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Home and Family Environment Related to Development of Obesity: A 21-Year Longitudinal Study

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Abstract

Background: Early-life conditions are important for the development of obesity. We hypothesized that home and family characteristics reflective of less supportive environments during childhood will be associated with higher adult BMI and faster BMI growth between ages 5 and 21 years. We also examined the timing and acceleration of BMI increase by adult weight status (normal weight, overweight, obese, and extremely obese) to discern how BMI increase differs across group and across time.

Methods: BMI was assessed in 1000 Chilean youth (52% female) at ages 5, 10, 15, and 21 years. Latent growth curve analysis modeled BMI trajectories from 5 to 21 years. Observer and maternal ratings assessed children's home and family environments and parenting at 1 and 10 years.

Results: The four weight groups differed in acceleration of BMI increase starting at age 5, with bigger children getting bigger faster. Higher 21-year BMI related to family stress, father absence, maternal depression, frequent child confinement (in playpen), an unclean home environment at 1 year, and low provision for active stimulation and few stimulating experiences at 10 years. Accelerated BMI increase related to lower learning stimulation in the home at 1 year and less parental warmth and acceptance at child age 10.

Conclusions: Home and family characteristics that reflect an absence of support for children's development were associated with overweight/obesity in young adulthood and accelerated BMI growth. Findings identify several home and family characteristics that can serve as preventive or intervention targets.

Keywords: BMI growth; family stress; home environment; latent growth curve analysis; parenting

Childhood obesity is a significant public health problem. Approximately one in five U.S. children is obese, with obese youth likely to develop cardiometabolic disease and remain obese as adults.[1–3] Early-life factors can impact the development of obesity.[4,5] Adverse childhood circumstances, such as poverty, single parenting, and maternal depression, have been associated with overweight and obesity in adulthood.[6–8] Aspects of children's built environment, such as living in substandard housing and lack of access to safe, appealing play space, also pose risks for obesity.[9,10] Family factors, such as fathers' involvement in caretaking, having many siblings, and warm nurturing parenting protect against childhood obesity.[11–15] Studies also show that early and rapid weight gain leads to increased risk of obesity and disease.[16–19] Thus, identifying childhood home and family factors associated with early and rapid growth would be important for understanding the developmental origins of obesity[5] and could provide targets for obesity intervention.[20,21]

This study sought to identify home, family, and parenting characteristics present during childhood that relate to adult BMI and rate of BMI growth. We also examined how BMI growth differs across time by adult weight status, that is, for normal weight, overweight, obese, and

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extremely obese individuals. To examine these issues, we modeled BMI trajectories of 1000 Chileans who were evaluated every 5 years from ages 5 to 21. Risk factors studied were home characteristics (provision for physical activity and availability of stimulating materials), family characteristics (family stress, father absence, and maternal depression), and parents' parenting (punitive and accepting).

We tested two hypotheses. First, we hypothesized that individuals classified as normal weight, overweight, obese, or extremely obese in young adulthood will have successively greater linear increases and more accelerated increases in BMI across development, or between ages 5, 10, 15, and 21 years. Although it is inevitable that the overweight and obese groups will have higher BMIs across time, the differential timing, level, and acceleration of growth among these groups are not known *a priori.* Identifying the developmental period in which growth diverges by weight group could inform obesity intervention. Quantifying the level of BMI change per age interval by group could provide a useful preventive guideline as to how much BMI increase is too much (*i.e.*, associated with subsequent overweight/obesity). In addition, finding successively greater growth acceleration by successively larger weight groups would highlight the speed of growth as a risk factor for later obesity.

Second, we hypothesized that home and family characteristics reflective of less supportive environments at child age 1 and 10 years will be associated with a higher BMI at 21 years, greater increases in BMI, and faster BMI growth between ages 5 and 21 years. We tested these hypotheses using data from a large cohort study in Santiago, Chile. Chile is an important context to study obesity, as it has the highest prevalence of overweight/obesity in South America, with 10.6% of preschoolers and 18.5% of 1st-graders obese.[22]

Methods

Participants and Study Design

Participants were drawn from the Santiago Longitudinal Study, which involved 1790 infants in a cohort study of nutrition and growth.[23] Infants were recruited from community clinics serving low-to-middle income families (1991–1996). Eligible infants were healthy, singleton, born at term, and weighed ≥3.0 kg at birth. Participants were of mixed European, Spanish, American Indian descent. Children were studied in infancy (6–18 months), at ages 5, 10, and 21 years, and up to three times in adolescence (*M* ages 14.6, 16.2, and 17.3 years). For participants assessed more than once during adolescence, we used data from the assessment closest to age 15 years, excluding those assessed <14 ($n = 52$) or >16 ($n = 123$). This was done so that age of assessment was consistent at that time point and the time intervals between the various age periods were relatively equivalent. At the 21-year assessment, 1000 participants had BMI data; these individuals form the current analytic sample (Table 1). Individuals studied here were similar in background characteristics to those not studied (*e.g.*, birth weight, family size, family socioeconomic status, father presence, mothers' age, and so on; Supplementary Table S1; Supplementary Data are available online at www.liebertpub
.com/chi). However, participation at 21 years was higher for females and those with more educated mothers. Analyses adjusted for these variables. The sample was highly breastfed: 61% were breastfed at 6 months and 29% at 1 year. Breastfeeding was not related to BMI growth and was not considered further. All study procedures were approved by the authors' institutional review boards in the United States and Chile. Signed informed parental consent was obtained at all time points through adolescence, and child assent was obtained at 10 years and adolescence. Signed informed consent was obtained from participants at 21 years.

Measures

Body mass index. Participants' weight (kg) and height (length at 1 year; cm) were measured at 1, 5, 10, 15, and 21 years by trained staff at the Institute for Nutrition and Food Technology (INTA) at the University of Chile. With minimal clothing without shoes, weight was measured to the closest 0.1 kg using a SECA scale, and height was measured to the closest 0.1 cm using a Holtain stadiometer at ages 5–21 years. Length at 1 year was assessed by a recumbent length board. Birth weight and length were obtained from medical records. BMI was calculated from weight and height (length at birth and 1 year) (kg/m^2). Analyses involved raw BMI scores (kg/m^2) at all ages, adjusted for sex and exact age (in number of days). Recent studies support the use of raw BMI scores in assessing children's obesity risk.[24,25] Moreover, although BMI z-scores may be preferred when studied cross-sectionally, z-scores are less useful as a measure of adiposity change.[24] We also adjusted for 1-year BMI in all analyses (see Covariates section). Adult weight status was defined using the International Task Force standards,[26] with normal weight (NW) BMI <25 (45.9%), overweight (OW) BMI ≥25 and <30 (30.9%), obese (OB) BMI ≥30 and <40 (20.9%), and extremely obese (E-OB) BMI ≥40 (2.3%). Less than 2% of the sample was underweight at any time point; these individuals were included in the normal weight group.

Family characteristics. Family characteristics were assessed by maternal report at child age 1 and 10 years (Table 1). Mothers completed the 30-item Social Readjustment Rating Scale[27] to assess family stress, the 20-item Center for Epidemiologic Studies-Depression Scale[28] to assess mothers' depressed mood, and the 13-item Graffar instrument to assess family socioeconomic status (*i.e.*, parent education, occupation, and housing conditions).[29] Each scale has been validated on populations similar to the current sample.[30–32] When children were 10 years, mothers reported their prepregnancy height and weight from which

Table 1. Participant Characteristics ($N = 1000$)

	Range	Mean (SD) or %	α	Number items
Child characteristics				
†Sex	(% male)	47.7%	—	
Birth weight (gm)	3000–5040	3542.8 (363.5)	—	
Age at 5 years	5.5–6.0	5.5 (0.1)	—	
Age at 10 years	9.9–11.0	10.0 (0.1)	—	
Age at 15 years	14.0–16.0	15.3 (1.2)	—	
Age at 21 years	20.5–25.4	21.3 (0.8)	—	
BMI				
†BMI at 1 year	13.7–23.2	17.8 (1.4)	—	
BMI at 5 years	13.4–28.6	17.0 (2.2)	—	
BMI at 10 years	13.4–33.5	19.4 (3.4)	—	
BMI at 15 years	15.1–45.2	23.1 (4.4)	—	
BMI at 21 years	17.2–57.0	26.3 (5.3)	—	
Weight status at 21 years				
Normal weight		45.9%		
Overweight		30.9%		
Obese		20.9%		
Extremely obese		2.3%		
Family characteristics				
†Maternal prepregnancy BMI[a]	17.8–64.1	28.3 (5.3)	—	
†Mothers' education (years) —1 year	1–17	9.5 (2.7)	—	
Maternal age at child's birth (years)	15–44	26.5 (6.0)		
Family SES[b]—1 year	11–47	27.3 (6.4)	0.54	13
Father absent—1 year		15%	—	1
Father absent—10 years		25%	—	1
Family stressors—1 year	0–14	4.6 (2.7)	—	30
Family stressors—10 years	0–15	4.9 (2.6)	—	30
Maternal depression—1 year	0–51	15.5 (11.7)	0.90	20
Maternal depression—10 years	0–57	17.6 (12.8)	0.91	20
Number children ≤15 years—1 year	0–12	2.1 (1.2)	—	1
Mother smokes—1y		25%	—	1
Freq. HH member smokes[c]—10 years	0–4	2.4 (0.9)	—	1
Home characteristics—1 year				
Appealing interior space	0–6	4.5 (1.3)	0.70	6
Organization of environment	0–6	5.1 (0.9)	0.63	6
Cleanliness of home[d]	1–4	2.9 (0.4)	—	1
Learning material stimulation	0–5	3.8 (0.9)	0.68	5
Total physical environment[e]	0–17	13.1 (3.0)	0.78	17
Clinical impression of home[f]	1–4	2.8 (0.5)	—	1

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Table 1. Participant Characteristics (*N* = 1000) *continued*

	Range	Mean (SD) or %	α	Number items
Home characteristics—10 years				
Appealing physical environment	0–8	4.9 (1.7)	0.69	8
Growth fostering materials	0–8	4.4 (1.5)	0.65	8
Developmental stimulating experiences	0–6	3.2 (1.3)	0.68	6
Provision for active stimulation	0–8	3.4 (1.5)	0.63	8
Total physical environment[g]	0–30	16.0 (4.4)	0.70	30
Parenting factors—1 year				
Acceptance of child	0–11	6.5 (0.9)	0.63	11
Punishment of child	0–5	0.2 (0.4)	0.41	5
Confinement of child	0–3	1.5 (0.8)	0.23	3
Parenting factors—10 years				
Warmth and acceptance	0–8	5.9 (1.5)	0.67	8
Punitive parenting	0–3	0.6 (0.8)	0.79	3

See text for description of scales and coding.

[†]Denotes a covariate.

[a]Maternal prepregnancy BMI was assessed retrospectively at child age 10.

[b]Higher scores reflect greater disadvantage.

[c]Frequency household member smokes: coded 0 = no days to 4 = every day.

[d]Coded 1 = very dirty to 4 = very clean.

[e]Reflects the sum of the home's appealing interior space, organization, and learning material stimulation.

[f]Coded 1 = deficient, 2 = regular, 3 = acceptable, 4 = optimal.

[g]Reflects the sum of the home's physical appeal, growth fostering materials, developmental stimulation, and provision for active stimulation.

maternal BMI was calculated. Several studies support the accuracy of women's recall of prior body size, height, and weight.[33–35]

Home and parenting characteristics. When children were 1 year, mothers and children were observed in natural interaction in their homes for approximately 1 hour using the Home Observation for Measurement of the Environment Inventory (HOME).[36] The HOME is a well-established measure that is sensitive to variations in family conditions, including in Latin American countries.[37] The HOME includes scales of: appealing interior space (six items: *''pictures in the home''*), organization of environment (six items: *''child's play environment is safe''*), learning material stimulation (five items: ''*child has toys that develop skills*''), total physical environment (sum of the above three scale scores), and acceptance of child (11 items: ''*parent caresses or kisses child during visit''*). Items were coded as absent (0) or present (1) and summed. The HOME also includes the observer's clinical impression of the home atmosphere, with rating options of *optimal, acceptable, regular*, or *deficient* (coded 4–1, respectively) and cleanliness of the home (coded as 1 = very dirty to 4 = very clean). Two additional scores were derived from the HOME: punishment of child (five items: *''parent slaps, spanks child during visit,'' ''parent scolds, criticizes child during visit''*) and confinement of child (three items: ''*child placed in front of TV for more than ½ hour every day,'' ''child in playpen during visit''*).

When children were 10 years old, mothers were interviewed using the Middle Childhood version of the HOME (HOME-MC).[36] The HOME-MC has scales of: appealing physical environment (eight items: *''wall pictures are visible''*), growth fostering materials (eight items: *''child has access to desk for reading or studying''*), developmentally stimulating experiences (six items: *''parent helps child achieve motor skills''*), provision for active stimulation (eight items: *''child has access to playground equipment in immediate vicinity''*), a total physical environment score (sum of the above four scale scores), and parental warmth and acceptance (eight items: *''parent uses term of endearment when talking about child''*). We also derived a score for punitive parenting (three items: ''*more than 1 physical punishment within last month''*). Items were coded as absent (0) or present (1) and summed.

Statistical Analyses

Our first analyses compared BMI at each age and BMI increase per age interval for the four 21-year weight groups (NW, OW, OB, and E-OB) using ANOVA (unadjusted)

and ANCOVA (adjusted for sex, 1-year BMI, maternal BMI, and maternal education). All possible pairwise comparisons were conducted using Bonferroni correction to adjust for multiple comparisons. We also tested whether BMI and BMI increase per age interval of the four weight groups became increasingly different across age using mixed effects modeling (SAS PROC MIXED) with random intercept and slope. We tested the interaction of weight group and time (indicator for age). A significant interaction would indicate that BMI and, separately, BMI increase become increasingly different among the groups across time.

We next conducted two separate growth curve trajectory analyses. In both analyses, we modeled growth trajectories on BMI scores assessed at 5, 10, 15, and 21 years of age using MPLUS 6.1 growth mixture modeling with maximum likelihood estimation.[38] Growth curve analyses estimate average slope (linear increase or decrease) and a quadratic term (nonlinear acceleration or deceleration or a speeding up or slowing down of BMI change).[39] A significant positive quadratic term would indicate that the rate of change is changing more rapidly.[39]

For the first growth analyses, we stratified BMI trajectories by weight group (with random intercepts and slopes) to describe and compare the growth parameters (linear and quadratic) across the weight groups. Second, we modeled an unstratified growth curve trajectory for the full sample and regressed home and family characteristics (at ages 1 and 10) onto the growth parameters (intercept, slope, and quadratic). We used 21-year BMI as the intercept to identify childhood predictors of adult BMI. Slope was allowed to vary. All cases were retained using the full information maximum likelihood (FIML) specification, which fits the model being tested directly onto the nonmissing data for each participant.[40] Missing data were <20% for all variables, which is an acceptable level when implementing FIML.[40]

Sensitivity analysis. To ensure temporality between the home and family characteristics assessed at 10 years and the growth parameters, we reran the regressions using the 10-year predictors onto growth excluding 5-year BMI (*i.e.*, growth was limited to 10, 15, and 21 years). This was done so that 10-year predictors were not predicting BMI growth that included 5-year BMI.

Covariates. Several covariates were considered. Sex, child BMI at 1 year, maternal BMI, and mothers' years of education were associated with at least one growth parameter and retained as controls. Controlling for 1-year BMI allowed us to examine BMI growth between 5 and 21 years while holding prior differences in BMI (<5 years) constant.

Results

BMI and BMI Increase by 21-Year Weight Group and across Time

The mean BMI values for the total sample and the four 21-year weight groups at each age are shown in Table 2 (top) and illustrated in Figure 1. The weight groups

Table 2. BMI across Age for the Total Sample and the Four 21-Year Weight Groups

	BMI							
	Total ($N = 1000$)	NW ($n = 459$)	OW ($n = 309$)	OB ($n = 209$)	E-OB ($n = 23$)			
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	F_{unadj}	F_{adj}	p
5 years	17.0 (2.2)	16.0 (1.4)	17.0 (1.7)	18.5 (2.4)	22.0 (3.7)	97.46	65.37	0.001
10 years	19.4 (3.4)	17.5 (2.3)	19.6 (2.4)	22.3 (3.1)	27.3 (3.1)	211.01	175.28	0.001
15 years	23.1 (4.4)	20.2 (2.3)	23.5 (2.8)	27.5 (3.6)	35.2 (5.3)	427.77	293.38	0.001
21 years	26.3 (5.3)	22.0 (1.9)	27.1 (1.3)	33.1 (2.5)	42.7 (4.1)	2097.42	1482.31	0.001
	Mean BMI Increase at Each Age Interval							
	Total ($N = 1000$)	NW ($n = 459$)	OW ($n = 309$)	OB ($n = 209$)	E-OB ($n = 23$)			
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	F_{unadj}	F_{adj}	p
5–10	2.4 (2.1)	1.5 (1.7)	2.6 (1.8)	3.8 (2.1)	5.3 (1.6)	63.30	62.88	0.001
10–15	3.7 (2.6)	2.7 (1.8)	3.9 (2.3)	5.2 (3.0)	7.9 (4.9)	61.41	48.81	0.001
15–21	3.2 (3.1)	1.8 (2.0)	3.6 (2.7)	5.6 (3.3)	7.5 (3.8)	124.63	116.42	0.001

Means shown are not adjusted. Adjusted models included sex, 1-year BMI, maternal BMI, and maternal education as controls (Adjusted means can be obtained from the authors upon request). All individual group paired contrasts for both BMI and BMI increase were significant: NW < OW < OB < E-OB.

M, mean; SD, standard deviation; NW, normal weight; OW, overweight; OB, obese; E-OB, extremely obese.

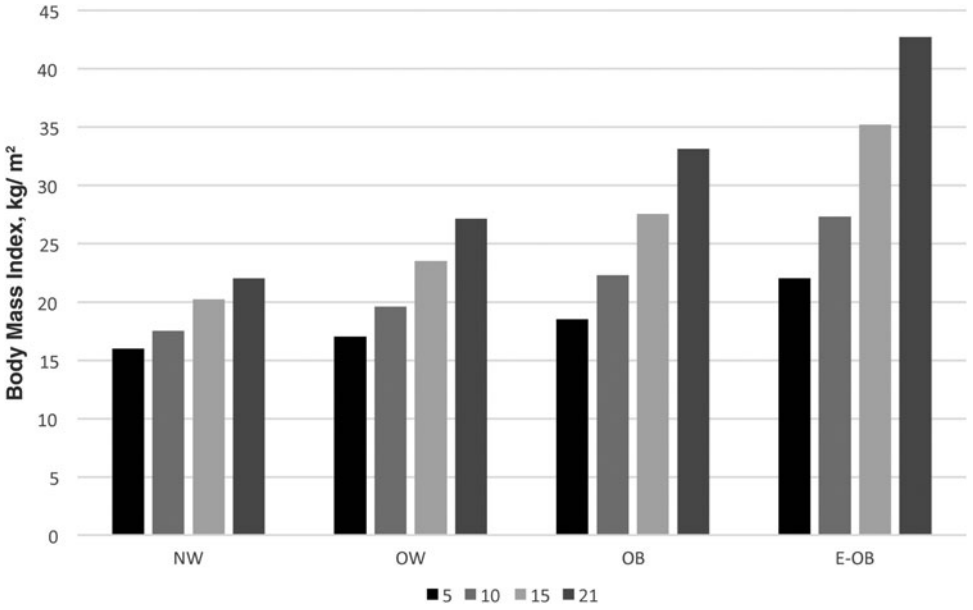

Figure 1. BMI per age by 21-year weight group. NW, normal weight; OW, overweight; OB, obese; E-OB, extremely obese.

differed in BMI at all ages (multivariate adjusted F [$df = 3$, 1311] = 535.00, $p < 0.001$). There was also a significant interaction between weight group and time (adjusted F [$df = 3$, 1311] = 579.09, $p < 0.001$), indicating that BMI of the four groups became increasingly different across time. The average BMI increase for the four weight groups across each age interval is shown in Table 2 (bottom) and illustrated in Figure 2. These values differed significantly by group, indicating that the groups had differential BMI increase per age interval (multivariate adjusted F [$df = 3$, 541] = 4.03, $p < 0.01$). There was also a significant weight group by time interaction on BMI increase per age interval (adjusted F [$df = 3$, 541] = 8.24, $p < 0.001$), indicating that BMI increase of the four groups became increasingly different across time.

Growth by 21-Year Weight Group

The growth trajectories for the four 21-year weight groups are shown in Figure 3, and the growth parameters for each weight group are shown in Table 3. All groups had significant slopes (Table 3), indicating that all groups had significant linear increases in BMI across time, with the NW, OW, OB, and E-OB groups averaging 1.8, 3.6, 5.3, and 7.6 increase in BMI per age interval, respectively. The quadratic terms were significant for the OW, OB, and E-OB groups, indicating that these groups had significant

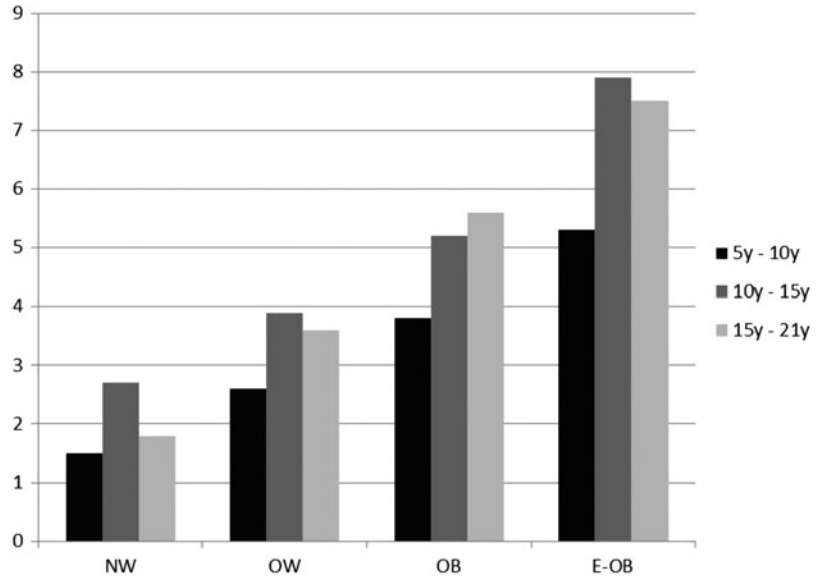

Figure 2. BMI increase per age period for each 21-year weight group.

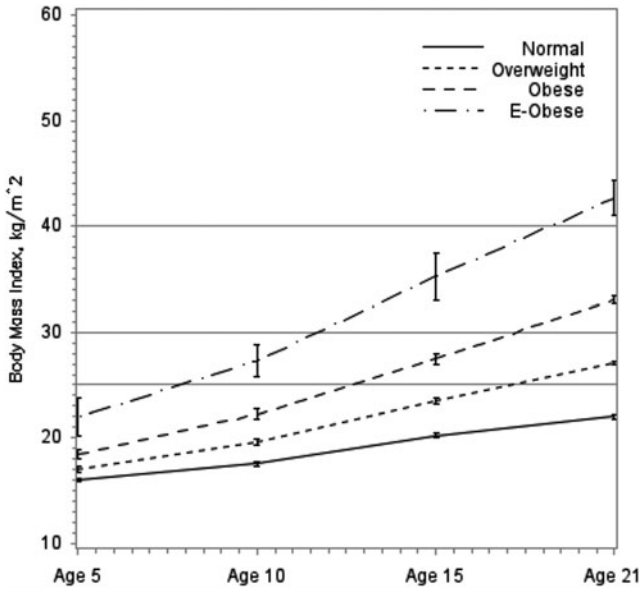

Figure 3. Growth trajectories of the four 21-year weight groups ($N = 1000$).

accelerated BMI increase (rapid growth). The nonsignificant quadratic term of the NW group indicates that this group experienced only steady linear growth.

When weight group was regressed on the growth parameters, it was significantly related to the intercept (Est. = 5.78, SE = 0.11, $p < 0.001$), slope (Est. = 1.73, SE = 0.12, $p < 0.001$), and quadratic term (Est. = 0.11, SE = 0.03, $p < 0.001$), indicating that the four groups differed significantly on BMI at 21 years, degree of linear change in BMI, and acceleration of BMI change. When contrasting the slope, and separately the quadratic, for all possible pairwise comparisons of weight groups (Table 3) (using a chi-square difference test comparing constrained parameters to unconstrained parameters), the slopes and quadratic terms of the four weight groups increased successively by increasing weight group (NW < OW < OB < E-OB) (Results available upon request).

BMI Growth of Total Sample and Home and Family Predictors

The growth parameters for the total sample are shown in Table 3. Results of the growth analyses indicated that higher BMI at 21 years was significantly related to greater linear change in BMI ($r_{is} = 0.61$, $p < 0.001$), and greater linear change in BMI was strongly related to higher growth acceleration (*i.e.*, faster growth; $r_{sq} = 0.84$, $p < 0.001$). BMI at 21 was not, however, related to greater growth acceleration ($r_{iq} = 0.15$, *ns*).

When home and family characteristics at child age 1 were regressed on the total sample's growth parameters (Table 4), a higher BMI at 21 years related to father absence, family stress, maternal depression, an unclean home, a poor clinical impression of the home atmosphere, frequent child confinement, and, marginally, to fewer children in the household and lower child acceptance. Significant linear increases in BMI (slope) related to the home's unappealing interior, lower learning stimulation, lower total physical environment, and marginally, a poorly organized and unclean home. Rapid acceleration of BMI increase (quadratic) was associated with lower learning stimulation and, marginally, an unappealing home interior.

Results of 10-year home and family characteristics predicting the sample's growth parameters (Table 5) indicated that a higher BMI at 21 years related to maternal depression, an unappealing home environment, few developmentally stimulating experiences, low provision for active stimulation, and, marginally, to high family stress and having few growth fostering materials. Significant linear increases in BMI (slope) related to family stress, maternal depression, an unappealing home environment, fewer growth fostering materials and developmentally stimulating experiences, lower total physical environment, and lower parental warmth and acceptance. Faster acceleration of BMI increase (quadratic) was associated with lower parental warmth and acceptance.

Table 3. Parameter Estimates of Growth for the Total Sample and the Four 21-Year Weight Groups from 5 to 21 Years

	Total sample ($N = 1000$)	NW ($n = 459$)	OW ($n = 309$)	OB ($n = 209$)	E-OB ($n = 23$)
	Est. (SE)	Est. (SE)	Est. (SE)	Est. (SE)	Est. (SE)
M 21-year BMI (intercept)	26.4*** (0.2)	22.0*** (0.1)	27.1*** (0.1)	33.1*** (0.2)	42.9*** (0.6)
M Change in BMI (slope)	3.21*** (0.11)	1.79*** (0.13)	3.56*** (0.17)	5.27*** (0.26)	7.64*** (0.62)
M Rate of BMI change (quadratic)	0.08** (0.03)	–0.04 (0.04)	0.12* (0.05)	0.21** (0.07)	0.40*** (0.13)

M change in BMI is the slope estimated from latent growth curve analyses, indexing linear change. *M* rate of BMI change is the quadratic term, indexing growth acceleration or deceleration.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

Table 4. Home and Family Characteristics at Infancy Regressed onto BMI Growth Parameters ($N = 1000$)

Family factors	Father absence	Family stressful events	Maternal depression	Number of children in household	Mother smokes	
	β ± SE	β ± SE	β ± SE	β ± SE	β ± SE	
21-year BMI (intercept)	1.59** ±0.60	0.16** ±0.06	0.03* ± 0.02	−0.24† ± 0.13	−0.14 ± 0.43	
Change in BMI (slope)	0.24 ± 0.37	0.01 ± 0.04	0.01 ± 0.01	0.13 ± 0.09	−0.28 ± 0.26	
Rate of BMI change (quadratic)	0.02 ± 0.09	−0.01 ± 0.01	−0.01 ± 0.00	0.04 ± 0.03	−0.05 ± 0.07	
Home environment factors	Appealing interior space	Organization of environment	Cleanliness of home	Learning material stimulation	Total physical environment[a]	Clinical impression of home[b]
	β ± SE	β ± SE	β ± SE	β ± SE	β ± SE	β ± SE
21-year BMI (intercept)	−0.08 ± 0.14	−0.08 ± 0.23	−1.22* ± 0.56	−0.25 ± 0.12	−0.07 ± 0.06	−0.71** ±0.26
Change in BMI (slope)	−0.22* ± 0.09	−0.27† ± 0.14	−0.67† ± 0.35	−0.44*** ±0.12	−0.10* ± 0.04	−0.29 ± 0.18
Rate of BMI change (quadratic)	−0.05† ± 0.02	−0.07 ± 0.04	−0.11 ± 0.09	−0.11** ±0.03	−0.02 ± 0.01	−0.03 ± 0.05
Parenting factors	Acceptance of child	Punishment of child	Confinement of child			
	β ± SE	β ± SE	β ± SE			
21-year BMI (intercept)	−0.41† ± 0.22	0.58 ± 0.44	0.50* ± 0.25			
Change in BMI (slope)	−0.03 ± 0.15	0.03 ± 0.32	0.07 ± 0.15			
Rate of BMI change (quadratic)	−0.03 ± 0.04	0.07 ± 0.09	−0.01 ± 0.04			

Models adjusted for sex, BMI at 1 year, maternal BMI, and mother education. Change in BMI is slope, indexing linear change. Rate of BMI change is the quadratic term, indexing growth acceleration and deceleration.

[a]Reflects the sum of the home's appealing interior space, organization, and learning material stimulation.

[b]Coded as optimal = 4, acceptable = 3, regular = 2, and deficient = 1.

†$p < 0.06$.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

Sensitivity analysis. Analyses excluding BMI at 5 years when evaluating associations with 10-year home and family characteristics revealed nearly identical findings to those presented above. Thus, when assumptions of temporality are met, or when BMI growth was limited to ages 10, 15, and 21 years, similar 10-year predictors emerged as when growth was analyzed between ages 5 and 21 years. (Findings available upon request).

Discussion

Using a large longitudinal sample of Chilean children, we investigated the relation between adult weight status and parameters of BMI growth and home and family predictors of BMI growth. Results indicated that bigger children got bigger faster, a result that augments research showing that being big or growing fast is related to later obesity.[41] Compared to those who were normal weight at 21, those who were overweight, obese, or extremely obese not only had significantly higher BMIs at age 5 but also they sustained higher linear increases in BMI and experienced faster growth. Thus, once a child starts to experience significant increases in BMI, he or she is likely to also experience faster growth. Preventive measures would involve setting weight targets among rapidly growing children to achieve lower BMI increases. The finding that only normal weight young adults experienced steady linear growth underscores the importance of slow graduated weight gain for optimal adult weight. In addition, all but the obese group had the largest BMI increase between ages 10 and 15, confirming adolescence as a critical period for development of obesity.[42,43] As a whole, findings highlight the intricate connections among early BMI, subsequent BMI increase, and acceleration of BMI increase, with all factors forecasting obesity in young adulthood.

Home and family characteristics reflective of less supportive environments—such as father absence, family stress, maternal depression, an unappealing unstimulating

Table 5. Home and Family Characteristics at 10 Years Regressed onto BMI Growth Parameters ($N = 1000$)

Family factors	Father absence	Family stressful events	Maternal depression	Freq.household member smokes	
	$\beta \pm$ SE	$\beta \pm$ SE	$\beta \pm$ SE	$\beta \pm$ SE	
21-year BMI (intercept)	0.02 ± 0.11	0.12† ± 0.06	0.04** ±0.01	–0.10 ± 0.11	
Change in BMI (slope)	0.09 ± 0.06	0.10* ± 0.01	0.02* ± 0.01	–0.02 ± 0.07	
Rate of BMI change (quadratic)	0.02 ± 0.02	0.02 ± 0.13	0.001 ± 0.002	0.01 ± 0.02	
Home environment factors	Appealing physical environment	Growth fostering materials	Developmentally stimulating experiences	Provision for active stimulation	Total physical environment[a]
	β ± SE	β ± SE	β ± SE	β ± SE	β ± SE
21-year BMI (intercept)	–0.29** ±0.11	–0.21† ± 0.11	–0.20* ± 0.09	–0.29** ±0.12	–0.16 ± 0.13
Change in BMI (slope)	–0.19** ±0.07	–0.19** ±0.07	–0.12* ± 0.05	–0.07 ± 0.07	–0.19* ± 0.08
Rate of BMI change (quadratic)	–0.03 ± 0.02	–0.03 ± 0.02	–0.01 ± 0.01	–0.01 ± 0.02	–0.04 ± 0.02
Parenting factors	Warmth and acceptance	Punitive parenting			
	β ± SE	β ± SE			
21-year BMI (intercept)	–0.05 ± 0.12	0.10 ± 0.22			
Change in BMI (slope)	–0.15* ± 0.07	0.09 ± 0.13			
Rate of BMI change (quadratic)	–0.04* ± 0.02	0.02 ± 0.03			

Models adjusted for sex, BMI at 1 year, maternal BMI, and mother education. Change in BMI is slope, indexing linear change. Rate of BMI change is the quadratic term, indexing growth acceleration and deceleration.

[a]Reflects the sum of the home's physical appeal, growth fostering materials, developmentally stimulating experiences, and provision for active stimulation.

†$p < 0.06$; *$p < 0.05$; **$p < 0.01$.

home, and low parental warmth/acceptance—were associated with a higher adult BMI or accelerated BMI growth. In a broad sense, these factors represent an absence of resources that support children's engagement with, and connection to, the environment. For example, because fathers are uniquely instrumental in involving children in boisterous, stimulating physical play, fathers lay the foundation for future physical activity and motor development.[12,44] Children whose fathers are absent during their early development may lack both physically arousing experiences, as well as opportunities to model this type of active play in later development. Having many children in the home who can act as playmates could be operating similarly.[11,13,45] In addition, child confinement (*e.g.*, in playpen and in front of T.V. for extended periods) represents not only a modeling of early sedentary behaviors but also forcibly restricts children's physical exploration and motor development. Altogether, factors that support children's active play were consistently related to slower BMI growth.

Several factors should be considered in interpreting study findings. All participants were born at term and had a birth weight ≥3.0 kg. Thus, premature and low-birth weight infants were not included, which likely affected the distribution of BMI in the sample.[46] Characteristics of the home and family (at 10 years only), as well as mothers' recall of their height and weight before the child's birth, were assessed by mothers' report. Thus, there are issues of recall bias and shared-reporter bias, for example, between maternal report of depression and the home environment. In addition, results may not generalize to children in U.S. families, although the results reported here for growth rate and speed are highly consistent with those found among American children predicting obesity status.[11–15] The small group size of extremely obese individuals also likely reduced the power to detect differences involving this group. However, extremely obese individuals are at elevated risk of poor cardiometabolic health, and the prevalence of extreme obesity is increasing rapidly, both in the United States and in children.[1,47,48] Thus, inclusion of this group was of particular interest.[49] The study had several strengths, such as the large sample studied over 20 years, the inclusion of important controls to adjust for pertinent confounders, the repeated assessments of objectively measured BMI, and ratings of several home and parenting characteristics measured at children's infancy and middle childhood.

Conclusions

Findings show that BMI increase and rate of increase as early as age 5 are important for predicting weight status in young adulthood. Early identification of accelerated weight gain in childhood, then, is a critical marker for later obesity and has preventive implications. Children exposed to unsupportive home and family conditions became overweight or obese as young adults, in part, because such factors relate to faster BMI increase. Identification of the home and family factors found here highlights a variety of possible intervention targets. Home-based interventions that guide parents to promote physical activity and limit child confinement would likely be beneficial. In addition, programs that provide stimulating and safe play activities for children showing early and rapid weight gain also would be helpful.

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