and detail of environmental correlates assessment?	Did the assessing instruments have acceptable validity or reliability?	Scores for the study (higher scores denote lower risk of bias)
Zmiri, 2011[52]	✓	✗	?	✓	✓	✓	?	✗	The number of caretakers per children (?)	4 / 9
Total	62.5% (5/8)	25%(2/8)	37.50%(3/8)	87.50%(7/8)	87.5%(7/8)	100%(8/8)	87.50%(7/8)	75%(6/8)	37.50%(3/8)	

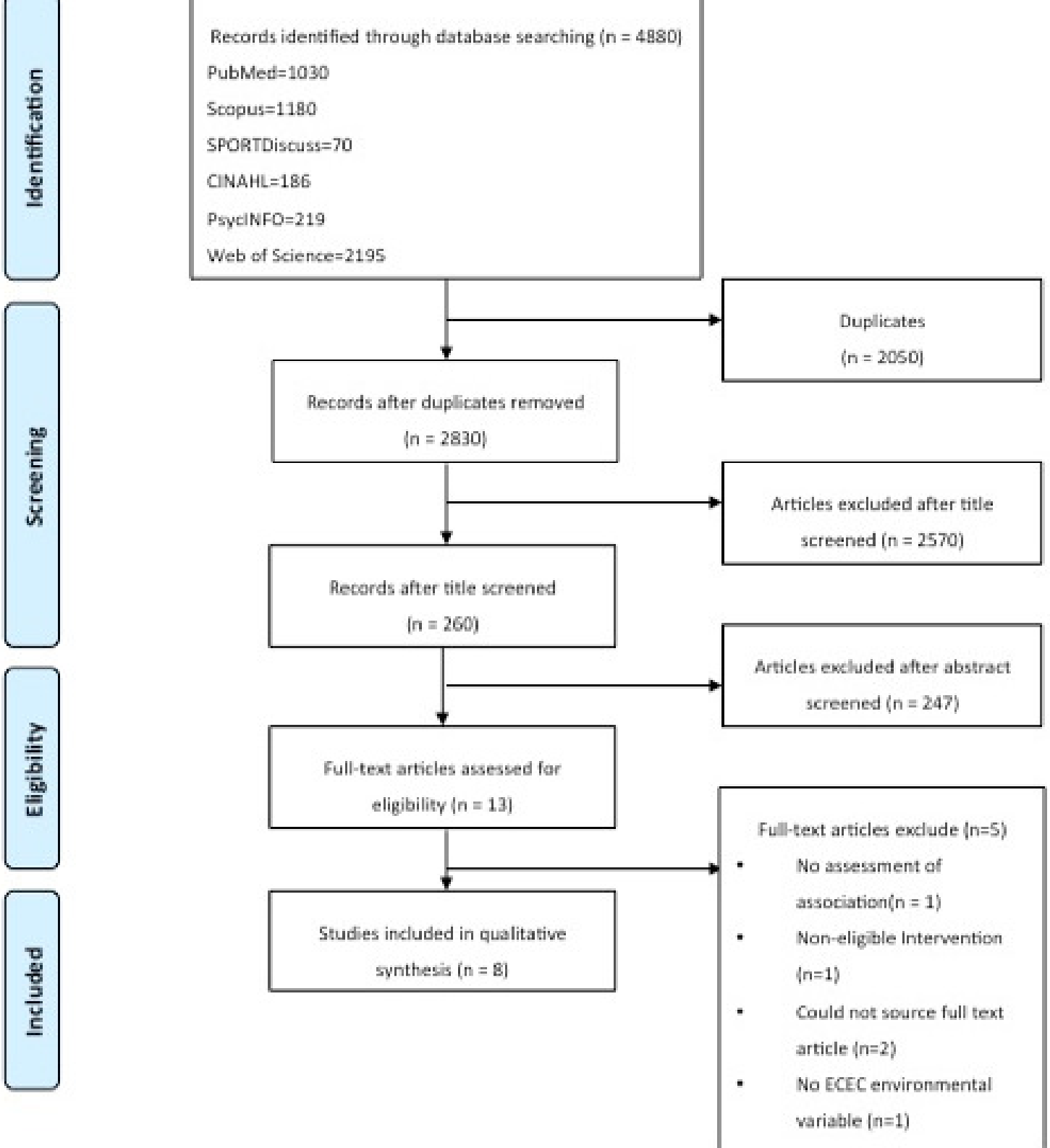
"✓" - met criteria, "✗" - did not met criteria, "?" - unclear whether it met criteria;
BMI – body mass index

Table 4. Summary of ECEC environmental correlates of weight status

Correlates	Positive related to weight status (reference)	Negatively related to weight status (reference)	Unrelated (reference)
Physical environmental			
Outdoor environment quality (total outdoor area; amount of trees, shrubbery and hilly terrain; integration between vegetation, open areas and play structures)			Soderstrom,2013[51,(a)]
Active environment (presence of equipment; suitability of indoor space for active play)		Sisson, 2016[50, (e)]	
The amount of play equipment			Huynh, 2011[47, (i)]
Sedentary environment (presence of electronic media; posters, pictures, books about physical activity)			Sisson, 2016[50,]
Food environment within ECEC (breakfast & lunch service style; presence and location of vending machines)			Sisson, 2016[50,]
The availability of unhealthy food around ECEC (within a radius of 200m)		Huynh, 2011[47, (h)]	Huynh, 2011[47, (j)]
Political environmental			
Sedentary opportunities (seated activities time, presence and duration of TV viewing; observation of video game playing)	Sisson, 2016[50, (d)], Ross, 2013[49, (b)]		
PA opportunities (duration of active play time; presence and duration of structured activity; presence and duration of outdoor play)			Sisson, 2016[50,]
Sedentary time			Sisson, 2016[50,]
Active play time		Sisson, 2016[50, (f)]	
Outdoor play time		Ansari, 2015[45, (k)]	Sisson, 2016[50], Soderstrom,2013[51,(a),(l)]
Structured PA time			Sisson, 2016[50]
Fruits & vegetables served			Sisson, 2016[50]
High sugar & high fat served	Sisson, 2016[50, (c)]		
Beverages & water served			Sisson, 2016[50]
The number of educators per children			Zimri, 2011[52, (g)]
Nutrition policies (Non-CACFP, CACFP, Head Start)			McBride, 2013[48]
Sociocultural environmental			
Educators' weight status	Hoffmann, 2014[46]		
Educators' habitual PA status		Hoffmann, 2014[46]	
PA educators' behaviors			Sisson, 2016[50]
Nutrition training and education			Sisson, 2016[50]
Nutrition educators' behaviors			Sisson, 2016[50]

a. No association with neither BMI nor waist circumference.
b. TV availability and rules and frequency of TV use; the association was significant with BMI and BMI z score, but insignificant with waist circumference; no association when controlling for cofounders.
c. The association was significant when controlling for years of operation, program size, director education or teacher education; no significant association in unadjusted model.
d. The association was significant in unadjusted model but insignificant when controlling for cofounders.
e. The association was significant when controlling for ethics; no significant association in unadjusted model.
f. The association was significant when controlling for ethics, program size, or director education; no significant association in unadjusted model.
g. No significant association with the change neither in weight nor in weight/height ratio.
h. The association was significant with girls' SSFs changes but not with boy's
i. No significant association with the change neither in BMI nor SSFs for both genders.
j. No significant association with the change in BMI for both genders.
k. The association was significant with the change both in BMI and in obesity likelihood.
l. The association was suggested to be significantly associated with weight status (normal weight/overweight) (p=0.07) in the study (according to the significance criteria"p-value < 0.1" in that study), this association was evaluated as insignificant in this review, judging by the significance level of p-value < 0.05.

PA-physical activity, BMI- body mass index, SSFs – the sum of skinfold thickness.


Identification
Screening
Eligibility
Included
Records identified through database searching (n = 4880)
PubMed=1030
Scopus=1180
SPORTDiscuss=70
CINAHL=186
PsycINFO=219
Web of Science=2195
Duplicates
(n = 2050)
Records after duplicates removed
(n = 2830)
Articles excluded after title
screened (n = 2570)
Records after title screened
(n = 260)
Articles excluded after abstract
screened (n = 247)
Full-text articles assessed for
eligibility (n = 13)
Full-text articles exclude (n=5)
No assessment of association(n = 1)
Non-eligible Intervention (n=1)
Could not source full text article (n=2)
No ECEC environmental variable (n=1)
Studies included in qualitative
synthesis (n = 8)