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Early Child Care and Adiposity at Ages 1 and 3 Years

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Abstract

BACKGROUND—The majority of infants in the United States are in non-parental child care, yet little is known about the effect of child care on development of obesity.

OBJECTIVE—To examine the relationship between child care attendance from birth to 6 months and adiposity at 1 and 3 years of age.

METHODS—We studied 1138 children from a prospective cohort of pregnant women and their offspring. The main exposure was time in child care from birth to 6 months of age, overall and by type of care: (1) child care center; (2) someone else's home; and (3) child's own home by nonparent. The main outcomes were weight-for-length (WFL) z score at 1 year and BMI *z* score at 3 years of age.

RESULTS—A total of 649 (57%) infants attended child care; 17% were cared for in a center, 27% in someone else's home, and 21% in their own home by a nonparent. After adjustment for confounders, overall time in child care was associated with an increased WFL z score at 1 year and BMI *z* score at 3 years of age but not skinfold thicknesses. Center and own home care were not associated with the outcomes, but care in someone else's home was associated with an increase in both the 1- and 3-year outcomes.

CONCLUSION—Child care in the first 6 months of life, especially in someone else's home, was associated with an increased WFL z score at 1 year and BMI *z* score at 3 years of age.

Keywords

child care; childhood obesity; nutrition; physical activity; infancy

In the United States, an estimated 9% to 12% of children <2 years of age are overweight.[1,2] Among preschool-aged children the prevalence is even higher, with 26.2% of children ages 2 through 5 years classified as either overweight or obese.[3] Infants with rapid weight gain during the first 2 years of life seem more likely to become overweight later in childhood,[4,5] and they also tend to have higher blood pressure as children[6] and adults[5] as well as recurrent wheezing in childhood.[7] Overweight in childhood is associated with type 2 diabetes mellitus,[8,9] hypertension and hyperlipidemia,[9,10] asthma and sleep apnea,[11,12] early

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maturation,[13] lower self-esteem,[14] and psychological and social stress.[15,16] To help prevent later obesity and its related health consequences, it is a public health priority to better understand the determinants of excessive weight gain in early childhood.

Infants spend more time in child care settings than any place but their own homes. The child care environment may promote excessive weight gain in early childhood, because child care providers may be less likely than parents to encourage healthful nutrition and physical activity behaviors.[17,18] Three previous studies examined the relationship between child care attendance and later obesity. Lumeng and colleagues[19] found that children who had attended child care 1 to 15 hours per week between ages 3 and 5 years had a lower risk of obesity between ages 6 and 12 years than those who had either not attended child care or attended for more hours. Maher et al[20] found that children who attended family, friend, or neighbor care the year before kindergarten were more likely to be obese than children who were cared for in other child care settings.[20] In the only study of infants in child care, Kim and Peterson[21] found that infants who were cared for by a relative during their first 9 months of life were less likely to have been breastfed, more likely to eat solid foods earlier than recommended, and gained more weight in that period than those receiving parental care. However, the authors were not able to assess weight status beyond 9 months of age, nor did they include measures of adiposity. The purpose of this prospective study was to examine associations of time in child care from birth to 6 months of age, both total time and in different types of child care, with measures of adiposity at 1 and 3 years of age. We hypothesized that our results for the 1-year analysis would be similar to those found by Kim and Peterson[21] and that this finding would remain for the 3-year analysis.

METHODS

Population and Study Design

Study subjects were participants in Project Viva, a prospective cohort study of pregnant women and their children. We recruited women attending their prenatal visit at 8 obstetric offices of a multi-specialty group practice in eastern Massachusetts. To participate, women were required to speak English fluently, be <22 weeks' gestation, and have a singleton pregnancy. Detailed recruitment and retention protocols for this study have been published elsewhere.[22] After obtaining informed consent, we collected health history and additional demographic information from participants via questionnaires and interviews. The human subjects committee of Harvard Medical School and Harvard Pilgrim Health Care approved this study and its protocol.

Of the 2128 women who delivered a single live infant, 74 withdrew from the study, 364 were lost to follow-up before their infant's 6-month assessment, and 7 disenrolled before the 1-year assessment. We excluded 545 additional participants for whom information was missing on 1-year clinical weight-for-length (WFL) *z* scores, leaving 1138 infants for the 1-year outcome analysis. Two hundred five additional infants did not have 3-year BMI *z*-score data, leaving a total sample size of 933 available for the 3-year outcome analysis.

Comparison of the 1138 participants included in this analysis with the 990 who were excluded showed a higher proportion of maternal white race (71% vs 61%) and annual household income exceeding $70 000 (65% vs 57%), a lower proportion of smoking during pregnancy (11% vs 15%), and longer breastfeeding duration (6.2 vs 4.9 months). The 2 groups did not differ on the other covariates such as maternal prepregnancy BMI, maternal education, and parity.

Exposures: Hours in Child Care, Total and According to Type of Child Care

Our main exposures were number of hours in child care, both total and in 3 different types of care, from birth to 6 months of age. When their infants were 6 months old, we asked mothers to report the age when their infants first began child care and the age when care stopped for each of 3 types of child care. Types of child care were (1) child care center, (2) someone else's home such as a licensed family child care home, or family, friend, or neighbor's home, and (3) child's own home by someone other than a parent, such as a nanny, a regular infant sitter, or a relative. We computed total months in child care from birth to 6 months by subtracting the age when care started from the age when care stopped. If start and stop were in the same month, we assigned a value of 0.5 months. To compute hours per week, we used the following question for each type of child care: "In the past month, on average, how many hours per week did your infant spend there?" If an infant spent time in child care, but not in past month (n = 39), we assigned a value equal to the median for each type of care (center: 30 hours/week, someone else's home: 27 hours/week, own home by nonparent: 16 hours/week). We imputed data for 12 infants for center, 18 infants for someone else's home, and 19 infants for own home by nonparent.

We then computed total hours in child care and total hours in each of the 3 types of child care from birth to 6 months as: (total months in child care from birth to 6 months) × (mean hours per week) × 4.3 weeks in a month. If an infant did not attend child care, we assigned a value of 0.

Outcome: 1- and 3-Year Adiposity

The main adiposity outcomes were WFL z score at 1 year of age and BMI z score at 3 years of age. Secondary outcomes at 3 years of age included sum of sub-scapular and triceps skinfold thickness (SS+TR) for overall adiposity and their ratio (SS/TR) for central adiposity. We obtained clinician-measured 1-year weight and length data for each infant from medical charts and calculated age- and gender-specific WFL z scores by using 2000 Centers for Disease Control and Prevention reference data.[23] In a previous study of clinical measures of weight and length, we found that clinical staff systematically overestimated length in children 0 to 23 months of age.[24] We found that the magnitude of this bias increased with the length of the child. Overestimation included a component proportional to the length of the child (95.3%) plus a constant of 1.88 cm. Therefore, for this analysis, we corrected clinical length measurements by using the following formula: corrected length in cm = (length in cm × 0.953) + 1.88.[24]

Project Viva research assistants measured height and weight by using a calibrated stadiometer (Shorr Productions, Olney, MD) and scale (Seca model 881; Seca Corporation, Havover, MD), and subscapular and triceps skin-fold thicknesses with a Holtain caliper (Holtain Ltd, Crosswell, Crymych, Dyfed Wales, United Kingdom). We calculated age- and gender-specific 3-year BMI z scores by using 2000 Centers for Disease Control and Prevention reference data.[23] Project Viva data collectors adhered to standard measurement techniques[25] and participated in twice-yearly anthropometric training.

Other Measures

Through maternal report by questionnaire and interview, we collected data on maternal race/ethnicity, age, education, parity, smoking (never, former, during pregnancy), prepregnancy BMI, paternal BMI, child's race/ethnicity, and household income. We calculated gestational age from the last menstrual period or from the second trimester ultrasound if the 2 estimates differed by >10 days. We calculated child age at 1 and 3 years on the basis of date of birth. On the 1-year questionnaires, we asked mothers to report if they were still breastfeeding. If they had stopped, we asked them to report children's ages at cessation. We also asked

mothers to report their children's sleep duration and television viewing in average hours per day at 6 months of age for the 1-year outcome; for the 3-year outcome, we used a weighted average from 6 months to 2 years.

Data Analysis

We used multiple linear regression models to examine the associations between child care attendance from birth to 6 months of age and 1- and 3-year adiposity. We modeled hours in child care as a continuous variable.

In multivariable models, we included only those covariates that were of a priori interest or that confounded associations of child care with our adiposity outcomes. The final multivariable model included child's age, gender, and race/ethnicity; mother's prepregnancy BMI, smoking during pregnancy, and parity; father's BMI; and household income. For the analyses of type of child care, because infants could spend time in >1 type of child care over the course of 6 months, we examined each of the 3 types of child care in separate linear regression models. For all analyses, we also examined the potential mediators of breastfeeding duration, sleep duration, and television viewing, adding each to the model individually and then all 3 at once. We conducted all analyses by using SAS version 9.1 (SAS Institute, Inc, Cary, NC).

RESULTS

Participant Characteristics

Between birth and 6 months of age, 649 (57%) of the 1138 infants spent time in child care (Table 1). Of those, 189 (17%) infants spent time in a child care center, 308 (27%) spent time in someone else's home, and 239 (21%) were cared for in their own home by someone other than a parent. Among all infants, mean (SD, range) hours per week in care were 12.4 (9.0, 0.1–52.5) hours for any child care, 11.3 (8.5, 0.1–34.3) hours for child care center, 11.7 (8.3, 0.1–46.3) hours for someone else's home, and 9.6 (9.4, 0.1–52.5) hours for child's own home.

Compared with children who had no child care arrangement, children who attended child care were breastfed for shorter durations (mean: 5.8 vs 6.7 months) (Table 1). They were also more likely to be black (15.3% vs 14.1%) or Hispanic/Latino (5.2% vs 3.9%) and come from families with incomes ≥$70 000 per year (69.7% vs 58.5%) but did not differ on sleep duration and television viewing during infancy.

Exposures: Hours in Child Care, Total and According to Type of Child Care

We ranked hours in child care into categories, keeping 0 hours as a separate category and ranking >0 values into tertiles and found the relationship between hours of child care and the adiposity outcomes to be relatively linear. Thus, for our final analyses we modeled hours in child care as a continuous variable.

Multivariate Analysis

In a multivariable linear regression model, after adjusting for child age, race/ethnicity, and gender, maternal parity, smoking during pregnancy, prepregnancy BMI, paternal BMI, and household income, we found that child care attendance during the first 6 months of life was directly associated with the 1-year WFL *z* score (0.08 U [95% confidence interval (CI): 0.01–0.15] per every increment of 10 hours per week) and 3-year BMI *z* score (0.09 U [95% CI: 0.02 to 0.16]) (Table 2). Additional adjustment for the potential mediators of breastfeeding, sleep duration, and television viewing yielded slightly lower estimates for the 1-year and 3-year outcomes. Because we were interested in fat distribution after controlling

for overall body size, we also adjusted for child's 3-year BMI *z* score in our analyses of SS/TR. We found no relationship between child care attendance and SS+TR (0.17 U [95% CI: −0.12 to 0.47]) or SS/TR at 3 years of age (0.04 U [95% CI: −1.12 to 1.19]).

In analyses of each of the 3 types of child care, center and own home care were not associated with either of the outcomes (Table 3). However, increased child care attendance in someone else's home was associated with a greater 1-year WFL *z* score (adjusted estimate: 0.11 U [95% CI: 0.01 to 0.20] per every increment of 10 hours per week) and 3-year BMI *z* score (0.12 U [95% CI: 0.02 to 0.21]) (Table 3). Additional analyses revealed that the 1-year outcome breastfeeding duration (0.04 U [95% CI: 0.008 to 0.06]) and the 3-year outcome television viewing (0.04 U [95% CI: −0.006 to 0.08]) were primarily responsible for this attenuation.

DISCUSSION

In this study, we found that more hours in child care during the first 6 months of life was associated with an increased WFL *z* score at 1 year of age and increased BMI *z* score at 3 years of age. The association was limited to child care attendance in someone else's home. Neither center-based child care nor care in the child's own home by a nonparent was related to the adiposity outcomes.

The finding that care in someone else's home was the only type of child care associated with our main outcomes raises the possibility that this setting may be a particularly obesigenic environment. In our questionnaires, we did not separate licensed family child care homes from other types of child care in someone else's home, but it is possible that either setting could contribute to greater gain in adiposity. Family child care homes tend to be less regulated by the state than child care centers, especially regarding nutrition and physical activity, practices that may affect obesity.[26,27] Consequently, family child care homes may provide less structure, which may not be an ideal setting for an infant. Family child care homes may have 1 or 2 infants and additional older children in care, which may mean less individual time for the infants, with longer exposure to restricted movement (eg, bouncy seat) and increased opportunities for inappropriate feeding practices (eg, early introduction of solid foods). We speculate that child care providers who care for a group of children of different ages, as in a family child care home, may also be more likely to advance infants beyond their developmental readiness to help match feeding of older children. Similarly, care by a family member, friend, or neighbor in that person's home may allow for improper feeding of infants, and among them relatives in particular seem to be less likely to follow infant-feeding guidelines.[21] This may be related to generational differences in feeding practices. In addition, without the support of other child care professionals, individuals caring for children in a home-based setting may be more isolated from other adults and consequently less likely to provide healthy nutrition and physical activity environments for children.

Our results are consistent with findings from a similar study of child care during infancy. Kim and Peterson[21] found that infant care by a relative, in either the relative's home or the child's own home, compared with parental care, was associated with introduction of solid foods before 4 months of age and increased infant weight gain at 9 months of age.[21] Our results extend those of Kim and Peterson[21] by examining adiposity outcomes at older ages.

An alternative explanation for our findings is that families with some unmeasured attribute, itself related to adiposity, may be more likely to choose child care in someone else's home for their infants. Additional adjustment for other potential confounding factors did not

materially change our estimates, although we were limited to variables collected in the study.

In contrast to care in someone else's home, child care centers serve a larger number of children and therefore may have multiple infants in care. Centers typically have a classroom devoted to infant care. This type of setting may allow child care providers to be more responsive to the individual needs of infants and therefore may be less likely to promote obesity. The child care center may also allow for increased movement and physical exploration by infants in a safe and protected environment. Our findings indicate that in addition to center-based care, care in the child's own home by someone other than a parent was not related to development of adiposity. We speculate that a nanny or regular infant sitter in the child's own home may be more likely to adhere to parental preferences for feeding and physical activity. Alternatively, having a nanny or regular baby-sitter may be a marker for families with more resources, which was not captured in the household income covariate used in our analyses.

If early child care is associated with later obesity, 1 question is what are the pathways by which this effect could occur? In this study, we found that potential mediators of breastfeeding, sleep, and television viewing slightly attenuated our estimates. For the 1-year adiposity outcome, breast-feeding duration seemed to drive the attenuation. When mothers return to work and their children enter child care, they often decrease breast-feeding frequency or discontinue it altogether.[28] Consistent with this inference is the results of Kim and Peterson,[21] who found that child care attendance that was initiated before 3 months of age and care by a relative at any age in infancy were associated with shorter breastfeeding duration. Longer duration of breastfeeding may protect against development of later obesity.[29,30]

Increased television viewing[31–43] and shorter sleep duration[44–46] are also linked to obesity in children. It is possible that certain child care settings differ from the family home in ways that allow for additional television viewing and shorter sleep durations. Little is known, however, about television use or children's sleep patterns, duration of sleep, and quality of sleep in child care.

Our study has several limitations. First, the relatively high family income and education level of study participants may limit generalizability. In our sample, infants from birth to 6 months of age spent an average of 12.4 hours per week in care, which is lower than other infants from birth to 12 months of age in the United States who spent ~22 hours per week in care.[47] This may be because of the sociodemographic characteristics of our sample. However, the greater number of hours may be explained, in part, by the older ages of the infants, because time in care increases with age.[47] Second, "child care center" included Head Start Program[48] centers as well as other centers. Head Start centers are required to meet specific federal nutrition and physical activity standards that are more stringent than state regulations for licensed child care centers. However, few Project Viva families were eligible to participate in the Head Start program, and consequently, it is unlikely that this issue affected our findings. Third, this study was based on observational data and was not a randomized, controlled trial. Finally, we were not able to consider all types of child care, including no child care, in the same model, because of collinearity of the exposure variables. In our analyses, we chose to examine the amount of time in each type of care separately, unadjusted for the other types of care.

CONCLUSIONS

With vast numbers of children spending much of their infancy and pre-school years in child care, it is important to consider what occurs in child care when investigating development of childhood obesity. In this study, we found that infants who attended child care in someone else's home during their first 6 months of life had greater measures of adiposity at 1 and 3 years of age. Given that this is the most common type of child care in the United States,[49] our results indicate a need for additional exploration of nutrition and physical activity practices in home-based child care and identification of opportunities for intervention. Future studies that address adiposity development in young children in child care should consider mediators of breastfeeding, television viewing, and sleep duration, which attenuated our results.

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ABBREVIATIONS

WFL	weight for length
SS+TR	sum of subscapular and triceps skinfold thickness
SS/TR	ratio of subscapular to triceps skinfold thickness
CI	confidence interval

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TABLE 1

Child and Family Characteristics of Project Viva Participants (N = 1138)

	No Child Care (N = 489)	Any Child Care (N = 649)
Child characteristics, mean (SD)		
Gestational age at birth, wk	39.5 (1.8)	39.5 (1.7)
Breastfeeding duration at 1 y, mo	6.7 (4.7)	5.8 (4.4)
Sleep duration at 6 mo, h/d	12.3 (1.2)	12.2 (1.1)
Television viewing at 6 mo, h/d	1.3 (1.0)	1.2 (0.9)
Age at 1-y visit, mo	12.4 (0.8)	12.5 (0.7)
Age at 3-y visit, mo	39.2 (3.9)	39.0 (3.6)
Outcome measures, mean (SD)		
1-y WFL *z* score	0.27 (1.01)	0.39 (1.05)
3-y BMI *z* score	0.32 (0.97)	0.51 (1.03)
3-y SS+TR, mm	16.5 (4.0)	16.8 (4.1)
3-y SS:TR, mm	0.64 (0.16)	0.64 (0.16)
Child care attendance, mean (SD), h/wk		
Child care center	—	11.3 (8.5)
Someone else's home	—	11.7 (8.3)
Own home	—	9.6 (9.4)
Gender, female, %	49.5	49.6
Child race/ethnicity, %		
Black	14.1	15.3
White	66.5	66.6
Hispanic	3.9	5.2
Other	15.5	12.9
Family characteristics, mean (SD)		
Maternal age, y	32.0 (5.1)	32.6 (5.0)
Maternal prepregnancy BMI, kg/m^2	24.7 (5.4)	25.1 (5.6)
Paternal BMI, kg/m^2	26.4 (4.0)	26.5 (3.9)
Annual household income, %		
<$40 000	15.4	10.5
$40 000–$70 000	26.2	19.8
>$70 000	58.5	69.7
Maternal education, %		
≤High school graduate	11.7	6.8
Some college	23.8	20.3
College graduate	36.7	36.8
Graduate degree	27.9	36.2
Maternal smoking, %		
Never smoker	67.0	69.0
Former smoker	21.0	21.3
Smoker while pregnant	12.1	9.8

	No Child Care (*N* = 489)	Any Child Care (*N* = 649)
Maternal parity, %		
0	44.0	50.2
1	32.3	38.4
2	23.7	11.4

TABLE 2

Unadjusted and Multivariable Adjusted Regression Estimates (95% CI) for Associations of Child Care From Birth to 6 Months of Age, per Increment of 10 Hours per Week, With Measures of Adiposity at 1 and 3 Years of Age

Model Covariates	1-y WFL *z* Score		3-y BMI *z* Score	
	Estimate (95% CI)	***P***	**Estimate (95% CI)**	***P***
0 (unadjusted)	0.09 (0.02 to 0.15)	.01	0.12 (0.05 to 0.19)	.001
1 (model 0 +age and gender)	0.09 (0.02 to 0.15)	.01	0.12 (0.05 to 0.19)	.001
2 (model 1 +potential confounders)[a]	0.08 (0.01 to 0.15)	.03	0.09 (0.02 to 0.16)	.01
3 (model 2 +potential mediators)[b]	0.07 (−0.001 to 0.14)	.05	0.06 (−0.02 to 0.15)	.16

[a] Child race, maternal smoking during pregnancy, parity, prepregnancy BMI, paternal BMI, and household income.

[b] Child breastfeeding duration, sleep duration, and television viewing.

TABLE 3

Multivariable Adjusted[a] Regression Estimates (95% CI) for Associations of Each Type of Child Care From Birth to 6 Months of Age, per Increment of 10 Hours per Week, and Adiposity at 1 and 3 Years of Age

Model 1[a]	1-y WFL *z* Score		3-y BMI *z* Score	
	Estimate (95% CI)	*P*	Estimate (95% CI)	*P*
Child care center	0.03 (−0.08 to 0.14)	.62	0.04 (−0.08 to 0.16)	.51
Own home by nonparent	0.02 (−0.09 to 0.13)	.73	0.03 (−0.08 to 0.15)	.56
Someone else's home	0.11 (0.01 to 0.20)	.02	0.12 (0.02 to 0.21)	.02

[a] Adjusted for child age, race, gender, maternal smoking during pregnancy, parity, prepregnancy BMI, paternal BMI, and household income.