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Obesogenic environments in tribally-affiliated childcare centers and corresponding obesity rates in preschool children

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ABSTRACT

Background: Determine the relationship between obesogenic characteristics of childcare and child adiposity in tribally-affiliated centers in Oklahoma. Methods: The two-day Environment and Policy Assessment and Observation (EPAO) included a total environment (TE), nutrition (N), and physical activity (PA) score and took place in 11 centers across Oklahoma. Eighty-two preschool children (3-5 years) participated. Child height and weight were measured and overweight status (≥85th percentile for age and sex) was determined. Regression models, fit using Generalized Estimating Equations methodology to account for clustering by center were used and adjusted for center characteristics. Results: Participants were 3.8 (0.8) years old, 55% male, 67% American Indian (AI) and 38% overweight. A healthier TE and PA was associated with a reduced odds of overweight, which remained significant after adjusting for some center characteristics, but not all. A healthier TE, N, and PA was associated with lower BMI percentile, which remained significant after some center-level adjustments, but not all. Lower sedentary opportunity and sedentary time were no longer associated with reduced odds of overweight following adjustment. Lower opportunity for high sugar and high fat foods and minutes of active play were associated with reduced odds of overweight in some adjusted models. Conclusions: Collectively unadjusted and adjusted models demonstrate that some aspects of a healthier childcare center environment are associated with reduced odds of overweight and lower BMI percentile in preschool children attending tribally-affiliated childcare in Oklahoma. Future research should examine the association of childcare and health behaviors and further explore the role of potential confounders.

Introduction

During 2011–2012, 8.4% of 2-to-5-year-old U.S. children (i.e., young children) were reported to be obese (Ogden et al., 2014). In the most recently available data for Oklahoma (i.e., 2010), preschool children have a higher obesity prevalence of 14.3% which has increased from 13.1% in 2005 (Weedn et al., 2014). An ethnic disparity is also present in North America such that American Indian (AI) children have higher odds of obesity (Weedn et al., 2012; Schell and Gallo, 2012; Katzmarzyk, 2008). Following California, Oklahoma has the second highest overall number of AI residents (United States Census Bureau, 2012) which constitutes 13% of the Oklahoma's total population (United States Census Bureau, 2010). Children who are overweight and/or obese are reported to have significant health effects, including cardiovascular and metabolic diseases (Dietz, 1998) which can persist into adulthood (Freedman et al., 2005; Singh et al., 2008) and predict adult onset cardiovascular disease (Janssen et al., 2005). Interventions to prevent obesity in young children have focused on diet, physical activity, and sedentary behaviors which contribute to overall energy intake or expenditure (Hesketh and Campbell, 2010).

Recent reviews (Trost et al., 2010; Ward et al., 2010; Larson et al., 2011) and reports (American Academy of Pediatrics et al., 2012; Institute of Medicine Committee on Obesity Prevention Policies for Young Children, 2011) indicate that childcare centers can be effectively targeted for obesity-prevention interventions (Story et al., 2006). Many

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children spend a substantial amount of time at childcare weekly. In Oklahoma, 58% of children under six years of age attend childcare (Oklahoma Child Care Resource and Referral Association, Inc., 2012). Those children with full-time working mothers, with full-time defined as working ≥35 h/week, spend an average of 38 h/week in non-parent child care (Mulligan et al., 2005). Several studies have examined obesity prevalence in children attending childcare (Belfield and Kelly, 2013; Benjamin et al., 2009; Geoffroy et al., 2013; Gubbels et al., 2010a; Kimbro et al., 2007; Lin et al., 2011; Lumeng et al., 2005; Maher et al., 2008; McGrady et al., 2010; McLaren et al., 2012; O'Brien et al., 2007; Pearce et al., 2010; Rapp et al., 2005; Zahir et al., 2013; Mandal and Powell, 2014). Although not all studies agree (Belfield and Kelly, 2013; Kimbro et al., 2007; Lumeng et al., 2005; O'Brien et al., 2007; Rapp et al., 2005; Zahir et al., 2013; Mandal and Powell, 2014), it has been reported that children attending childcare are more likely to be overweight. (Geoffroy et al., 2013; Gubbels et al., 2010a; Maher et al., 2008; McGrady et al., 2010) This is likely a complex relationship, given the variability in childcare environment, child exposure and the child's home environment. There is substantial variation in obesogenic characteristics of childcare centers (Cradock et al., 2010; Benjamin et al., 2008; Kaphingst and Story, 2009; Vanderloo et al., 2012). In Oklahoma, childcare centers are subjected to limited regulations regarding nutrition and physical activity (PA) (Oklahoma Department of Human Services, 2013), thus variation would also be likely.

To most appropriately develop interventions, we need to understand the characteristics of the environment that are associated with overweight and obesity. The relationship of obesogenic childcare environments and the specific attributes of the classroom, center, and teacher interactions to overweight and obesity is relatively unreported (Vanderloo et al., 2014; Bower et al., 2008; Lyn et al., 2013; Gubbels et al., 2010b), and has not been examined among childcare that serve high-risk AI populations. Previous studies have demonstrated the physical activity and/or nutrition environment is associated with child health behaviors. (Vanderloo et al., 2014; Bower et al., 2008; Lyn et al., 2013; Gubbels et al., 2010b) However, they have not examined the combined obeseogenic environment nor the association with weight status. Tribally-affiliated childcare are facilities supported by different AI tribes and predominately serve AI children although not all children are required to be of AI descent to enroll. The purpose of this study was to determine the relationship between obesogenic characteristics of classrooms and child overweight and obesity among tribally-affiliated childcare in Oklahoma. It was hypothesized that children attending centers with less obesogenic environments would have lower adiposity, as determined by body mass index percentile and overweight classification.

Materials and methods

Study design and participants

This was a cross-sectional descriptive study of 11 AI tribally-affiliated childcare centers that provide all-day care and prepare a substantial meal (i.e., lunch) to preschool age (3–5 years) children across Oklahoma. All parents/guardians of 3–5 year old children receiving services (n = 286) were invited to participate in the project. One hundred thirty seven (48%) parents/guardians of the invited children returned a signed consent form. Eighty-two children were present on days of observation and were included in the analysis. Data were collected in 2012 and analyzed between 2013 and 2015. The University of Oklahoma Health Sciences Center, Indian Health Services, and specific participating tribes' ethics committees all approved this protocol.

Tribally-affiliated centers were recruited via telephone from the Oklahoma Tribal Child Care Association roster. Centers were located across Oklahoma, however, all were located in rural areas. There is currently a lack of standardization across all childcare in Oklahoma pertaining to health curriculum, staff training on health, or facilities and equipment. All participated in the Child and Adult Care Food Program (CACFP) which requires minimum portions and nutrient quality. Attempts were made to contact all 38 tribal child care programs within the state; 10 programs could not be contacted; 13 programs were not eligible as they did not have a facility or did not care for preschool-age children; eight programs were interested but conflicts arose with scheduling; and seven programs representing 11 centers were successfully recruited. A two-consecutive day environmental observation was conducted in all centers, including the preschool classroom(s), the lunch room if separate from the classroom, and outdoor and indoor play areas. One center had three classrooms, separated by age. Two centers had two preschool classrooms with mixed age grouping. The remaining eight centers had one classroom for children of all eligible ages.

Measures

Environment and Policy Assessment and Observation Instrument (EPAO)

The observation component of the Environment and Policy Assessment and Observation Instrument (EPAO) was used (Ward et al., 2008). The instrument consists of a full-day observation; inter-rater observations have been reported to be sufficient (87.3% agreement) (Ward et al., 2008). Researcher training consisted of several hours of classroom training and, at minimum, two days of field training. Before researchers could observe independently, agreements between classroom comparisons of trainees and a master observer, trained by EPAO instrument developers, were reached. As questions arose, the research team discussed these for consistency in scoring. Six observers contributed to classroom observations over the course of the study. Following training, percent agreement across observers was not determined. The document review component of the EPAO was not included to reduce burden for center directors.

The EPAO includes 64 individual items and is described elsewhere (Ward et al., 2008). Those individual items are integrated into six nutrition subscores and five PA subscores (Table 1). The item responses on the EPAO observation were converted from their raw response to a 3-point score (0, 1, and 2) with higher scores for more desired characteristics, averaged within a given subscale, and multiplied by 10, with the average of all subscale scores representing the respective nutrition or PA score (Ward et al., 2008). The nutrition and PA scores were summed to create the total environment score. Environment scores were averaged across both days of observation for analyses. A higher value for each scale indicated a more healthful, less obesogenic environment, including opportunities for sedentary activity and sedentary environment

Time in activity and activity bouts

In addition to the EPAO observation and subsequent score development, the total time spent in sedentary activities, TV viewing, active play, outdoor active play, number of PA bouts, and structured PA were recorded using a digital wrist watch. Sedentary time included TV viewing and other seated activities. Active play included free play outdoors and indoors and did not include structured PA led by teachers or staff. Structured PA was exclusive of outdoor time and active play. Structured PA was not included in outdoor time or active play time, since the activity was teacher-led and children did not have a choice to participate or not. Time in activity and activity bouts were averaged across both days of observation.

Weather

The daily high temperature and presence of precipitation were recorded for each day of observation. Weather was a hypothesized extraneous factor in EPAO scores due to potentially lower outdoor time and participation in physical activity (Tucker and Gilliland, 2007; Carson and Spence, 2010). The daily temperature high for the location was recorded by the observer using reliable smart phone weather application.

Table 1
Environmental attributes contributing to EPAO scores.

Scale	Subscale	Attributes
Nutrition		
	Fruits and vegetables served	Frequency of fruit and vegetable (including dark green, red, orange, and yellow) servings; Fresh, frozen, canned fruit and vegetables served; Frequency of fried vegetables; Vegetable preparation with additional fats
	High sugar/high fat foods served	Frequency of pre-fried meats served; Frequency of pre-fried potatoes served; Frequency of high fat meats served; Frequency of lean means served; Frequency of sweet, high fat, high salt food served
	Access to beverages and water	Frequency of 100% juice served; Ease and availability of drinking water indoors and outdoors; Frequency of sugar drinks served; Frequency and type of milk served
	Nutrition staff behaviors	Determination of fullness before removing plate; Determination of hunger before serving seconds; Encouragement of picky eaters; Use of food as reward; Use of food as behavioral control; Frequency and number of staff sitting with children during meals; Staff food and beverage consumption
	Nutrition environment	Breakfast and lunch service style; Presence and location of vending machines
	Nutrition training and education	Frequency of staff talking with children about healthy foods; Observation of formal nutrition education
Physical activity		
	Opportunities for physical activity	Duration of activity play time; presence and duration of structured activity; presence and duration of outdoor play
	Opportunities for sedentary activity	Frequency of extended sitting; presence and duration of TV viewing; Observation of video game playing
	Sedentary environment	Presence of TV, VCR/DVD, computer, video games; Posters, pictures, books about physical activity
	Physical activity environment	Presence of climbing structures, balance surfaces, running space, swinging equipment, play structures, floor play equipment, jumping equipment, twirling equipment, miscellaneous equipment; Suitability of indoor space for active play
	Physical activity staff behaviors	Restriction of active play; Increasing active play; Staff joining active play; Making positive statements about activity; Providing prompts to INCREASE activity; Providing prompts to decrease activity; Observation of physical activity education

The researcher recorded the presence of precipitation during the day of the observation.

Body mass index percentile

Height and weight were measured by trained researchers using standard protocols using a portable SECA scale and stadiometer (Hanover, MD). Body mass index (BMI; kg/m^2) and age- and sex- percentile were calculated and weight status determined (≥85th percentile) (Kuczmarski and Flegal, 2000).

Child demographic characteristics

Parents completed a demographic questionnaire that asked their child's age, sex, hours per day attending child care, and race/ethnicity. Participants could select up to three race/ethnicity categories. Responses were combined into three mutually exclusive groups: 1) any indication of AI; 2) White with no indication of any non-White race/ethnicity; and 3) all other responses.

Center demographic characteristics

Directors reported center characteristics including the percent AI enrollment; years of center operation; participation in the CACFP; number of 3–5 year old children enrolled (i.e., center size); and director and teacher education.

Statistical analyses

Descriptive characteristics of the children and the center environment, including means, standard deviations, and frequencies were calculated. Children in centers with multiple classrooms were assigned to the classroom in which they spent the majority of the day, for analysis purposes. When investigating the association between classroom-level EPAO scores and child-level overweight and body mass index, children in the same classroom were assigned the classroom-level EPAO score as the independent variable and child-level overweight measures were modeled as the outcome variable.

Univariate analyses examined the relationship between independent factors, including EPAO total environment, nutrition score, PA score, individual respective subscores, and time spent in various daily activities, and the outcome variables. Logistic regression models were used for classification of overweight. Linear regression models were used for BMI percentile. Given potential model instability due to a small sample size, none of the subscores were examined in association with BMI percentile. Univariate analyses were adjusted for center demographic variables. Each potential confounding factor was considered separately due to the limited number of centers participating. A 10% change in the regression coefficient for linear models or in the odds ratio for logistic models for the environmental factor was used to determine if the center demographic characteristic was indeed a confounder (Maldonado and Greenland, 1993). Due to the correlation among measures made on children in the same center and the overall small number of centers, a Generalized Estimating Equations (GEE) methodology with a small sample adjusted standard error was used to fit the univariate logistic and linear regression models (Liang and Zeger, 1986; Mancl and DeRouen, 2001). A working exchangeable correlation structure was used when fitting the regression models. An exchangeable structure was chosen because children with the same center may switch classrooms throughout the day and interact with other children beyond those in a particular classroom. Also, some factors were center-level exposures and therefore, it is reasonable to assume equal correlation among all children in the same center. A 2-sided 0.05 alpha level was used to define statistical significance. SAS 9.3 was used for all analyses.

Results

Eleven tribally-affiliated centers across Oklahoma participated. Child characteristics are in Table 2. Among the children whose parent/guardian returned a signed consent form but were not present on the observation day, 60% were male and 49% were American Indian. Center demographics are in Table 3. The time spent in physical activities and sedentary behaviors is presented in Table 4. The two-day average EPAO scores are presented in Fig. 1.

Table 2
Descriptive characteristics of three to five year old participants in childcare centers across Oklahoma ($n = 82$) in 2012.

Variable	Mean (*SD*) or percentage
Age (yrs)	3.8 (0.8)
Sex	
Male	55%
Race[a]	
American Indian	67%
White	28%
Other	5%
Hours per day at child care	7.6 (1.6)
Body mass index percentile	69.8 (26.7)
Weight status	
Normal weight	62.2%
Overweight (≥85th percentile)	37.8%

SD = standard deviation.
[a] Race/ethnicity categories were combined into three mutually exclusive groups: any indication of American Indian or Alaska Native, white only with no indication of any non-White race or ethnicity, and all other responses.

Table 3
Descriptive characteristics of participating childcare centers ($n = 11$).

Variable	Mean (*SD*) or percentage	Range
Number children/center	7.5 ± 3.6	3–14
Percent American Indian enrollment	37.3 ± 25.8	25.0–100.0
Percent overweight/obese	40.3 ± 16.0	14.3–66.7
Percent observations by month in 2012		n/a
March	9.1	
May	27.2	
June	18.2	
July	18.2	
August	9.1	
September	9.1	
November	9.1	
Years of center operation	13.9 ± 8.2	6–28
Center size	27.0 ± 21.1	3–78
Director education (% of centers)		n/a
Some college	50	
≥4 year college	50	
Teacher education (% of centers)		n/a
GED/HS + 120 h early care (CDA)	30	
College degree (BA/BS)	10	
Some with CDA and some BA/BS	20	
Participate in CACFP (% of centers)	100	n/a
Family style meal service (% of centers)	36.4	n/a

CDA = Child Development Associate. Certification requiring 120 h of early education plus GED/HS.
CACFP = Child and Adult Care Food Program.

Daily high temperatures ranged from 60 to 111 degrees Fahrenheit. Of the 22 days of observation, there were five days with some precipitation. Neither temperature nor precipitation was correlated with total environment, nutrition, or PA scores and was therefore not included as a covariate.

Classification of overweight

A higher total environment score and PA environment score was associated with 9% and 18% reductions in the odds of overweight in unadjusted analyses, respectively (Table 5). Although none of the center characteristics were determined to be confounders, the inclusion of director and teacher education eliminated statistical significance for both the total and PA environment scores. Adjustment for center size eliminated statistical significance for the total environment. Adjustment for years of operation altered statistical inference regarding the PA score. The nutrition score was not significantly associated with the odds of overweight nor were any of the center demographic characteristics determined to be confounders or alter statistical inference.

Regarding individual nutrition subscores and overweight classification, high sugar and high fat is of note. In unadjusted models, this subscore was not associated with odds of overweight classification. However, in models adjusted for years of operation ($OR = 0.72$, 95% CI 0.60, 0.87, $p = 0.0005$), center size ($OR = 0.74$, 95% CI 0.56, 0.97, $p = 0.027$), or director ($OR = 0.69$, 95% CI 0.56, 0.86, $p = 0.0007$) and teacher ($OR = 0.74$, 95% CI 0.62, 0.88, $p = 0.0008$) education, the association became significant. Only teacher education met confounding requirements.

Regarding individual PA subscore analyses and overweight classification, sedentary opportunities and the PA environment are of note. In unadjusted models, fewer sedentary opportunities were associated with 5% lower odds of overweight classification. However, when adjusted for confounders, it ceased to be statistically significant. Interestingly, unadjusted models did not show a relationship between the PA environment and overweight. However, when adjusted for percent AI, a healthier PA environment was associated with lower odds of overweight ($OR = 0.94$, 95% CI 0.90, 0.98, $p = 0.0022$) although percent AI did not meet the criterion for confounding.

Regarding time in various daily activities, a one minute higher recorded sedentary time was associated with 1% higher odds of being overweight, in unadjusted models. When adjusted for center characteristics, it was no longer significant. Unadjusted models did not show minutes of active play to be associated with odds of overweight. However, when adjusted for percent AI (OR = 1.0, 95% CI 0.99, 1.0, p = 0.0398), center size ($OR = 1.0$, 95% CI 0.99, 1.0, $p = 0.0102$), and director education ($OR = 0.99$, 95% CI 0.99, 1.0, $p = 0.0125$), minutes of active play became associated with odds of overweight, statistically significant, although none met the criterion for confounding. Each of the center characteristics were determined to be confounders, in at least some of the models, although there were no concomitant changes in statistical inference.

Table 4
Time spent in physical activity and sedentary behavior in 11 childcare centers across Oklahoma.

Variable	Mean (*SD*)	Range
Number of activity bouts/day	3.5 (1.9)	(1.0–8.0)
Total minutes active play time/day	118.9 (74.6)	(28.5–273.5)
Total minutes structured activity/day	8.2 (11.7)	(0.0–45.0)
Total minutes outdoor play time/day	99.3 (70.2)	(28.5–261.5)
Total minutes of sedentary time/day	90.7 (46.4)	(32.0–153.5)
Total minutes of TV viewing time/day	38.8 (45.4)	(0.0–107.5)

Minutes of time in physical activity and sedentary behaviors as recorded by a stop watch, averaged over two days of observation per child care center classroom. Active play time can include outdoor play time, but does not include structured activity. Total sedentary time can include TV viewing time. A bout of physical activity was defined as an occasion of physical activity, by at least half the class lasting longer than 1 min.
SD = standard deviation.

Body Mass Index Percentile

In unadjusted analyses, the total environment score (linear regression coefficient $\beta = -1.15$, standard error (SE) = 0.49, $p = 0.019$), nutrition score ($\beta = -1.70$, SE = 0.84, $p = 0.044$), and PA score ($\beta = -2.47$, SE = 1.09, $p = 0.023$) were significantly associated with BMI percentile. Percent AI children attending childcare was determined to be a confounder for some of the associations. The relationship between the PA environment and BMI percentile ceased to be significant once adjusted for percent AI. The association between total environment score, nutrition score, and PA score and BMI percentile were no longer statistically significant when adjusted for years of operation, center size, teacher education, and director education. As noted above, the limited sample size precluded all confounders being included in a single model. These findings indicate, that when examining BMI percentile, the inclusion of potential confounders in the model eliminated the relationship between the environment score (total, nutrition, and physical activity) and weight outcome. The change in regression coefficient estimates, standard error estimates, and elimination of statistical significance was not observed as frequently in the models utilizing categorical overweight status as the outcome compared to the continuous measure of BMI percentile. There was greater consistency in the estimated regression parameter values with the use of the categorized obesity variable compared with the continuous outcome of BMI percentile.

Discussion

The primary findings of this study are that elements of the childcare environment, particularly related to nutrition and PA, are associated with child adiposity in unadjusted, and some adjusted, statistical models in tribally-affiliated childcare in Oklahoma. A less obesogenic, healthier total environment was associated with lower BMI percentile and lower odds of overweight classification in preschool children. Although, this relationship was tempered with adjustment of center-level variables. Both nutrition and PA environment scores indicating a more healthful environment were associated with lower BMI percentile. Additionally, a healthier PA environment score was associated

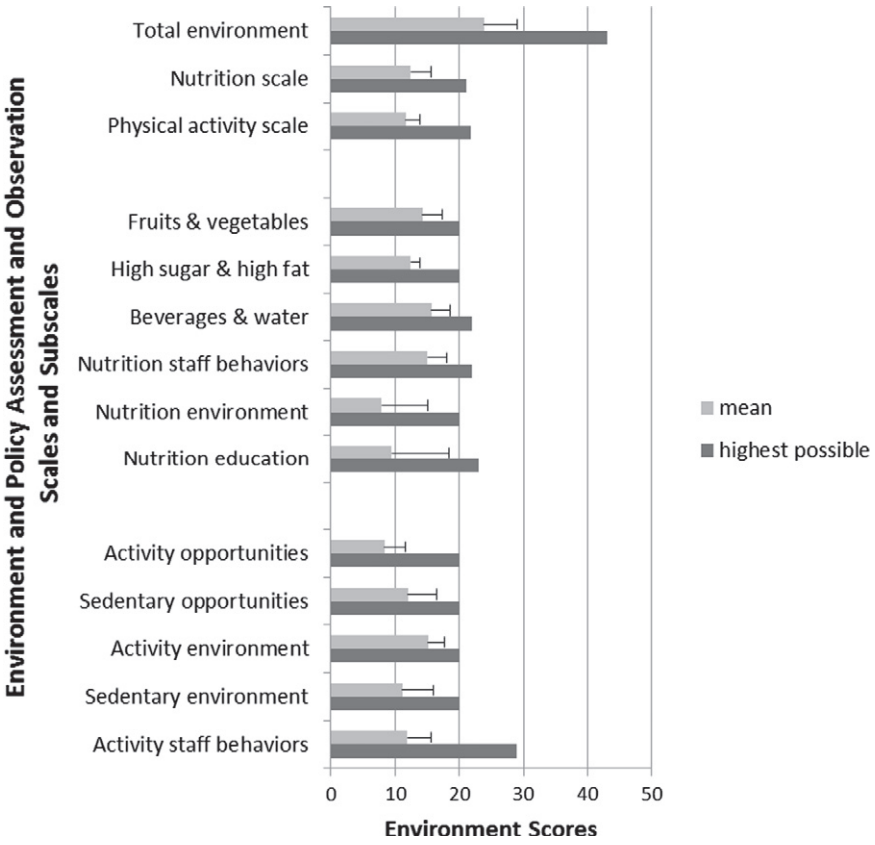

Fig. 1. Obesogenic environment scores for 11 American Indian child care centers across Oklahoma in 2012.

with lower odds of children being overweight. Although, with adjustment for center demographic characteristics, some of these relationships ceased to be statistically significant, which may be a product of small sample size. Other findings of note include the lower presence of high sugar and high fat foods associated with lower odds of overweight, when adjusted for center-level characteristics; an environment with more support for activity was associated with lower odds of overweight when adjusted for the percent AI enrolled at the center; and higher minutes of active play was associated with lower odds of overweight when adjusted for center-level attributes. Lower opportunities for sedentary activities and actual minutes in sedentary time were associated with lower odds of overweight, however, once adjusted for center-level characteristics those associations were no longer significant.

The consistency and strength of the relationship between the environment and adiposity outcomes leads us to conclude that attributes of the environment that support PA and nutrition are important for obesity prevention in young children. These findings are particularly important given the higher obesity prevalence observed in AI populations in Canada (Katzmarzyk, 2008), the U.S. (Harris et al., 2006; Zephier et al., 2006) and in Oklahoma (Weedn et al., 2014; Dennison et al., in press). Further, analyses of the individual environmental attributes that may be driving this observed relationship revealed five subscores that were associated with either one or both adiposity outcomes in the hypothesized direction. These include fewer opportunities for sedentary behavior, actual minutes spent in sedentary time, high fat and high sugar foods, and the actual minutes spent in active play time (Table 4).

A few studies have conducted environmental assessments of childcare centers (Vanderloo et al., 2014; Bower et al., 2008; Lyn et al., 2013; Gubbels et al., 2010b). However, those studies examined only the PA environment (Vanderloo et al., 2014; Bower et al., 2008; Gubbels et al., 2010b) or the nutrition environment (Lyn et al., 2013), not the combined obesogenic environment. The mean nutrition environment score in the current study (12.5) was similar to that reported in childcare in Georgia (12.1) (Lyn et al., 2013). The mean PA environment score in the current study was 11.7, which is higher (healthier) than previous reports from studies in North Carolina (10.2) (Bower et al., 2008) and Canada (8.3) (Vanderloo et al., 2014). Comparisons could not be made to Gubbels et al. (Gubbels et al., 2010b) as the total PA environment score was not reported. However, these three studies agree and demonstrate that as the PA environment is less obesogenic, children engage in more PA (Vanderloo et al., 2014; Bower et al., 2008; Gubbels et al., 2010b). Both Bower et al. (Bower et al., 2008) and Vanderloo et al. (Vanderloo et al., 2014) showed that access to play equipment in the PA environment is important for engaging in PA. This supports our finding that the PA environment score is associated with adiposity. Our study demonstrates that the sedentary opportunities score, which in part assesses access to TV, was associated with adiposity. In the previous literature examining sedentary opportunities, one study (Vanderloo et al., 2014) reported that the sedentary opportunities score was associated with children's PA, while another did not (Bower et al., 2008). This is not surprising, as high volumes of TV viewing have been associated with overweight classification in school age children and adolescents. While other studies have not examined the nutrition environment of childcare and adiposity, previous literature

Table 5
Unadjusted and adjusted association between child care center environment and preschooler overweight classification.

	Unadjusted analysis			Adjusted for % American Indian children ([b])		Adjusted for years of operation ([c])		Adjusted for program size ([d])		Adjusted for director education ([e])		Adjusted for teacher education ([f])	
Environmental variable	OR	95% CI	p-value	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Total environment	**0.91**	**0.86, 0.97**	0.004	**0.90**	**0.81, 0.99**	**0.92**	**0.87, 0.98**	0.92	0.84, 1.01	0.93	0.87, 1.00	0.96	0.85, 1.08
Nutrition Scale	0.90	0.80, 1.01	0.066	0.91	0.73, 1.13	0.92	0.8, 1.05	0.9	0.79, 1.03	0.92	0.81, 1.05	0.98	0.81, 1.19
Physical Activity Scale	**0.82**	**0.73, 0.92**	0.002	**0.81**	**0.66, 0.99**	0.86	0.71, 1.04	0.86	0.74, 0.99	0.86	0.73, 1.00	0.9	0.64, 1.26
Nutrition subscale													
Fruits & vegetables	0.95	0.82, 1.10	0.53	0.97	0.83, 1.14	0.93	0.83, 1.03	0.93	0.79, 1.11	0.9	0.77, 1.05	0.93	0.84, 1.04
High sugar & high fat	0.77	0.55, 1.08	0.13	0.72	0.46, 1.14	**0.72**	**0.6, 0.87**	**0.74**	**0.56, 0.97**	**0.69**	**0.56, 0.86**	**0.74**	**0.62, 0.88**
Beverages & water	0.99	0.80, 1.24	0.95	1.00	0.82, 1.21	0.97	0.75, 1.26	0.99	0.82, 1.18	0.98	0.81, 1.2	1.03	0.85, 1.24
Nutrition staff behaviors	0.89	0.77, 1.04	0.16	0.90	0.77, 1.06	0.96	0.81, 1.14	0.94	0.76, 1.15	0.93	0.76, 1.14	0.99	0.84, 1.17
Nutrition environment	0.97	0.85, 1.11	0.67	0.96	0.88, 1.06	0.96	0.9, 1.02	0.96	0.89, 1.03	0.97	0.91, 1.04	1.00	0.92, 1.08
Nutrition education	0.99	0.91, 1.07	0.77	0.99	0.92, 1.08	0.99	0.93, 1.06	0.98	0.92, 1.04	0.99	0.92, 1.06	1.01	0.94, 1.08
Physical activity subscale													
Activity opportunities	0.85	0.63, 1.14	0.28	0.96	0.86, 1.07	0.98	0.83, 1.15	0.95	0.86, 1.05	0.95	0.83, 1.09	0.98	0.84, 1.14
Sedentary opportunities	**0.95**	**0.90, 1.00**	0.031	0.93	0.80, 1.08	0.95	0.82, 1.09	0.94	0.83, 1.08	0.94	0.82, 1.08	0.96	0.85, 1.09
Activity environment	0.91	0.83, 1.00	0.051	**0.94**	**0.90, 0.98**	0.96	0.85, 1.08	0.93	0.84, 1.03	0.93	0.83, 1.04	0.96	0.86, 1.07
Sedentary environment	1.00	0.89, 1.13	0.97	0.99	0.88, 1.10	0.94	0.83, 1.07	1.02	0.93, 1.13	1.02	0.91, 1.14	1.00	0.91, 1.1
Activity staff behaviors	0.91	0.81, 1.03	0.14	0.98	0.85, 1.14	0.96	0.79, 1.18	0.95	0.83, 1.08	0.95	0.79, 1.14	0.99	0.78, 1.24
Recorded Time in Activities													
Sedentary time	1.01	1.00, 1.01	0.004	1.00	0.99, 1.01	1.00	0.99, 1.02	1.00	0.99, 1.01	1.00	0.99, 1.02	1.00	0.98, 1.01
TV viewing	1.00	0.99, 1.01	0.55	1.00	0.99, 1.02	1.00	1, 1.01	1.00	0.99, 1.02	1.00	0.99, 1.01	1.00	1, 1.01
Active play	1.00	0.98, 1.01	0.76	**1.00**	**0.99, 1.00**	1.00	0.99, 1.00	**1.00**	**0.99, 1.00**	**0.99**	**0.99, 1.00**	1.00	0.99, 1
Outdoor active play	1.00	0.98, 1.01	0.66	1.00	0.99, 1.00	1.00	0.99, 1.00	1.00	0.98, 1.01	1.00	0.99, 1.00	1.00	0.99, 1
Number of activity bouts	0.88	0.71, 1.09	0.24	0.96	0.86, 1.07	1.05	0.59, 1.9	0.91	0.72, 1.15	0.93	0.48, 1.81	1.01	0.72, 1.4
Structured physical activity	1.00	0.89, 1.12	0.96	1.01	0.92, 1.10	1.00	0.89, 1.13	0.99	0.85, 1.14	0.99	0.86, 1.14	1.00	0.89, 1.12

Bold denotes statistical significance as determined by a univariate and adjusted logistic regression models fit using Generalized Estimating Equations with an adjusted standard error $p \leq 0.05$. OR = odds ratio, SE = standard error, CI = confidence interval.

supports the current study's findings that frequency of serving high fat and high sugar foods is associated with adiposity (Millar et al., 2014).

While childcare demographic characteristics were not consistently determined as confounders, they did alter the statistical significance of some associations. These variables include the teachers' level of education, years of operation, center size, the director's level of education, and the percent of AI children in attendance. These changes in statistical inference, particularly in the instances where the environment ceased to be significant with the inclusion of the potential confounder (i.e., total environment score and PA environment score) could potentially be a product of a small sample size; inclusion of more variables in the model may have increased the instability of the model estimates (Peduzzi et al., 1996). However, it is clear these variables should not be ignored and do contribute to the relationship between the childcare environment and overweight classification and should, therefore, be explored in future studies.

The strengths and limitations of this study warrant discussion. Strengths include the use of reliable environmental observation tool (Ward et al., 2008) and the rigorous classroom and field training completed by researchers. Exclusion of the document review in the current study protocol is a limitation as perhaps the center had policies and trainings that were not clearly communicated. Understanding the childcare policies could better help interpret the current study findings. Measurement of height and weight by trained researchers, rather than parent report, reduces the error associated with recall and social desirability bias. The partnership with tribally-affiliated childcare across the state is also a strength given the cohesiveness of their community and their willingness to allow outsiders in for the future benefit of their young. Focusing on American Indians is important, given their increased risk for obesity-related disease most notable being diabetes and the high proportion of American Indians living in Oklahoma. However, it also limits generalizability to other populations.

Limitations also include the small sample size which precludes the inclusion of multiple potential confounders in a single analytical model, as addressed above. Several of the center demographic characteristics were determined to be confounders, at least in some models, and/or alter the statistical significance even if the burden of confounding was not met. Since all possible confounders could not be included in the same model, it is unknown which of these may be the most pertinent or relevant to consider in future studies. Additionally, accounting for the length of time children had been enrolled would provide understanding regarding the exposure of the center environment. Even though this study was conducted in 11 facilities, the number of preschool age children at each childcare was small, thereby limiting the sample which could be recruited. The research team worked closely with the center directors for several weeks before the scheduled observation, to ensure maximal study enrollment. However, not all enrolled children were present on the days of observation, further reducing the sample size. Demographic characteristics for those who were absent were similar to those who were present. Future observations should be conducted on non-consecutive, randomly determined days and account for the number of hours spent in childcare. Finally, centers that participate in the CACFP provide more nutritious food than those that do not (Ritchie et al., 2012). All centers in this study participated in the CACFP which may have limited variability in foods served and policies thus limiting the potential relationship between the childcare nutrition environment.

In conclusion, this is the first study to demonstrate that elements of the childcare environment are associated with BMI percentile and overweight classification in young children attending tribally-affiliated facilities. It appears that extended bouts of sedentary time, access to TVs and video games, frequency of high fat and high sugar foods, time spent in active play, and access to play equipment are primary driving features of this relationship, although more research is needed. Future studies should examine if these attributes can be modified and the best methods for doing so within the larger context of the center and family environments in which children live. Additional research should assess the short- and long-term effectiveness of interventions addressing these environmental attributes.

Conflict of interest

This study was supported by the Gretchen Swanson Center for Human Nutrition, the University of Oklahoma Health Sciences Center Stephenson Cancer Center, and the University of Oklahoma Health Sciences Center Department of Nutrition Sciences. Partial funding provided by National Institutes of Health, National Institute of General Medical Sciences, grant 1 U54GM104938. Study sponsors had no role in the study design, data collection, analyses, data interpretation, manuscript writing, or submission. No authors have any conflicts of interest to disclose. No financial disclosures were reported by the authors.

Transparency document

The Transparency document associated with this article can be found, in online version.

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