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Determinants of Cognitive Development of Low SES Children in Chile: A Post-transitional Country with Rising Childhood Obesity Rates

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Abstract Studies conducted in developing countries have noted associations between concurrent stunting, social-emotional problems and poor cognitive ability in young children. However, the relative contribution of these variables in Latin America is likely changing as undernutrition rates decline and prevalence of childhood obesity rises. We conducted a cross-sectional study of 106 normal-weight and 109 obese preschool children to compare the relative contribution of early nutrition, sociodemographic factors and psychosocial variables on cognitive development in normal-weight and obese preschool children in Chile. The study variables were categorized as: (1) socio-demographic (age, sex, birth order and socioeconomic) (2) early nutrition (maternal height, birth weight, birth length and height at 5 years) (3) psychosocial factors (maternal depression, social-emotional wellbeing and home space sufficiency). In order to assess determinants of cognitive development at 4–5 years we measured intelligence quotient (IQ); variability in normal children was mostly explained by socio-demographic characteristics ($r^2 = 0.26$), while in obese children early nutritional factors had a significant effect ($r^2 = 0.12$) beyond socio-demographic factors ($r^2 = 0.19$). Normal-weight children, who were first born, of slightly better SES and height Z score >1, had an IQ $\geq$ 6 points greater than their counterparts ($p < 0.05$). Obese children who were first born with birth weight >4,000 g and low risk of socio-emotional problems had on average $\geq$5 IQ points greater than their peers ($p < 0.05$). We conclude that in Chile, a post-transitional country, IQ variability of normal children was mostly explained by socio-demographic characteristics; while in obese children, early nutrition also played a significant role.

Keywords Childhood obesity · Normal-weight · Cognitive development · Post-transitional country

Introduction

It is estimated that in developing countries, more than 200 million preschool children do not reach their full cognitive potential due to poverty, insufficient nutrition and inadequate access to health care during infancy [1]. It has been demonstrated that both child malnutrition and poor psychosocial environment affect cognitive performance of preschool children [2]. However, it is unclear how the relative contribution of these variables changes as prevalence of overweight and obesity in children rise progressively.

Early malnutrition, due to energy excess or nutritional deficiencies, has been shown to impact cognitive development. On the one hand, there is strong evidence that undernutrition (i.e. low maternal BMI, low birth weight, inadequate breast feeding and micronutrient deficits) compromises cognitive development in later life [3, 4]. On the other hand, the association of obesity with poor cognitive function is now well recognized; obesity in some diseases, such as in hypothyroidism, may be associated with poor cognitive function which in this case is partly explained by reduced brain volume [5, 6]. Obese individuals have also

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been shown to have a relative intellectual disadvantage when compared to non-obese individuals [7]. For example a case–control study in Chinese school age children (mean age 10 years), showed a lower overall intelligence score in the overweight group [8]; and another study in young obese teenagers documented a relatively poorer cognitive performance compared to non-obese individuals independent of social status [9]. However there is also evidence for no effect of obesity on cognitive performance [10]. Few studies have been carried out in preschool children from countries experiencing rapid economic, social and nutrition transition.

Poverty is also a powerful determinant of cognitive development [11]. Children living under poverty receive less stimulation at home, are more exposed to psychosocial stress, and their mothers are more likely to exhibit socio-emotional and mental disturbances [12]. Poor children are less able to establish social networks and to tolerate stress, as well as having decreased attention and memory, and poor learning skills [13]. The adverse influences of living in poverty most likely apply to both obese and normal-weight children.

Psychological factors are also important determinants of cognitive development. Obese children are often stigmatized and are susceptible to suffer isolation, low self-esteem, depression and anxiety [14]. In two studies of preschool children where parents provided the information, a significant association between overweight and behavioral problems was found [14, 15]. However in both studies low socioeconomic status was the strongest predictor of these problems, indistinctly of the nutritional status of the children.

Chile is a country that over the past decades has improved its economic situation rapidly, decreasing poverty rates from 39 % in 1990 to <14 % in 2006 [16]. Simultaneously, undernutrition (weight for age <2 SD) and micronutrient deficiencies in children have been virtually eradicated due to the implementation of effective national maternal and infant nutrition programs [17]. Presently, acute malnutrition has been virtually eradicated; mean height among children at 6 years is close to international standards (118 ± 5.3 cm) [18]. Over the past decade, the main nutritional problem of children in Chile is obesity, especially among lower income children [19]. In Chile, the prevalence of obesity in children <6 years has increased rapidly from <5 % in 1980, to 7 % in 1987 and over 21 % in 2010 [20]. However, despite these improvements, a recent national survey indicates that almost a third of Chilean preschool children exhibit delays in their cognitive development [21]. Therefore, the objective of this study was to assess the contribution of early nutrition, psychosocial variables and sociodemographic factors on cognitive development of Chilean preschool children of low income families.

Methods

Study design and subjects

We report results of a cross-sectional follow-up of a subsample of Chilean preschool children participating in a cohort study of child growth and obesity [22]. Details of the original study have been described elsewhere [22]. Singleton children born in 2002–2003, with a gestational age between 37 and 42 weeks and a birth weight >2,500 g. (data retrieved from medical registries; national prevalence of birth weight, 2,500 g is 5.0 %) [23] and who were enrolled in 2006 in day care centers of the National Nursery Schools Council Program (JUNJI) in Santiago and had no physical or psychological conditions that could severely affect growth were eligible for the study. Final sample size for the cohort study was 1089.

The present study was conducted in November 2007 when the children were 4–5 years of age. All obese children (Ob) (BMI-for-age Z-scores (BAZ) ≥ 2 to ≤ 5) (WHO 2006) from the cohort ($n = 115$) were invited to participate. An equal number of normal-weight children (Nw) (≥ -1 to ≤ 1 BAZ) (WHO 2006) with similar characteristics of sex and age were selected as a comparison group. For these analyses, we excluded fifteen children who did not meet inclusion criteria: 5 children >6 years; 2 with Apgar score ≤7 at 5 min of life; and 8 with implausible anthropometric values at 4–5 years (weight-for age z-score < -6 or > 5, height-for age z-score < -6 or > 6, BAZ < -5 or > 5). Thus, our final sample size was 109 obese and 106 normal-weight children (Fig. 1). Assuming 80 % power and a 2-tail significance level of 0.05, the smallest r squared (r^2) we could detect considering sample size was 0.12 [(for a model of 4 variables and two categories (obese and normal-weight children)] [24]. The study protocol was approved by the Executive Director of JUNJI, and of the human research ethics committee at the institute of nutrition and food technology (INTA) of the University of Chile. Written informed consent was obtained from all parents or guardians.

Dependent variables

Cognitive development was assessed using the wechsler preschool and primary scale of intelligence (WPPSI-R) [25]. Two trained psychologists applied the test to assess the children's intelligence quotient (IQ); they had extensive previous training and experience applying these tests to young children. The WPPSI-R includes scoring subtests of: information, comprehension, vocabulary, similarities, and arithmetic for the verbal scale; and object assembly, block design, geometric design, picture completion, and labyrinths for the manual scale. Preschool children were

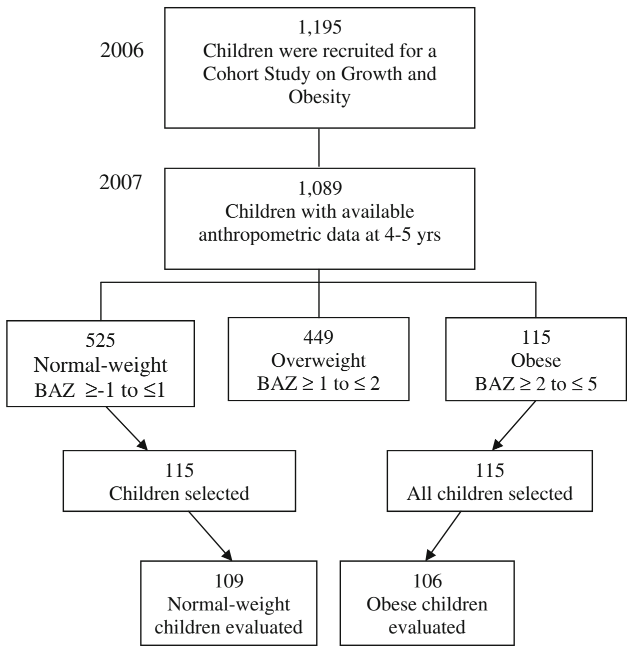

Fig. 1 Flow of participants in the study

evaluated in a private room at each school; IQ score was treated as a continuous variable.

Independent variables

Three blocks of potential determinants of IQ were defined:

Block 1. Child socio-demographic characteristics: age, sex, birth order and socioeconomic status (SES). Mothers reported date of birth and birth order of the child, as well as educational level of the head of household and ownership of ten household goods: color TV, hot shower, refrigerator, washing machine, microwave oven, mobile phone plan, cable TV, computer, internet, and car. This socioeconomic classification has been widely used in Chile [26, 27].

Block 2. Early nutrition: maternal height, birth weight, birth length and height at 5 years: birth weight and length were retrieved from health records. In Chile, newborns are measured at birth following a standardized protocol [28]. In 2007, a single dietitian evaluated the children′s and mother′s weight and height using standardized procedures. Weight was measured with a portable electronic scale (Seca 770) with a precision of 0.1 kg; height was measured with a stadiometer (Seca 2002) to the nearest 0.1 cm.

Block 3. Psychosocial factors: maternal depression, social-emotional wellbeing and space for children at home. Maternal depression: A single trained sociologist applied the Spanish version of the Composite International Disease Instrument-Short Form [29] to all mothers. This is a 37 item questionnaire that detects depressive symptoms over the past year. *Social-emotional Wellbeing of the Children*: A single trained psychologist applied a self-reported socio-emotional scale to assess the child's adaptation to the school system. This is a 22 item scale that evaluates 7 dimensions: (a) tasks adaptation, (b) social adaptation, (c) assertiveness, (d) self -esteem, (e) independence and autonomy, (f) optimism, and (g) emotional response. This scale has been validated for Chilean school-age children (alpha de Cronbach $= 0.78$ and test re-test stability ≥ 0.75) [30]. *Space for children at home:* In the interviews, mothers also reported aspects of preschool′s home environment, particularly with respect to the space available for playing.

Computed Indices

Block 1. Child socio-demographic characteristics: we defined SES based on an index that combined educational level and household goods. Discriminant analyses confirmed that this categorization was adequate and explained 70 % of the SES variability of the children. Since all the children were of low SES, we defined sub categories: mid-low (university, +8 to 10 goods); low (high school, +5 to 7), and very-low SES (elementary school, +1 to 4).

Block 2. Early nutrition: Z-score of length at birth (BLZ), height-for-age at 4–5 years (HAZ), and BAZ at 4–5 years were estimated based on the WHO 2006 Growth Standards [31]. Given that all children had a birth weight >2,500 g and that stunting was almost non-existent (<1 % <−2 HAZ, WHO 2006), we classified birth weight as: low (2,500–2,999 g), normal (3,000–4,000 g) and high (>4,000 g); birth length as: low (≤ -1.0), normal (> -1.0 to ≤ 1.0) and high (> 1.0); and height at 5 years as: low (≤ -1.0 HAZ), normal (> -1.0 a ≤ 1.0 HAZ), and high (> 1.0 HAZ). We used two cut-offs to categorize maternal height (≤155 and >155 cm) [32].

Block 3. Psychosocial variables: Maternal depression: Mothers were classified as depressed when they reported low mood or no hedonic interests nearly on a daily basis, most of the day, or during at least 2 weeks; plus presence of ≥5 depressive symptoms (loss of interest, fatigue, weight change, sleep problems, decreased concentration, feeling of worthlessness, and thinking about death) [33]. *Socio-emotional Wellbeing of the Children:* Children with scores below 25 % of the sample distribution (<17 score) were classified as being at socio-emotional risk. *Space for children at home*: Preschool children were classified as having "sufficient space" if they slept in

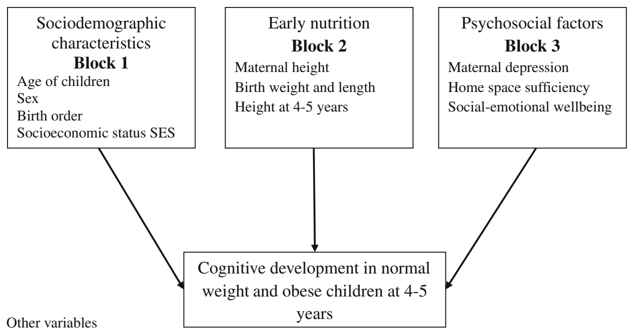

Fig. 2 Conceptual framework: potential predictors of cognitive development in normal weight and obese Chilean children at 4–5 years of age

their bedroom had space to play and also to put their toys away.

Data analysis

The analyses were based on a pre defined conceptual model (Fig. 2). Mann–Whitney and Kruskal–Wallis tests served to assess the differences of mean IQ scores among groups given that most of the study variables were not normally distributed. We conducted multiple linear regression analyses to assess the relative contribution of each of the blocks on IQ level in normal-weight and obese children. Within each of the blocks, variables were sequentially incorporated testing for all possible combinations of variables. The models for each blocks revealed no multicolinearity (i.e variance inflation factors <5 and condition index <25). Interactions among variables within each block were tested; all were non-significant ($P > 0.05$). Significance was defined as a P value <0.05. All analyses were carried out in Stata 10, Stata Corporation, College Station, TX, USA [34].

Results

In Table 1 we present descriptive statistics of normal-weight and obese preschool children. Mean age of normal-weight and obese children participants was 5 years, half of them were girls, and 80 % were in the low and very-low SES category. Maternal height and anthropometry at birth were similar between obese and normal-weight children. Anthropometric indicators at 4–5 years (height and BMI) reflected differences between normal-weight and obese children. There was more maternal depression and higher social-emotional risk in obese than in normal-weight children.

Table 1 Descriptive statistics of normal-weight and obese preschool children of the JUNJI, Chile, 2007

Variables	Normal-weight n = 106 (mean ± SD)	Obese n = 109 (mean ± SD)
Age (years)	5.1 ± 0.3	5.0 ± 0.3
Gender (%)		
Girls	57.5	44.0
Boys	42.5	56.0
Birth order (%)		
First	34.9	41.3
Second or higher	65.1	58.7
Socioeconomic status (%)		
Mid-low	21.6	23.8
Low	37.7	42.2
Very low	40.5	33.9
Maternal height (cm)	157.1 ± 5.2	156.4 ± 6.3
Birth weight (g)	3.3 ± 0.4	3.5 ± 0.4
Birth length (cm)	49.7 ± 1.8	49.9 ± 1.7
Height at 4–5 years (cm)	109.2 ± 4.3	112.3 ± 4.8
BMI at 4–5 years (Kg/m^2)	15.6 ± 0.7	20.9 ± 1.7
Maternal depression (%)		
Presence (≤5 score)	82.1	68.8
Absence (>5 score)	17.9	31.2
Social-emotional wellbeing (%)		
No risk	74.5	70.6
At risk	25.5	29.4
Home space sufficiency (%)		
No	34.9	27.5
Yes	65.1	72.5

SD standard deviation

The univariate association of each of the potential determinants and IQ in normal-weight and obese children is presented in Table 2. There were significant differences ($p < 0.05$) between girls and boys, birth weight categories, birth length categories and maternal depression score of normal-weight and obese children; all other variables had no significant differences on cognitive development.

Table 3 shows the multiple linear regression analysis of determinants of IQ in normal-weight and obese children. In normal-weight children, socio-demographic variables explained 26 % of the variability in IQ; gender was also significantly associated with IQ. Early nutrition and psychosocial variables explained less than 1 % of variability in IQ; none were significantly associated with IQ at 4–5 years, except for a marginal effect of height at 4–5 years. Overall, in normal-weight children the three blocks of potential determinants explained 26 % of the IQ variability at 4–5 years. In obese children, 19 % of the IQ variance was

Table 2 IQ of normal-weight and obese preschool children of the JUNJI, according to sociodemographic characteristics, early nutrition and psychosocial factors, Chile, 2007

Blocks and variables		(n) IQ mean ± SD		Comparison Nw and Ob children
		Normal weight (Nw)	Obese (Ob)	P value
Block 1: sociodemographic characteristics				
Age (years)	4	(36) 93.8 ± 9.0	(44) 93.5 ± 8.3	0.29
	5	(70) 91.1 ± 8.9	(65) 90.8 ± 8.7	
Sex	Girls	(61) 91.7 ± 8.6	(48) 90.1 ± 7.1	0.024*
	Boys	(45) 92.4 ± 9.5	(61) 93.3 ± 9.4	
Birth order	First	(37) 95.5 ± 9.1	(45) 95.1 ± 8.5	0.227
	Second or higher	(69) 90.6 ± 8.5	(64) 90.0 ± 7.8	
Socioeconomic status	Mid-low	(23) 97.3 ± 6.6	(26) 92.3 ± 8.1	0.475
	Low	(40) 93.8 ± 8.0	(46) 91.9 ± 7.2	
	Very low	(43) 87.5 ± 8.9	(37) 91.2 ± 10.6	
Block 2: early nutrition				
Maternal height (cm)	≤ 155	(36) 90.3 ± 8.5	(49) 90.0 ± 8.5	0.069
	>155	(70) 92.7 ± 8.9	(60) 94.1 ± 8.1	
Birth weight (g)	2500 to 2999	(30) 90.3 ± 8.6	(09) 91.3 ± 8.6	0.001*
	3000 to 4000	(67) 92.4 ± 9.1	(82) 90.1 ± 8.0	
	>4000	(09) 94.7 ± 9.3	(18) 98.7 ± 7.7	
Birth lenght (Z score)	≤ − 1.0	(16) 91.2 ± 7.6	(13) 91.5 ± 10.4	0.001*
	> − 1.0 to ≤ 1.0	(70) 92.5 ± 9.4	(81) 90.6 ± 8.0	
	>1.0	(20) 90.9 ± 8.4	(15) 98.9 ± 6.8	
Height at 5 years (Z score)	≤ − 1.0	(18) 90.1 ± 11.8	(7) 95.4 ± 7.6	0.542
	> − 1.0 to ≤ 1.0	(78) 91.9 ± 8.4	(74) 91.4 ± 8.9	
	>1.0	(10) 96.6 ± 6.2	(28) 92.1 ± 7.9	
Block 3: psychosocial factors				
Maternal depression	≤5 score	(87) 92.6 ± 9.1	(75) 92.1 ± 8.9	0.038*
	>5 score	(19) 90.3 ± 6.8	(34) 92.4 ± 8.1	
Social-emotional wellbeing	No risk	(79) 92.6 ± 8.6	(77) 93.3 ± 7.6	0.611
	At Risk	(27) 90.6 ± 9.9	(32) 89.0 ± 10.2	
Home space sufficiency	No	(37) 90.3 ± 8.5	(30) 89.9 ± 10.0	0.228
	Yes	(69) 92.9 ± 9.0	(79) 92.6 ± 7.9	

* $P < 0.05$ Pearson Chi square

explained by early nutrition, higher birth weight and greater length were associated with higher IQ at 4–5 years. Sociodemographic characteristics explained 12 % of the IQ variance and all variables were significantly associated with IQ, except for SES. In the case of block 2 (early nutrition) 19 % of the IQ variance in obese children is explained by these factors. As observed in normal-weight children, psychosocial factors explained <1 % of the IQ variance and social-emotional status of the child was the only factor significantly associated with IQ at 4–5 years ($P < 0.05$). Overall, in obese children the three blocks of potential determinants explained 31 % of the IQ variability at 4–5 years.

Discussion

In this study we demonstrate that in a post-transitional country cognitive development of normal-weight children is mainly associated with sociodemographic characteristics while IQ of obese children is associated with both early nutritional factors and sociodemographic variables; in addition we find a small but measurable effect from psychosocial variables. No significant differences were found in the IQ of normal-weight and obese children at 5 years. Other studies have shown a negative effect of childhood obesity on socio-emotional wellbeing and cognitive performance [7, 35]. In this line of thought, body weight

Table 3 Multiple linear regression models by sociodemographic characteristics, early nutrition and psychosocial predictors of intelligence quotient in normal weight and obese children of the JUNJI, Chile, 2007

Variables and blocks	Normal weight n = 106				Obese n = 109			
	R^2	β	Standard error	P value	R^2	β	Standard error	P value
Block 1: sociodemographic	26.0				12.0			
Characteristics								
Age (years)								
4 years								
5 years		−6.4	2	0.002*		−4.2	1.9	0.037*
Sex								
Girls								
Boys		0.6	1.6	0.686		3.1	1.6	0.049*
Birth order								
First								
Second or higher		−4	1.6	0.021*		−5.4	1.6	0.001*
Socioeconomic status								
Mid-low		8.2	2	0.001*		0.8	2	0.704
Low		6	1.7	0.001*		−0.1	1.7	0.987
Very-low								
Block 2: early nutrition	0.2				18.8			
Maternal height (cm)								
≤155		−1.8	1.9	0.338		−3.2	1.5	0.44
>155								
Birth weight (g)								
2500 to 2999		−6	3.8	0.119		−1.5	3.5	0.663
3000 to 4000		−2.9	3.3	0.385		−5.6	2.3	0.020*
>4000								
Birth length (Z score)								
≤−1.0		5	3.4	0.145		−6.1	3.5	0.086
>−1.0 to ≤1.0		3.9	2.4	0.106		−5.7	2.5	0.027*
>1.0								
Height at 4–5 years (Z score)								
≤−1.0		−8	3.9	0.046*		5.4	3.4	0.112
>−1.0 to ≤1.0		−5.2	3.3	0.12		−0.7	1.8	0.669
>1.0								
Block 3: psychosocial factors	0.1				0.2			
Maternal depression symptoms								
≤5 score								
>5 score		−0.6	2.5	0.786		−0.1	1.8	0.994
Social-emotional wellbeing								
Not risk								
Risk		−2.7	2	0.19		−4.3	1.9	0.032*
Home space sufficiency								
Yes								
No		−2.7	1.9	0.167		−1	2.1	0.593

* $P < 0.05$, R^2 Determinant coefficient (%), β Coefficient

would not be a primary risk factor for poor cognitive development, but rather would predispose to other risk factors such as impaired insulin receptor signaling, low levels of leptin in brain, and altered glucose metabolism. In obese children, hyperinsulinemia has been linked to disturbances in glucose metabolism and insulin, signaling a possible effect in several the brain regions [36, 37]. This raises the possibility that obesity exerts a metabolic impact which mediates mental performance. A longer term follow-up of our cohort of children could confirm or negate this hypothesis.

The average WPPSI-R scores in our study participants was about 10 points higher than IQ levels of preschool children from countries in an early or intermediate stage of the nutrition transition, showing that cognitive development improves as the nutritional condition of the population progresses [38]. The variability of IQ in obese and normal-weight preschool children was lower than that reported previously [39]; this is probably due to the fact that our study sample was relatively homogeneous in age, SES background, and all were beneficiaries of a social welfare program (i.e. 90 % were classified as low and low-medium SES by JUNJI) [40].

Most of the variability in IQs of normal-weight children was explained by the socio-demographic characteristics. Of interest, we found that 4 years old children had higher IQ scores than 5 years old children; suggesting that a potential cohort effect with younger cohorts exhibiting better results; this is similar to results obtained from routine cognitive development assessments of low income Chilean children, which indicates that performance gaps are higher with advancing age [41]. Similar findings have been reported in other countries, suggesting that in populations living in less favorable conditions, intellectual and cognitive development tend to deteriorate with age [42]. We also found that first-born children had a significantly better performance on IQ tests; this finding is consistent with previous cross-sectional reports [43]. The apparent relationship between birth order and intelligence may be mediated by mother′s characteristics (education level, age, etc.) [44]; most models have emphasized explanations relating to intra family interactions and more favorable environmental conditions for intellectual stimulation in low-birth-order children [45]. Normal-weight preschool children of low SES have lower cognitive development than better-off children, probably due to the differential response of low income children facing a microenvironment of limited psychosocial and affective stimulation [38]. Presently, children living in a context of poverty in Chile have adequate sanitary conditions and virtually no under-nutrition, however they still suffer from psychosocial consequences of poverty. Conversely, nutritional and psychosocial variables were almost unrelated to IQ at 4–5 years of age. In the case of nutritional variables this is likely due to the fact that prevalence of stunting is low and micronutrient deficiencies in normal-weight children are almost non-existent [46]. However, we found that one in four normal-weight children were at high socio-emotional risk. This condition was unrelated to IQ scores, suggesting that normal-weight children with psychosocial problems build up compensatory strategies to achieve normal cognitive development.

The important variability in IQ scores among obese children was only partially explained by socio-demographic characteristics (age, sex and birth order). In contrast to that observed in normal-weight children, in this group SES was not a significant predictor of IQ at 4–5 years. This may be due to the fact that few obese children were of very low SES.

This study in obese children confirms the strong link between IQ and early nutritional factors; multiple studies consistently show strong correlations with birth weight and general maternal health as well as psychosocial well-being during the early years [47, 48]. We found that a higher birth weight and length were associated with higher IQ scores. In Chile, mean birth weight and length have significantly increased over the past three decades as a result of an overall economic improvement [27]. In countries with a history of food insecurity, a normal birth weight might play a protective role in terms of mental development [4]. We show that this is also be the case in obese children of post-transitional countries. Social-emotional wellbeing in obese children was also significant in predicting IQ scores at 4–5 years of age. Infants and preschool children are highly vulnerable, especially in their social and emotional development [49]. Positive environments and teacher attitudes improve school performance while negative ones decrease performance [50]. Implementing initiatives to improve socio-emotional conditions of children as early as possible is important since socio-emotional risk tracks into adolescence [51].

This study considered several potential predictors of cognitive development in normal-weight and obese preschool children. It included socio-demographic, nutritional, and psychosocial variables using a conceptual framework to organize and analyse the data. On the other hand SES data and maternal psychological factors were collected only once, when the child was evaluated for IQ; thus both factors might have changed in either a positive or negative direction during the course of a child's early life. For this reason, our assessment of cognitive development may be overly simplistic [52]. The cross-sectional nature of our study precludes any causal inference. The analysis of cognitive development in preschool children was performed separately from the contribution of distal and proximal variables; this further limits the interpretation of our results. Future studies should include cohorts followed from birth with repeated measurements during the first years of life.

In conclusion, we observed no differences in IQ between obese and normal-weight children in low income 4–5 years old children in a country with very low stunting prevalence. IQ variability among normal-weight children was mostly explained by socio-demographic characteristics while in obese children, early nutrition also played a significant role. These results suggest that in order to achieve children's full cognitive development potential, we need to go beyond providing adequate nutrition in support of normal physical growth; we clearly need to place greater emphasis on the psychosocial environment. Our results provide further insights to questions raised by J. Cravioto over 50 years ago "If the reductions in body size characteristic of survivors of early malnutrition were associated with reduced mental development… the implications for policy making and national economic planning would be of such an importance that a systematic investigation of the intervening nutritional and non-nutritional factors should be carried on" [53]. Transitional countries should implement comprehensive programs that integrate nutrition, health, poverty reduction, and psychosocial stimulation in order to facilitate the cognitive development in children of low-income families. In the long run these programs will contribute not only by increasing educational performance and labor productivity but also by decreasing social and economic inequalities thus reaping the full benefits of investment in human capital.

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Conflict of interest All authors have no conflict of interest to declare.

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