IOSR Journal of Nursing and Health Science (IOSR-JNHS)
e-ISSN: 2320–1959.p- ISSN: 2320–1940 Volume 11, Issue 3 Ser. I (May. – June. 2022), PP 47-57
www.iosrjournals.org

How does obesity influence cognitive development in children? Empirical evidence from the Ecuadorian case

Darwin Toaquiza-Cuzco[1], Jeferson Crespo-Asqui[2], Byron Coronel-Miranda[3], Diego Mueses-Guerrero[4,5], Tiffany Arauz-Gonzalez[6], Roberto Aguilar-Vásquez[7], Marcos Vásquez-Mendoza[8]

[1](*Medical Doctor, Gobierno Autónomo Descentralizado Provincial de Cotopaxi, Cotopaxi, Ecuador)*
[2](*Educational Sciences, Biology, Chemistry and Laboratory, Universidad Nacional de Educación, Cañar, Ecuador)*
[3](*School of Medicine, Universidad Técnica de Ambato, Ambato, Ecuador)*
[4](*Nurse, Área de Medicina Interna, Hospital General Docente Calderón, Quito, Ecuador)*
[5](*School of nursing, Instituto Tecnológico Superior Libertad, Quito, Ecuador)*
[6](*Resident Doctor, Hospital Pediátrico Baca Ortiz, Quito, Ecuador)*
[7](*Resident Doctor, Área de Emergencia, Hospital General IESS Quito Sur, Quito, Ecuador)*
[8](*Resident Doctor, Área de Emergencia, Hospital General IESS Manta, Manta Ecuador)*

Abstract:
Background*: Analyzing the empirical relationship between obesity and cognitive development in children, contributes significantly to the literature, since it has been shown that sedentary lifestyles, poor diet and nutritional status, play an important role in physical, psychosocial, emotional and cognitive development in childhood and adolescence and therefore are responsible for the limited motor patterns they present in the first years of life.*
Materials and Methods*: We used a representative sample of 3877 children aged 3 to 5 years from the 2018 National Health and Nutrition Survey (ENSANUT). We used a binary logistic linear regression model where we estimated the Odds Ratio (OR) with their 95% confidence intervals (95% CI) for each of the independent variables.*
Results*: Our results show that the odds ratio (OR) associated with the obesity variable is significant and greater than 1. This shows that a child with obesity has approximately 2.01 times more (CI=-1.986- -2.321) risk of suffering from poor cognitive development. In addition, males have a higher risk of low cognitive development OR of 1.592 (CI=1.341- 1.978). Another important finding is that a greater number of siblings at home increases the risk of having low cognitive development by 1.032 times. Our data also reveal that a higher number of hours in front of the TV could increase the risk of low cognitive development, while the number of hours of play causes an opposite effect, as the OR reveals that children with higher number of hours of play have 1.68 times lower risk of low cognitive development.*
Conclusion: *Based on our findings we can determine that both intellectual capacity and the development of fine and gross motor skills depend on the nutritional status of infants and therefore it is suggested to work on public policies aimed at regulating the eating habits of the population at all ages, starting with school life.*
Key Word*: Overweight, obesity, cognitive development.*

Date of Submission: 05-05-2022 Date of Acceptance: 19-05-2022

I. Introduction

Nutritional status is an important factor determining health and cognitive and psychosocial development in early childhood.[1] In the growth stage, the first contact with the environment is initiated and, in this way, they gain knowledge about the world in which they are growing and developing.[2] There are a number of individual and environmental factors that occur throughout a child's development that can encourage or discourage exploration and natural, spontaneous movement in children.[1] The development of psychomotor skills, from the perspective of a practice appropriate to the level of child development, should be a priority in physical education programs. Unfortunately, in recent times, children and adolescents have been practicing less physical activity, and this inactivity has become one of the major causes of increased body weight and low motor competence in children.[3]

Obesity is one of the most important public health problems worldwide at this time, since obese and overweight children are at greater risk of developing early chronic diseases and are more likely to remain obese in adulthood.[4]. According to the World Health Organization (WHO), it was estimated that in the year 2020, there will be 170 million children with obesity and overweight.[5]Likewise, there was an increase of 400 thousand new cases of overweight children in Latin America, so that this year a total of almost 4 million was reached, that is, 3 out of every 10 children live with obesity.[6]All this arises as a consequence of the low time dedicated to physical activity, due to the exaggerated time that children currently dedicate to sedentary activities, in addition to the bad eating habits adopted. A clear example of sedentary lifestyle is the indiscriminate use of screens (cell phones, laptops, computers, video games).[7]

The relationship between obesity and cognitive development may be due mainly to physiological factors. For example, obese children are at increased risk for health problems such as sleep apnea, hypertension and type 2 diabetes.[8]. This, in addition, is associated with increased school absenteeism due to doctor visits or illness-related indisposition, which hinders children's learning and affects their human capital endowment.[4]. Likewise, obese and overweight children may also suffer cognitive deficits due to deficiencies of certain micronutrients such as zinc, iron and iodine.[8]. As a rule, obese and overweight children tend to tire more quickly when performing normal daily activities, execute and present a motor competence lower than expected for their age, in balance, running, lateral running, galloping, jumping, receiving, throwing, kicking, kicking and hitting a ball.[9] Lower levels of physical fitness leads to less interaction with their environment, and subsequently ends up excluding children from various physical activities and childish pranks, leading to inactivity and isolation during playtime.[10] Low opportunities for movement have a negative impact on their development leading to very poor motor skill levels.[11]

Although causal factors have been identified, empirical evidence has focused on the relationship between childhood weight and the development of cognitive skills, and to a lesser extent their link to children's non-cognitive skills. However, the direction in which these associations are generated remains unclear. Several investigations have found a negative relationship between obesity and children's cognitive performance.[12]. For example, Datar and Sturm[13] found that overweight girls between kindergarten and third grade had lower scores on math and reading tests compared with girls who were never overweight, but for boys they found no significant association. Meanwhile, Castelli et al.[12]found that children's Body Mass Index (BMI) was inversely related to educational achievement (math and reading performance) when examining public school students in third and fifth grades.

In the same way, Weisstaub, Schonhaut and Salazar[2]in their study show that obesity can have a negative impact on motor skills, resulting in less cognitive and motor development, and difficulties in physical activities, leading to increased sedentary lifestyles and emotional difficulties. Other authors coincide with these results when comparing the psychomotor development of children with normal weight versus children with overweight and obesity, concluding that the population with an adequate body mass index has better motor performance than children with weight gain at ages 4 to 4.5 years; and determined that the overweight condition can cause children to be victims of bullying, causing psychosocial problems and poor school performance. Martin et al.[14] conducted a research involving children from 5 to 11 years of age, in conditions of obesity, within the results they found a negative association between this condition and academic performance; reflected in obtaining low scores in subjects such as mathematics, reading and emotional difficulties that affect the relationship between peers and participation in the classroom.

On the other hand, it has also been described that children with a high BMI are affected in the acquisition of writing, spelling and arithmetic skills; as well as difficulty in processing speed, decrease in perceptual reasoning and working memory; as a consequence, a lower motivation in daily activities.[13] It has also been described that obesity can lead to sedentary conditions with internalizing symptoms at an emotional level, as a result of the negative evaluation they make of themselves with respect to their body perception, reinforced by social feedback. However, these results are not conclusive, since other studies have not found a direct relationship between nutritional status and psychomotor profile.[15]

Therefore, proper nutrition and physical activity favor cognitive development and learning, which are necessary in the early childhood schooling process.[16] The health problem of obesity, economic conditions and the low academic expectations of parents is a health problem that has a negative impact on the self-concept or perception that each child has of himself or herself, a situation that can influence behavior and dysfunctionality at the academic level and interpersonal relationships in the school stage.

In this context, the present work studies the relationship between childhood weight and cognitive development in Ecuadorian children under 5 years of age, with the objective of evaluating the effect of children's weight on their learning capacity and their ability to establish relationships with others. Therefore, it could be evidenced that obesity/overweight not only affects cognitive learning, but could also have negative implications in adult life, such as lower probabilities of finding employment and lower salaries. This evidence would also provide information to educational and health policy makers to focus their efforts on

obesity/overweight prevention initiatives and to foster non-discriminatory school environments that impact on children's well-being and future economic benefits.

II. Material And Methods

Study Design and Population: A cross-sectional study was conducted with data obtained from the 2018 National Health and Nutrition Survey of Ecuador (ENSANUT), whose data were obtained and presented by the National Institute of Statistics and Census (INEC). After cleaning the database, a total of 3877 Ecuadorian children under 5 years of age were obtained.

Inclusion and Exclusion Criteria:. The working universe was considered to be children aged 3 to 5 years whose anthropometric measurements were reported in the Household form of the 2018 ENSANUT survey.

Source of Information: ENSANUT 2018 is a survey included in the National Statistical Program that employs probability sampling applied every 5 years and whose target population is all household members in the 24 provinces of Ecuador. The ENSANUT 2018 includes the form Household, in section 7: Anthropometry for all persons in the household.

Study Variables. Our dependent variable of interest is the cognitive development of the children. The information for this variable was obtained through 11 questions: Did you ever attend a CIBV/ CDI Child Development Center or day care center, Did you ever receive assistance from CNH educators in your home, Who do you spend most of your time with from Monday to Friday, Can you identify or name at least ten letters of the alphabet, Can you read at least four simple, common words, Can you read at least four simple, common words, Can you recognize the symbol for numbers 1 to 10 and know their names, Can you pick up a small object with two fingers, such as a finger, or can you read at least four simple, common words, Can you recognize the symbol for numbers 1 to 10 and know their names, Can you pick up a small object with two fingers, such as a finger, or can you read at least four words, Can he/she recognize the number symbols 1-10 and know their names, Can he/she pick up a small object with two fingers, such as a stick or a rock from the floor, Does he/she sometimes feel tired/discouraged and not want to play, Can he/she follow simple instructions on how to do something correctly, When given something to do, can he/she do it by him/herself, Is he/she easily distracted, Does he/she get distracted easily, Can he/she do it by himself/herself, Can he/she do it by himself/herself, Is he/she easily distracted, Can he/she do it by himself/herself? These variables and their original coding are shown in **Table 1**. With these variables we created a weighted index whose procedure is detailed below and subsequently dichotomized the variable. On the other hand, our variable of interest (obesity) was generated from the Body Mass Index (BMI) of the children and, following Saldaña and Mendoza [17] we classified as obese children those children with a BMI greater than or equal to the 95th percentile of the distribution, otherwise they are considered as children without obesity. In this way, the dichotomous variable obesity was generated, which takes the value of 1 if a child suffers from obesity and 0 if he/she does not suffer from obesity Other control variables were also used, which are detailed in **Table 1**.

Statistical Analysis. The ENSANUT 2018 survey database was analyzed with the statistical package Stata v15 (Stata Corporation, College Station, Texas, USA). A value of $p<0.05$ was considered to determine statistical significance between variables. The Chi-square test was used to determine the overall correlation between the variables of interest. The association was evaluated using prevalence ratios with their respective 95% confidence intervals with an analysis for each of the variables included in the study, with the independent variable of interest being NPC. To determine the model of risk factors affecting postpartum depression in the postpartum period, binary logistic regression was applied to calculate the OR with their 95% confidence intervals; in addition, the sociodemographic characteristics were reported as absolute frequencies; the numerical variables were reported as means.

Finally, for the determination of the predictor variables, the ROC curve was applied with the probabilities estimated by applying logistic regression under the method of introducing their confidence intervals and their statistical significance $p < 0.05$.

Ethical considerations. The present study did not require the approval of an institutional ethics committee for its execution, since it is an analysis of data freely available to the public and it was not necessary to use informed consent.

III. Result

First, we will detail the process of constructing the dependent variable. Within our research we specifically used 11 items from the questionnaires and considered that cognitive development is a multidimensional concept, and we used a principal component factor analysis (PCA) to ensure that the items can be grouped into a factor dimension. Through PCA with a varimax rotation, we obtained 1 eigenvalue greater than 1. Therefore, we confirmed that we can explain the index of cognitive development through a one-dimensional index, where the factor loadings of each variable have the greatest weight in their respective dimension and these explain 78% of the variance. The questionnaire questions and their initial coding in the

questionnaires are presented in **Table 1**. Our index of cognitive development was standardized in such a way that we obtained a number between 0-1 where a number closer to 1 means greater cognitive development. To standardize our index to a number between 0-1 we followed the following procedure:

$$Standarized\ index = \frac{(X_i - X_i min^{sample})}{(X_i max^{sample} - X_i min^{sample})}$$

Where X_i is the factor value for individual i, $X_i min^{sample}$ is the minimum factor value for individual i in the entire sample and $X_i max^{sample}$ is the maximum factor value for individual i in the entire sample.

Subsequently, we dichotomized our index of cognitive development so that we could simplify our analyses. All children with a cognitive development index of ≤ 0.79 (median index) were considered as children with low cognitive development, while children with an index >0.79 were considered as children with high cognitive development. We coded all children with low cognitive development as 1 and all children with high cognitive development as 0.

Table N°1: ENSANUT questions and coding

ENSANUT question	Codification
(...) Did you ever attend a CIBV/ CDI Child Development Center or day care center?	0=No/1=Yes
(...) DID YOU EVER RECEIVE assistance from CNH educators in your home?	0=No/1=Yes
WITH WHOM do you stay (...) most of the time from Monday to Friday?	0=No/1=Yes
Can (...) identify or name at least ten letters of the alphabet?	0=No/1=Yes
Can you (...) read at least four simple, common words?	0=No/1=Yes
Do you recognize (...) the symbol of the numbers from 1 to 10 and know their names?	0=No/1=Yes
Can (...) pick up a small object with two fingers, such as a stick or a stone from the floor?	0=No/1=Yes
Do you sometimes (...) feel tired/ discouraged and don't feel like playing?	0=No/1=Yes
Can (...) follow simple instructions on how to do something correctly?	0=No/1=Yes
When given something to do, can he/she (...) do it by him/herself?	0=No/1=Yes
Are you easily distracted (...)?	0=No/1=Yes

Table 2 shows the results of the validity and reliability tests. Here we observe that the total number of items is 11, moreover, the average inter-item correlation is 0.621. That is, we observe that there is a high correlation between the 11 items, so that we can see that the items are highly correlated and explain our index in a good way. Crombach's alpha also shows an acceptable level, since it presents a value of 0.712. The Kayser Meyer Olin (KMO) statistic shows a high level. The KMO takes values between 0 and 1, and small values indicate that, in general, the variables have too little in common to justify a PCA analysis. In our case, we observed that our 11 items considered for analysis have a lot in common. We also note that Barlet's test is significant, indicating that the items are good measures for constructing the index of cognitive development.

Table N°2: Results of the sample reliability and validity test.

Test		Cognitive development index
Number of items		
Average interitem correlation		0.621
Cronbach's alpha		0.714
Kayser Meyer Olin measure (KMO)		0.801
Bartlett's test	Chi square	3.47e+05
	df	
	Sig.	0.000

Table 3 shows the results of the factor loadings from principal component analysis. Here we can observe each of the items used to construct our index of cognitive development. We observe that the factor loadings are high, meaning that each item contributes significantly to the constructed index. Furthermore, we observe that all our 11 items explain 78% of the variance, suggesting that our index has a large variance explained through each item used to construct it.

Table N°3: Results of the principal component analysis.

KMO= 0.801 **Variable**	**Cognitive Development Index**
(...) Did you ever attend a CIBV/ CDI Child Development Center or day care center?	0.723
(...) DID YOU EVER RECEIVE assistance from CNH educators in your home?	0.899

WITH WHOM do you stay (...) most of the time from Monday to Friday?	0.850
Can (...) identify or name at least ten letters of the alphabet?	0.825
Can you (...) read at least four simple, common words?	0.723
Do you recognize (...) the symbol for the numbers 1 to 10 and know their names?	0.899
Can (...) pick up a small object with two fingers, such as a stick or a stone from the floor?	0.850
Do you sometimes (...) feel tired/ discouraged and don't feel like playing?	0.825
Can (...) follow simple instructions on how to do something correctly?	0.745
When given something to do, can he/she (...) do it by him/herself?	0.882
Are you easily distracted (...)?	0.695
Variance explained	*78%*

Table 4 presents the descriptive statistics of the variables used in this study. Here we observe that the average index of cognitive development is 0.79 on a scale of 0 to 1. We also observe that 28.55% (CI=25.55%-30.55%) of the children in our sample reported suffering from obesity. This is a significant percentage. Our data also reveal that 53.33% (CI=50.33%-55.33%) of children are male. The number of siblings at home is 4 and our data show that the number of hours that the child is exposed to TV is 4 and the average number of hours spent playing is 3. Regarding the consumption of micronutrients, 82% (CI=79.52%-84.52%) of the mothers reported that they consumed micronutrients during their child's pregnancy. Meanwhile, 75.61% of the mothers are of mixed ethnicity, while the average number of prenatal checkups is 7 and 55. 61% (CI=52.51%-57.51%) of the mothers reported having a normal delivery.

Table N°4: Descriptive statistics of the variables used in this study

Variable	N	Mean-Percent	SD	Min	Max	95% CI
Cognitive development						
Low cognitive development	616	15..89%	0.44	0	1	15.02% - 16.77%
High cognitive development	3261	84.11%	0.89	0	1	83.17% - 85.43%
Obesity						
No	2770.11	71.45%	0.12	0	1	68,45% - 73,45%
Yes	1106.89	28.55%	0.43	0	1	25,55% - 30,55%
Child's age						
Age	3877	3.8	0.12		5	3.13 - 4.22
Sex of child						
Woman	1809.39	46.67%	0.14	0	1	43,67% - 48,67%
Man	2067.61	53.33%	0.33	0	1	50,33% - 55,33%
Siblings at home						
Number of siblings at home	3877	4.12	0.25	0		4.01 - 4.98
Hours of TV watched by the child						
Number of hours watching TV	3877	4.01	0.67	0	5	3.68 - 4.49
Child's hours of play						
Number of hours of play	3877	3.08	0.54	1		2.97 - 3.96
Do you think a child should be punished?						
No	2692.57	69.45%	0.66	0	1	66,45% - 71,45%
Yes	1184.43	30.55%	0.26	0	1	27,55% - 32,55%
Mother's age						
Age	3877	34.78	0.55			31.54 - 36.86
Did you consume micronutrients during pregnancy?						
No	677.70	17.48	0.89	0	1	14,48% - 19,48%
Yes	3199.30	82.52%	0.67	0	1	79,52% - 84,52%
Mother's ethnicity						
Indigenous	571.08	14.73%	0.35	0	1	14.26% - 15.20%
Afro-Ecuadorian	156.24	4.03%	0.20	0	1	3.77% - 4.29%

Mongrel	2931.39	75.61%	0.43	0	1	75.04%	-	76.18%
White	51.17	1.32%	0.11	0	1	1.17%	-	1.47%
Montubio	167.09	4.31%	0.20	0	1	4.04%	-	4.58%
Prenatal checkups								
Number of prenatal checkups	3877	7.01	0.25	1		4,01%	-	9,01%
Type of delivery								
Normal delivery	2152.12	55.51%	0.54	0	1	52,51%	-	57,51%
Cesaria	1724.88	44.49%	0.36	0	1	41,49%	-	46,49%

Subsequently, we performed a correlation matrix to perform a detailed analysis of the correlation between the variables and to highlight possible multicollinearity problems. **Table 5** shows significant correlations between cognitive development and the independent variables: Obesity, child's sex, number of siblings at home, number of hours watching TV, number of hours playing, should a child be punished, mother's age, micronutrient intake, number of prenatal controls. All these variables have an expected sign which is correct. In addition, we note that no correlation between the independent variables is greater than 50%. This shows that there are probably no serious multicollinearity problems among the variables. Below we perform a formal test to test for multicollinearity among the variables.

Table N°5: Correlation matrix of the variables

	Var 1	Var 2	Var 3	Var 4	Var 5	Var 6	Var 7	Var 8	Var 9	Var 10	Var 11	Var 12	Var 13
Var 1	1												
Var 2	-0.1005*	1											
Var 3	0.0089	0.0095	1										
Var 4	-0.0826*	0.0739*	-0.0023	1									
Var 5	-0.1001*	0.0485*	-0.0045	-0.0116	1								
Var 6	-0.0840*	0.0307*	0.0046	-0.0119	0.6216*	1							
Var 7	0.0113	0.0394*	-0.0054	0.0014	0.0220*	0.0251*	1						
Var 8	-0.0276*	0.3312*	0.0061	0.0217*	0.0689*	0.0787*	0.0489*	1					
Var 9	-0.0468*	0.0058	0.0073	0.0000	0.0114	0.0148*	0.0547*	-0.0697*	1				
Var 10	0.0716*	0.4734*	0.0021	0.0529*	-0.0685*	-0.0404*	-0.0471*	0.1700*	-0.1847*	1			
Var 11	-0.0393	-0.0979*	0.0080	0.0074	-0.0207*	-0.0267*	-0.0781*	-0.0228*	-0.2026*	0.1239*	1		
Var 12	0.0098*	0.0531*	0.0099	-0.0440*	0.0219*	0.0187*	0.1295*	0.1134*	0.1410*	-0.3042*	-0.1964*	1	
Var 13	0.0087	0.0548*	-0.0007	0.0015	-0.0123	-0.0021	0.0529*	0.0065	0.2222*	-0.1598*	-0.1992*	0.3081*	1

Note: Var 1: Cognitive development index. Var 2: Obesity. Var 3: Child's age. Var 4: Sex of child. Var 5: Number of siblings at home. Var 6: No. of hours watching TV. Var 7: N. hours of play. Var 8: Should a child be punished. Var 9: Age of mother. Var 10: Micronutrients in pregnancy. Var 11: Mother's ethnicity. Var 12: Number of prenatal checkups. Var 13: Type of delivery. Asterisks mean: *p < 0.05.

As mentioned above, we performed a formal test to rule out the presence of multicollinearity among our independent variables. In **Table 6** we present a multicollinearity analysis. We use the Variance Inflator Factor (VIF) to perform this test. Previous literature indicates that a VIF greater than 5 can demonstrate that multicollinearity exists in our data. As we can see, no variable has a VIF greater than 5, therefore we rule out multicollinearity problems in our independent variables. This analysis is important since multicollinearity problems cause instability of the parameters of a regression, incorrect signs and higher standard errors, which translates into statistical insignificance of the parameters.

Table N° 6: Multicollinearity test of the variables

Variable	**VIF**	**SQRT VIF**	**Tolerance**	**R-Squared**
Cognitive development index	1.25	1.55	0.9433	0.3305
Obesity	132	1.11	0.9966	0.0004
Child's age	1.01	1.54	0.9918	0.0082
Sex of child	1.77	1.28	0.6101	0.3899
N. of siblings at home	1.88	1.28	0.6145	0.3855
N. of hours watching TV	1.97	1.01	0.9764	0.0236

N. hours of play	1.45	1.06	0.8821	0.1179
Should a child be punished?	1.66	1.05	0.8812	0.1188
Mother's age	1.58	1.45	0.6310	0.3690
Micronutrients in pregnancy	1.09	1.66	0.9146	0.0854
Mother's ethnicity	1.29	1.14	0.7746	0.2254
N. of prenatal checkups	1.17	1.08	0.8583	0.1417
Type of delivery	1.05	1.05	0.9537	0.0463
Mean VIF	1.49			

Table 7 below shows a multivariate logistic regression analysis to analyze the factors that influence cognitive development. Our logistic regression involves 3877 children aged 3 to 5 years. Here we observe that the dependent variable is the index of cognitive development constructed weighted across 11 variables described above. We found that, as expected, the odd ratio (OR) associated with the obesity variable is significant and greater than 1 (with negative sign). This shows that a child with obesity has approximately 2.01 times (CI=-1.986- -2.321) the risk of suffering from poor cognitive development. Another significant OR is associated with the child's sex variables with an OR of 1.592 (CI=1.341- 1.978), showing that males have a higher risk of suffering from poor cognitive development. Likewise, a greater number of siblings at home increases the risk of having low cognitive development by 1.032 times. Our data also reveal that a greater number of hours in front of the TV could increase the risk of low cognitive development, while the number of hours of play causes an opposite effect, as the OR reveals that children with a greater number of hours of play have 1.68 times less risk of having low cognitive development. We also evidenced that parents who answered that they believe that children should be punished show that they have 1.45 times more risk of low cognitive development. Having consumed micronutrients during pregnancy also reduces 1.567 (CI=-1.354- -1.853) times the risk of suffering from poor cognitive development. These results are in line with the results showing that a higher number of prenatal controls reduces the risk of low cognitive development by 1.654 times.

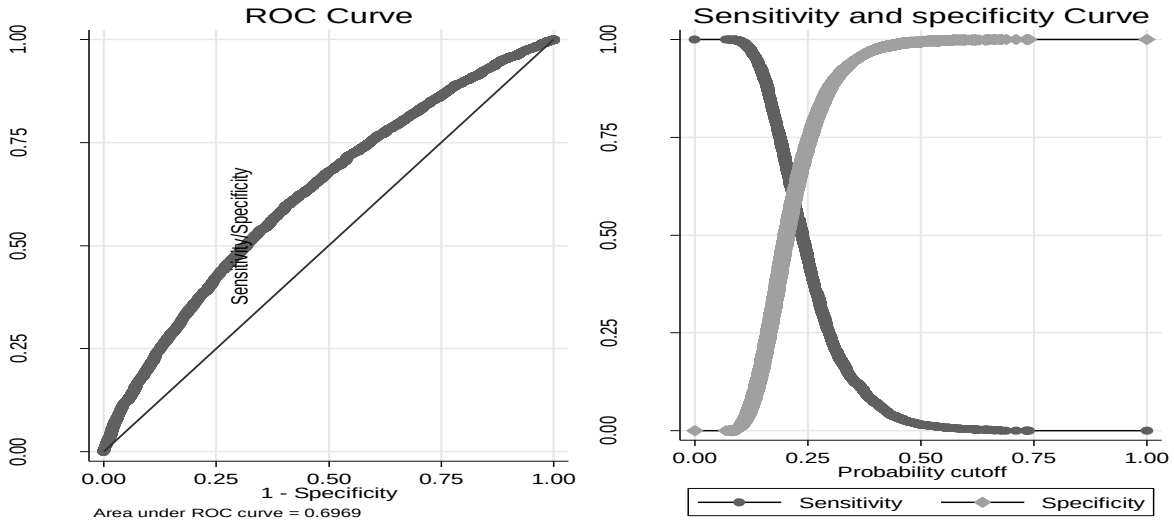
In **Table 7** we observe that the chi-square (X^2) and log-likelihood statistics are stable and statistically correct. The chi-square statistic is significant suggesting that, taken together, the independent variables jointly explain the variability of the dependent variable. On the other hand, the log-likelihood statistic is negative and it is observed that it collects as much information as possible.

Table N° 7: Logistic regression analysis between the index of cognitive development and obesity

Variable	**OR**	**Std. Err.**	**P>z**	**95% CI**
Obesity				
No	Ref.			
Yes	2.011**	0.982	0.002	1.986 - 2.321
Child's age				
Age	1.001	0.863	0.057	0.872 - 1.321
Sex of child				
Woman	Ref.			
Man	1.592**	0.765	0.003	1.341 - 1.978
Siblings at home				
Number of siblings at home	1.032**	0.054	0.004	1.012 - 1.453
Hours of TV watched by the child				
Number of hours watching TV	1.034	0.987	0.872	1.001 - 1.321
Child's hours of play				
Number of hours of play	-1.686***	0.542	0.001	-1.543 - -1.754
Do you think a child should be punished?				
No	Ref.			
Yes	1.455*	0.216	0.032	1.321 - 1.765
Mother's age				
Age	1.653	0.654	0.035	1.345 - 1.897
Did you consume micronutrients during pregnancy?				
No	Ref.			
Yes	-1.567*	0.535	0.045	-1.354 - -1.853

Mother's ethnicity						
Indigenous	Ref.					
Afro-Ecuadorian	-1.043	0.312	0.067	-1.012	-	-1.231
Mongrel	1.065	0.432	0.655	1.001	-	1.198
White	-1.986	0.563	0.192	-1.452	-	-2.004
Montubio	1.654	0.643	0.431	1.594	-	1.865
Prenatal checkups						
Number of prenatal checkups	-1.654**	0.543	0.031	-1.493	-	-1.985
Type of delivery						
Normal delivery	Ref.					
Cesaria	-1.456	0.753	0.912	-1.321	-	-1.764
Observations	3877					
AIC	23975.03					
BIC	23138.09					
R^2	0.025					
X^2	3.956***					
Log-likehood	-31461.51					

Finally, to determine the discriminatory power of the predictor variables, the ROC curve was applied with the probabilities estimated by applying the logistic regression under the method of introducing their confidence intervals and their statistical significance $p < 0.05$. The ROC Curve coincides with the probability of correctly distinguishing a case of low cognitive development from one that is not, through the significant predictor variables, being the worst case scenario when the area is equal to 0.50. In our case, the significant variables: obesity, sex of the child, number of siblings at home, number of hours of play, punishing the child, consuming micronutrients during pregnancy, and the number of prenatal controls, represented an area under the curve of 0.6969 (95% CI: 0.651-0.794), considering that they adequately predict cases of low cognitive development ($p < 0.001$). On the other hand, the sensitivity and specificity curve shows an adequate shape, given that it is observed to have a normal behavior. Specifically, we observed that the curves cross at an approximate value of 0.25, given a good formation of the curves.



ROC curve and sensitivity and specificity curve for the determination of the sensitivity of the model of cognitive development and obesity.

IV. Discussion

Excessive weight gain is a public health problem that affects a large majority of people worldwide, especially children. This condition can lead to the appearance of other health problems or, in turn, enhance existing ones. In particular, it has been possible to find evidence in the literature that identifies the consequences of childhood overweight and obesity at the physical and psychological level, establishing a negative relationship

between nutritional diagnoses of overweight and obesity with low performance in psychomotor and motor tests, i.e. psychomotor development. [18]The analysis of the anthropometric data of the children in our study shows that out of 3877 children 28.55% (CI=25.55%-30.55%) reported suffering from obesity. This is a significant percentage.

In addition, our data also reveals that 53.33% (CI=50.33%-55.33%) of children are male. The number of siblings at home is 4 and our data shows that the number of hours the child is exposed to TV is 4 and the average number of hours of play is 3. This shows that a child who presents obesity has approximately 2.01 times (CI=-1.986- -2.321) higher risk of suffering from low cognitive development. These results are consistent with the study by Poh et al. [19]in which children with severe obesity (BAZ > 3SD) had the highest prevalence of low/borderline nonverbal IQ compared to their non-obese counterparts with higher socioeconomic levels. Another study carried out in Sao Paulo in 2007 on 113 children between 6 and 70 months showed that children aged 25 to 60 months with body enlargement have difficulties in language, social development and fine and gross motor skills.

Lack of physical activity has been associated with poorer cognitive performance, including executive control, working memory, and cognitive flexibility in children. Changes in children's physical activity habits and academic pressures for higher performance have been proposed as the main culprits of children's sedentary lifestyles. In addition to changes in eating habits, some behavioral, emotional and cognitive characteristics detected in sedentary children have led to a considerable increase in the levels of childhood overweight/obesity today.[20] In our research we determined that on average an Ecuadorian child spends more time exposed to TV than playing. Therefore, the odds ratio (OR) associated with the obesity variable is significant and greater than 1 (with a negative sign). This means that a greater number of hours in front of the TV could increase the risk of low cognitive development, while the number of hours of playing causes an opposite effect, since the OR reveals that children with a greater number of hours of playing have 1.68 times less risk of having low cognitive development. These results are consistent with the research conducted by Rossi[21] where found that almost half (48%) of children under 6 years of age have used a computer and almost a third (30%) have played video games. Forty-three percent of children under 2 years of age watch television every day, and 26% have a television in their bedroom. Therefore, it determines that the low time dedicated to physical activity, the exaggerated time dedicated to sedentary activities or bad eating habits are behaviors that are being adopted in a large part of the western child population, mainly due to the indiscriminate use of screens (cell phones, laptops, computers, video games) which has a direct impact on the lower amount of hours of physical activity in children, which has a direct impact on the high rate of childhood obesity that we have these days.[21]Likewise, the Kaiser Family Foundation[22] determined that currently, in the United States, children spend an average of five and a half hours per day watching television or using electronic screens, which is equivalent to a full day of full-time work.

The poor interaction with natural environments and the restriction of movement from an increasingly early age, leads to a poor execution of motor proposals necessary for a correct psychomotor development. As a result, these children do not present the necessary motor skills during playtime, which will lead them to be rejected during playtime and to occupy their free time in activities that promote sedentary lifestyles and even more obesity.[1]These results open the possibility that excess body weight may make a significant difference in children's cognitive function, generating a long-term negative effect. Our work also suggests that children who are only overweight still have the possibility of avoiding the development of cognitive impairment if they change their habits.

Another important finding in our research suggests that maternal micronutrient intake during pregnancy reduces 1.567 (CI=-1.354- -1.853) times the risk of poor cognitive development in the child. Nyaradi et al. [23] agrees with our findings as it suggests that a deficiency of micronutrients or vitamins such as fatty acid, folic acid, zinc, iron and iodine, which, together with health problems, socioeconomic, environmental, biological and family factors can affect the normal functioning of motor and cognitive development of children.

On the other hand, the available evidence suggests that children of both sexes classified as overweight or obese present alterations in their psychomotor development in various areas, according to the results presented. However, some differences in motor performance according to gender can also be appreciated, since, as we stated in our results, a significant OR was obtained in the child's sex variable of 1.592 (CI=1.341- 1.978), showing that males have a higher risk of suffering from low cognitive development. In contrast, Cigarroa et al. [24] states that girls show a low motor performance in skills that require the presence of basic motor patterns (running, jumping, balance) and a better performance in fine motor activity in relation to boys.

Finally, the presence and combination of factors, both biological and socio-cultural, can influence with equal or greater intensity in the generation of psychomotor deficits. Variables such as: low exercise practice, low motivation for physical activity, the type of physical activity performed, perceived barriers to exercise and time spent in sedentary activities, are the main causes of low cognitive development.

V. Conclusion

This cross-sectional study u a representative sample of 3877 Ecuadorian children aged 3 to 5 years from the 2018 National Health and Nutrition Survey (ENSANUT) of Ecuador. A linear regression model was used to estimate the associated parameters and a binary logistic regression to estimate the Odds Ratio (OR) and their 95% confidence intervals (95% CI) for each of the independent variables.

Our results show that the average index of cognitive development is 0.79 on a scale of 0 to 1. We also observed that 28.55% (CI=25.55%-30.55%) of the children in our sample reported suffering from obesity. It is also evident that 53.33% (CI=50.33%-55.33%) of the children are male. The number of siblings at home is 4 and our data show that the number of hours the child is exposed to TV is 4 and the average number of hours playing is 3. This would indicate that on average an Ecuadorian child spends more time exposed to TV than playing. Regarding micronutrient intake, 82% (CI=79.52%-84.52%) of the mothers reported that they consumed micronutrients during their child's pregnancy. Our logistic regression shows that the dependent variable is the cognitive development index constructed weighted across 11 variables described above. We were able to determine that the odd ratio (OR) associated with the obesity variable is significant and greater than 1. Therefore, a child with obesity has approximately 2.01 times (CI=-1.986- -2.321) the risk of suffering from poor cognitive development. Another significant OR is associated with the child's sex variables with an OR of 1.592 (CI=1.341- 1.978), showing that males have a higher risk of suffering from poor cognitive development. Likewise, a greater number of siblings at home increases the risk of having low cognitive development by 1.032 times. Our data also reveal that a greater number of hours in front of the TV could increase the risk of low cognitive development, while the number of hours of play causes an opposite effect, as the OR reveals that children with a greater number of hours of play have 1.68 times less risk of having low cognitive development. We also found that having consumed micronutrients during pregnancy also reduces 1.567 (CI=-1.354- -1.853) times the risk of low cognitive development.

Based on our findings, we recommend working on policies aimed at regulating the eating habits of the population at all ages, starting with school life. We should be aware of the strong association that overweight and obesity have in the progressive reduction of certain physical and cognitive capacities. Therefore, it is recommended to perform daily 60 minutes of physical activity, which can be spread over several sessions throughout the day. In addition, greater interaction of day care professionals with the children's parents, through meetings, conferences and social activities, would allow a better understanding of the needs and deficiencies of each child, making it possible to customize appropriate intervention strategies.

References

[1]. Calceto-Garavito L, Garzón S, Bonilla J, Cala-Martínez D, Calceto-Garavito L, Garzón S, et al. Relación Del Estado Nutricional Con El Desarrollo Cognitivo Y Psicomotor De Los Niños En La Primera Infancia. Rev Ecuat Neurol. August 2019;28(2):50-8.

[2]. Weisstaub N G, Schonhaut B L, Salazar R G. Breastfeeding, motor development and obesity, is there a causal association? Rev Chil Pediatrics. 2017;88(4):451-7.

[3]. Bucco-dos Santos L, Zubiaur-Gonzalez M. Development of fundamental motor skills as a function of sex and body mass index in schoolchildren. Cuad Psicol Deporte. December 2013;13(2):63-72.

[4]. Black N, Kassenboehmer SC. Getting Weighed Down: The Effect of Childhood Obesity on the Development of Socioemotional Skills. J Hum Cap. June 2017;11(2):263-95.

[5]. World Health Organization. Establishing priority action areas for the prevention of childhood obesity in the population: toolkit for Member States to determine and identify priority areas for action [Internet]. Geneva: World Health Organization; 2016 [cited 2016 Apr 26, 2022]. 88 p. Available from: https://apps.who.int/iris/handle/10665/250750

[6]. Overweight-in-new-age-report-2021.pdf [Internet]. [cited 2022 Apr 26, 2022]. Available from: https://www.unicef.org/lac/media/29006/file/Sobrepeso-en-la-ninez-reporte-2021.pdf

[7]. Cigarroa I, Sarqui C, Zapata-Lamana R. Effects of sedentary lifestyles and obesity on psychomotor development in children: A review of Latin American current events. Univ Salud. April 2016;18(1):156-69.

[8]. A Mediation Model Linking Body Weight, Cognition, and Sleep-Disordered Breathing - PMC [Internet]. [cited 2022 Apr 24, 2022]. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3297090/

[9]. Mujica EAS. Motor learning in the first three years of a child's life. Pensam Educ Rev Investig Latinoam PEL. April 30, 2006;38(1):218-30.

[10]. Guimarães LV, Barros MB de A, Martins MSAS, Duarte EC. Factors associated with overweight in schoolchildren. Rev Nutr. February 2006;19:5-17.

[11]. Motor learning: a brief theoretical review [Internet]. [cited 2022 Apr 29, 2022]. Available from: https://www.efdeportes.com/efd109/aprendizaje-motor-una-breve-revision-teorica.htm

[12]. Castelli DM, Hillman CH, Buck SM, Erwin HE. Physical fitness and academic achievement in third- and fifth-grade students. J Sport Exerc Psychol. April 2007;29(2):239-52.

[13]. Datar A, Sturm R. Childhood overweight and elementary school outcomes. Int J Obes 2005. September 2006;30(9):1449-60.

[14]. Martin A, Booth JN, Young D, Revie M, Boyter AC, Johnston B, et al. Associations between obesity and cognition in the pre-school years. Obes Silver Spring Md. Jan 2016;24(1):207-14.

[15]. Comparative study between psychomotor development and nutritional status in kindergarten children belonging to a municipal and a private school in the city of Temuco [Internet]. [cited April 27, 2022]. Available from: http://repositorio.ucm.cl/handle/ucm/1701

[16]. Afzal AS, Gortmaker S. The Relationship between Obesity and Cognitive Performance in Children: A Longitudinal Study. Child Obes Print. August 2015;11(4):466-74.

[17]. Saldaña BF, Mendoza JMG. Childhood obesity and school achievement: Is there a relationship between obesity and school achievement? :7.

[18]. Pérez-Vega DJ, Males-Villegas MS, Reinoso-Mena E. Influence of overweight and obesity on disabilities, cognitive impairment and school performance. ScientiAmerica. May 10, 2021;10(1):92-110.
[19]. Poh BK, Lee ST, Yeo GS, Tang KC, Noor Afifah AbR, Siti Hanisa A, et al. Low socioeconomic status and severe obesity are linked to poor cognitive performance in Malaysian children. BMC Public Health. June 13, 2019;19(4):541.
[20]. Cigarroa I, Sarqui C, Zapata-Lamana R. Effects of sedentary lifestyles and obesity on psychomotor development in children: a review of Latin American current events. Univ Salud. April 2016;18(1):156-69.
[21]. Rossi RR. Childhood obesity and the effects of electronic media. 2006;4.
[22]. The Role of Media in Childhood Obesity. 2004;12.
[23]. Nyaradi A, Li J, Hickling S, Foster J, Oddy W. The role of nutrition in children's neurocognitive development, from pregnancy through childhood. Front Hum Neurosci [Internet]. 2013 [cited May 4, 2022];7. Available from: https://www.frontiersin.org/article/10.3389/fnhum.2013.00097
[24]. Cigarroa I, Sarqui C, Zapata-Lamana R. Effects of sedentary lifestyles and obesity on psychomotor development in children: a review of Latin American current events. Univ Salud. April 2016;18(1):156-69.

Darwin Toaquiza-Cuzco, et. al. "How does obesity influence cognitive development in children? Empirical evidence from the Ecuadorian case." *IOSR Journal of Nursing and Health Science (IOSR-JNHS)*, 11(03), 2022, pp. 47-57.