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The association of intelligence quotient with obesity and some related factors in children girls

Behnaz Abiri[1], Mohammadreza Vafa[2], Parvin Sarbakhsh[3], Leila Saleck[4], Elnaz Mousavi[4], Fatemehsadat Amiri[5], Zohreh Amiri[6]*

[1]Department of Nutrition, School of Public Health, Iran University of Medical Sciences, Tehran, Iran; [2]Department of Nutrition, School of Public Health, Iran University of Medical Sciences, Tehran, Iran - E-mail: rezavafa@yahoo.com; [3]Department of Statistics and Epidemiology, School of Public Health, Tabriz University of Medical Sciences, Tabriz, Iran; [4]Faculty of Behavioral Sciences and Mental Health, Iran University of Medical Sciences, Tehran, Iran; [5]Department of Nutrition, School of Public Health, Iran University of Medical Sciences, Tehran, Iran; [6] National Nutrition and Food Technology Research Institute, Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Summary. *Background & aim:* Childhood obesity is a major public health challenge and a leading cause of various chronic diseases, and reducing the quality of life. Some studies have shown that obesity may harm both the body and the brain. The aim of this study is to investigate the association of Intelligence Quotient (IQ) with obesity and some related factors in children girls in Tehran. *Methods:* In this cross-sectional study, a total of 286 students (143 obese and 143 non-obese) in the first grade of primary school (aged 6-7 years) were chosen randomly from 19 regions of the ministry of education, from Tehran city. Variables consist of anthropometric indices, dietary intakes, physical activity level, IQ, and some socioeconomic factors were assessed. Statistical analysis was performed using SPSS-V 23 software. *Results:* There was no statistically significant difference between the obese (ob) and non-obese (non-ob) groups for the total score of IQ (IQ_{ob}: 97.11±11.1 and $IQ_{non\text{-}ob}$: 95.94±11.9; P= 0.43). In both obese and non-obese groups, there was no significant relationship between IQ with fat mass percentage (FM%) (P_{ob}= 0.939, $P_{non\text{-}ob}$= 0.729) and fat free mass percentage (FFM%) (P_{ob}= 0.969, $P_{non\text{-}ob}$= 0.729). Also, for the total sample, there was no significant relationship between Body Mass Index and IQ (P= 0.186). Moreover, in both groups, neither dietary intakes of total energy (P_{ob}= 0.978, $P_{non\text{-}ob}$= 0.386), fat (P_{ob}= 0.637, $P_{non\text{-}ob}$= 0.223), carbohydrate (P_{ob}= 0.541, $P_{non\text{-}ob}$= 0.701), or protein (P_{ob}= 0.921, $P_{non\text{-}ob}$= 0.476) intake nor physical activity (P_{ob}= 0.144, $P_{non\text{-}ob}$= 0.319) has significantly been related to IQ. But in both groups, IQ was positively associated with parent's education level and also there was positive relationship between economic status and IQ (P<0.05). *Conclusion:* It seems, in this aged girls group, there was no significant relationship between obesity and IQ, and in these children, IQ varied according to socioeconomic status.

Key words: obesity, body composition, intelligence quotient, school children

Introduction

Obesity, explained by accumulation of surplus adipose tissue, has become a global epidemic with notable results for health because of its relationship with increased heart disease, hypertension, diabetes, stroke and cancer (1,2). While some of these medical conditions are associated with unfavorable cognitive effects (3-6), a recent study indicates that adiposity has a particular relationship with cognitive function. Obese rats have been shown to carry out worse on learning and memory compared with normal weight rats (7,8).

Remarkably, non-obese rats were provided a high-fat diet have also been demonstrated to be cognitively damaged compared with those provided normal chow (9-13). The trends toward elevated energy intake and body mass in combination with reduced physical activity behaviors may have negative effects for cognitive health and scholastic achievement (14).

Social-emotional wellbeing in early years of life contributes to form behavior later in life (15). Children living in poverty get less cognitive stimulant at home and may demonstrate reduced attention span, deficient memory and weaker acquiring skills and all of these impact on cognitive development (15).

However, the findings about the association between obesity and cognitive function during childhood are inconclusive (16-18). Thus, the present study aimed to investigate the association of Intelligence Quotient with obesity and some related factors in children girls in Tehran, and to our knowledge it is the first study that selecting the equal number of obese and non-obese children and evaluating the obesity according to both body composition and body mass index in this aged children girls group.

Methods

Study design and sampling

This cross-sectional study has been organized on children girls aged 6-7 years in Tehran, in 2014-2015. A random sample of 286 healthy girls (143 obese and 143 non-obese) chosen in a multistage sampling from government elementary schools. One school from each of the 19 educational regions of Tehran city was selected randomly. In the second step, first grade student were chosen randomly from each of schools. Children could participate in the study if they were first grade students, children girls, to be healthy (were not suffering from any chronic and acute disease), were not mental retarded, with the gestational age between 37-42 weeks and birth weight 2500-4000 g, and were not taking vitamin, mineral, laxative, or hormonal medication.

The number of participants computed for each group was 143, at 80% power, $Z\beta=0.84$, $Z\beta/2=1.96$, confidence interval=95%, SD=15, and to detect a difference of 5 units and equality of variances in two groups (15). Collectively, the sample of 286 children girls were recruited.

In this study, obese children (according to body composition; FM%≥28.4% (19)) (n=143) and an equal of non-obese children were selected. Parents were invited to the schools. The aims and the method of research were described for them. This study was approved by the Ethics Committee of the Iran University of Medical Sciences (IUMS).

Intelligence Quotient (IQ) assessment

Intelligence Quotient (IQ) is a highly authentic measure of general intellectual function that included overall ability different cognitive functions. Student's IQ scores was determined using the Wechsler Intelligence Scale-βV (21), for children aged 6-16 years. This scale had a mean score of 100 and a standard deviation of 15. Two trained psychologists gave these tests. Each child was assessed in the school.

Anthropometric, dietary intakes, physical activity, and socioeconomic measurements

Weights and heights of the children were assessed. Weights were measured using a portable Beurer scale with minimum clothing and without shoes to the nearest 0.1 kg. Heights were measured with a precision of 0.5 cm, in standing position and without shoes, using a fixed tape meter. Body Mass Index (BMI) was computed using the formula kg/m^2. Body composition including fat mass and fat free mass was assessed by portable Beurer scale. Sensitivity of the scale was 0.1 kg and 0.1% for weight and body composition, respectively. Obesity was defined as a FM% of 28.4% or higher (19).

Dietary intakes were assessed with a 24-h food recall for 2 days (1 week day and 1 weekend day), and calorie and macronutrient (total fat, carbohydrate, protein) intakes were estimated using Nutritionist 4 software. Physical activity level was evaluated by the Persian and short form of the International Physical Activity Questionnaire (IPAQ) and indicated in Met-Min/week (20).

The socioeconomic status of participants was obtained from the mothers, using an economic indicator based on the presence or absence of private bedroom, computer, automobile, and travelling on holydays. According to this scale, three economic groups were defined: low, medium and high. The level of education of parents was evaluated as a social factor (primary, secondary, or university). This socioeconomic frame has been commonly used in Iran (22).

Statistical Analysis

Data analysis was performed using SPSS-V 23 software. The Kolmogorov-Smirnov test was applied to evaluate normality of data. Mean±SD was used to describe normal distributed data. Non-normally distributed data was described as Median (IQ).

The mean values of the IQ, dietary intakes, physical activity, and socioeconomic measurements were compared between obese and non-obese children using independent *t*-test for normal distributed continuous variables and Mann-Whitney *U* test for non-normal distributed continuous variables. ANOVA was performed to compare the mean of IQ among the levels of socioeconomic status of children. Pearson correlation for normal data and spearman correlation for non-normal variables were used to detect all possible bivariate associations. Multiple linear regression was used to assess association between IQ and obesity adjusted for potential confounders. Post Hoc (Tukey-HSD) test was performed for determining the differences of IQ between levels of socioeconomic status. A two-tailed P value < 0.05 was considered significant.

Results

Descriptive statistics of obese and non-obese children girls are demonstrated in table 1. Results were presented for 286 children girls (143 obese and 143 non-obese), and no statistically significant difference between the two groups was seen for the mean score of IQ (P=0.43). Obese girls were taller (P=0.01), heavier and had higher BMI and FM% than non-obese girls (P<0.001). The results of correlations between FM% and FFM% with IQ in both groups are shown in table 2. According to this table, There was no significant correlation between IQ with FM% (P_{ob}= 0.939, P_{non-ob}= 0.729) and FFM% (P_{ob}= 0.969, P_{non-ob}= 0.729) in both groups. Even none of these correlations were not significant after discriminant of economic status and adjusting for age and physical activity level (P >0.05) (data not shown). In addition, for the total sample, no significant association was found for BMI and IQ (P= 0.186).

We found no significant relations between IQ and dietary intakes of total energy (P_{ob}= 0.978, P_{non-ob}= 0.386), fat (P_{ob}= 0.637, P_{non-ob}= 0.223), carbohydrate

Table 1. Characteristics of obese and non-obese participants

Variables	Obese (n=143)	Non-obese (n=143)	P-Value
Age, years[a]	6.42±0.5	6.46±0.5	0.47
Height, cm[a]	120.8±5.74	119.2±5.2	0.01*
Weight, kg[a]	26.63±5.87	21.75±3.41	<0.001**
BMI, kg/m2[a]	18.08±2.76	15.22±1.55	<0.001**
Fat Mass, (%)[b]	28.9(29.5-30.6)	9.1(15.7-19.5)	<0.001**
Fat Free Mass,(%)[b]	69.4(70.5-71.2)	80.5(84.3-90.9)	<0.001**
IQ,(total score)[a]	97±11.1	95.94±11.9	0.43
Energy intake, kcal/day[b]	1000(1280-1572)	1080(1325-1589)	0.23
Carbohydrate intake,g/day[b]	111.7(137.5-195.3)	119.4(143.5-186.6)	0.77
Fat intake, g/day[b]	45.33(54.46-70.57)	46.32(58.71-74.51)	0.26
Protein intake, g/day[b]	30.83(43-54.12)	35.46(47.45-59.53)	0.02*
Physical activity, Met- Min/week[b]	546(1038-2076)	405(834-1655)	0.07

*[a]Values are described as mean±SD, (t-test); [b]Median (Inter Quartiles), (Mann Whitney U test); *Results are statistically significant at P<0.05; ** Results are statistically significant at P<0.001 Abbreviation: IQ, Intelligence Quotient. BMI, Body Mass Index*

(P_{ob}= 0.541, $P_{non\text{-}ob}$= 0.701), or protein (P_{ob}= 0.921, $P_{non\text{-}ob}$= 0.476) in both groups (data shown in table 3). In addition, for both groups, there was no significant correlation between physical activity level and IQ (P_{ob}= 0.144, $P_{non\text{-}ob}$= 0.319). The analysis of the economic status of families of children demonstrated that in obese group 29.37% of families were classified as low economic status, 51.04% were middle and 19.58% of them were at high level. In non-obese group, 28.67% of families were classified as low economic status, 46.15% were middle, and 25.17% of them were as high level. In both obese and non-obese groups, we found a positive significant relationship between IQ and economic status (P_{ob}<0.001, $P_{non\text{-}ob}$= 0.03). Moreover, there was a positive significant association between IQ and education level of both parents in obese ($P_{mother's\ education}$<0.001, $P_{father's\ education}$<0.001) and non-obese ($P_{mother's\ education}$= 0.004, $P_{father's\ education}$<0.001) groups (data shown in table 4).

Post Hoc (Tukey-HSD) analysis showed that in both obese and non-obese groups, there was a significant difference between low and high levels of economic status for the mean score of IQ (P_{obese} <0.001 and $P_{non\text{-}obese}$= 0.002). Moreover, according to this analysis (Tukey-HSD), only in obese group, a significant difference between low and middle levels of economic status was seen for the mean score of IQ (*P* <0.001), but not in non-obese group (*P*=0.120). Also, these results revealed that in none of obese and non-obese groups, there was no significant difference between middle and high levels of economic status for the mean score of IQ (P_{obese}= 0.460 and $P_{non\text{-}obese}$= 0.129) (data not shown).

Discussion

In this study we found no significant association between obesity and IQ, in both obese and non-obese groups. In a study, Datar *et al*. (23), investigated the association between weight and test score in mathematics, among ≥ 11000 kindergarteners in the US. They showed that overweight children in compare with children of normal weight had lower test scores. However, when the data were adjusted for socioeconomic status, and other variables, the associated decreased, with the exception of the relationship between boy's overweight status and mathematics (23). They found that overweight status is not associated with lower test scores but may be as a marker for poorer scholastic achievement. Similar findings supporting the results of Datar *et al.* (23) were mentioned by Judge and Jahns (24), who revealed that the association between overweight and weaker performance on mathematics and reading was adjusted by demographic features in a sample of 14000 3rd grade children from the Early Childhood Longitudinal study. Moreover, Sargent and Blanch Fower (25) showed that teen obesity is related to a significantly

Table 2. Correlations between IQ with body fat mass percentage and fat mass percentage in obese and non-obese participants

	Fat Mass (%)		Fat Free Mass (%)	
IQ	r*	P, Sig. (2-tailed)	r	P, Sig. (2-tailed)
Obese (n=143)	0.006	0.939	-0.003	0.969
Non-obese(n=143)	0.029	0.729	-0.029	0.729

* Spearman Correlation; Abbreviation: IQ, Intelligence Quotient

Table 3. Correlations between IQ with food intake in obese and non-obese participants

	IQ (total score)			
	Obese (n=143) r*	P	Non-obese (n=143) r	p
Energy intake, kcal/day	0.002	0.978	-0.073	0.386
Carbohydrate intake,g/day	0.052	0.541	-0.032	0.701
Fat intake, g/day	0.040	0.637	-0.010	0.223
Protein intake, g/day	-0.110	0.192	-0.060	0.476

** Spearman Correlation; Abbreviation: IQ, Intelligence Quotient*

Table 4: Socioeconomic variables and IQ in each group*

	IQ (total score)			
	Obese (n=143)		Non-obese (n=143)	
Socioeconomic Variables	N	Mean±SD	N	Mean±SD
Economic status	P <0.001***		P =0.03**	
Low	42	90.55±9.38	41	91.54±11.3
Middle	73	98.93±10.71	66	96.08±10.76
High	28	101.64±10.27	36	100.72±13.00
Total	143	97.00±11.05	143	95.94±11.92
Mother's education	P <0.001***		P =0.004**	
Primary	24	88.67±7.05	22	89.14±11.20
Secondary	65	96.86±10.76	84	96.12±11.47
University	54	101.31±10.37	37	99.59±11.90
Total	143	97.00±11.05	143	95.94±11.92
Father's education	P <0.001***		P <0.001***	
Primary	33	90.73±9.38	30	89.00±9.81
Secondary	61	96.16±10.29	70	95.84±9.95
University	49	102.27±10.68	43	100.95±13.82
Total	143	97.00±11.05	143	95.94±11.92

*Abbreviation: IQ, Intelligence Quotient; *ANOVA (analysis of variance); **Statistically significant at P<0.05; *** Statistically significant at P<0.001*

lower education degree continuing into adulthood. Another study (26) found that obese children performed worse on the Wechsler Intelligence Scale for Children than their normal weight peers. In spite of these findings, it was mentioned that the causality could not be determined, because the cross-sectional nature of the study left open the likelihood that other effective variables may have been associated with the observed results (26), and could not find the temporality of obesity and low IQ. To advance research and purify causal reasoning about the obesity-IQ association, life-span studies are required. These studies can check within-individual changes in IQ from childhood, before the beginning of obesity to adulthood, after obesity expands (27,28). Some of studies revealed that adults who were obese in midlife were more possible to suffer cognitive decrease and progress dementia than were their lean counterparts (29-31). Furthermore, Galvan *et al.* (15) in a study examined the relationship between childhood obesity, cognitive development, physical fitness and social-emotional wellbeing, in a sample of 107 non-obese and 108 obese pre-school children. The authors concluded that only in non-obese children, there is a positive trend between IQ and socioeconomic status. However, for mid-low socioeconomic status, BMI has a negative effect on IQ (15).

In the current study, in both obese and non-obese groups, there was no significant correlation between IQ and food intake variables. In a study, Kata *et al.* (32) investigated the association between dietary pattern and IQ at 8 years of age. They found that a poor diet with high fat, sugar and processed food in early childhood may be related to little decreases in IQ in later childhood, while a healthy diet may be related to little elevations in IQ in later childhood. In addition, in current study, misreporting of food intake and snack foods could occur by parents, because of social appealing. Moreover, it should be noted that many other environment effects, regulate the impacts of nutrition on cognition and behavior.

In both obese and non-obese children groups, IQ was positively correlated to parent's education level, and also there was significant positive relationship between economic status and IQ. Similar finding supporting these results, were published by Galvan *et al.* (15) concluded that in normal children, IQ changes according to socio-demographic features; while in obese children, early nutrition also had an important role. Children living in poverty get less cognitive stimulant at home and may demonstrate reduced attention span, deficient memory and weaker acquiring skills and all of these impact on cognitive development (15).

Our findings demonstrated that in both groups, there was no significant relationship between physical activity levels with IQ. Data propose that the time spent in physical activities is useful, because it does not diminish scholastic performance and in fact it can enhance overall health and function (33-36). In this study lack of association between IQ and physical activity may be due, in part, to dissimilar methods used to evaluate physical activity. Different ages and sexes of the participants involved, have also affected the comparison of studies.

In brief, theories that noted obese adults are at more considerable risk pay attention to dysregulation and promoted systemic inflammation (37,38). Our results showed that, at least during the childhood, these exposures do not damage the IQ. In addition, controversial findings may be due to multidimensional nature of cognition.

The strengths of this study are: selecting the equal number of obese and non-obese children and assessment the potential confounders, evaluating the obesity according to body composition, but it was better to evaluate body composition by using DEXA or BIA.

Some limitations of our study should be noted: cross-sectional of this study, further researches are required to evaluate whether obesity in childhood is associated with late-life impaired intellectual function. Moreover, our study was conducted without neuroimaging assessment, and only was done according to neuropsychological testing to evaluate brain performance.

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Correspondence:
Mohammadreza Vafa,
Department of Nutrition, School of Public Health,
Iran University of Medical Sciences, Tehran, Iran
Email: rezavafa@yahoo.com