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Association of anthropometric parameters with intelligence quotient in early school-aged children: a cross-sectional study in Iran

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Abstract

Background While the link between body growth indices in the first three years of life and neurodevelopment is well established, the relationship between these indicators and intelligence levels in later stages is not well understood. This study aimed to investigate the association between various anthropometric indices and Intelligence Quotient in early school-aged children.

Methods This cross-sectional study recruited healthy students aged 7 to 8 years from four primary schools in Tehran, Iran. Measurements included body weight, height, body mass index, arm circumference, waist circumference, and hip circumference. Intelligence Quotient was assessed using the Raven's Standard Progressive Matrices Test, with scores standardized by age according to the Raven's manual. Separate univariate linear regression analyses evaluated the association between each anthropometric index and children's Intelligence Quotient scores. Multivariate linear regression analyses were then performed to adjust for potential confounding factors, including the child's sex, age, and parental education levels.

Results A cohort of 160 children (80 females), with a mean age of 7.5 ± 0.6 years, was included in the study. The participants exhibited the following mean anthropometric values: weight 27.7 ± 6.5 kg, height 1.2 ± 0.1 m, body mass index 17.9 ± 3.4 kg/m^2, arm circumference 20.7 ± 2.8 cm, waist circumference 56.4 ± 6.4 cm, and hip circumference 68.1 ± 6.6 cm. Their mean Intelligence Quotient score was 106 ± 16.6. In the univariate analysis, children's weight was not significantly associated with Intelligence Quotient score (*P*-value = 0.153, β = 0.288 [-0.108, 0.684]), while height was negatively associated (*P*-value = 0.048, β = -31.685 [-63.142, -0.228]) and body mass index showed a positive association (*P*-value = 0.001, β = 1.265 [0.524, 2.006]). Abdominal circumference was not significantly associated with Intelligence Quotient (*P*-value = 0.913, β = 0.051 [-0.870, 0.972]), but both waist circumference (*P*-value = 0.007, β = 0.542 [0.147, 0.937]) and hip circumference (*P*-value = 0.013, β = 0.484 [0.102, 0.866]) demonstrated significant positive associations with Intelligence Quotient. However, none of the anthropometric indices maintained statistically significant associations with Intelligence Quotient after adjusting for potential confounders (*P*-values > 0.05).

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Conclusions This study indicated no strong relationship between various body measurements and intelligence levels in school-aged children after adjusting the analyses for confounders. This suggests that intelligence in these children may be largely shaped by genetic and sociodemographic factors, with minimal influence from physical growth patterns.

Keywords Body mass index, Body weight, Childhood obesity, Intelligence quotient, Raven's progressive matrices

Background

The relationship between various anthropometric indices and cognitive performance across different life stages has garnered increasing research attention [1, 2]. Previous investigations have highlighted the profound influence of maternal nutrition before and during pregnancy, breastfeeding practices, offspring's birth weight, and appropriate nutrition during the initial three years of a child's life on their Intelligence Quotient (IQ) [3–6]. Notably, a correlation has been established between low birth weight and diminished IQ scores in adolescence and adulthood [7]. Furthermore, research involving monozygotic twins revealed lower IQ levels in offspring with reduced birth weight compared to their counterparts [8]. This highlights the significant association between anthropometric indices and the level of neurodevelopmental progress during the early stages of life, including the fetal, infant, and early childhood periods [9].

However, the potential association between the body composition indicators and anthropometric measures with intelligence level in school-age children remains unclear. Studies on this topic have yielded conflicting results. Some have reported that obese children exhibit diminished cognitive function, highlighting a negative association between Body Mass Index (BMI) and IQ scores in school-age children [10, 11]. However, this relationship seems to be largely mediated by sociodemographic factors [10]. On the other hand, a substantial body of evidence has found no significant association between children's body growth indices and IQ scores [12, 13]. These inconsistencies underscore that the precise relationship between IQ and various anthropometric parameters in school-aged children is still inadequately understood.

Therefore, the present study was conducted to examine the correlation between IQ scores and various anthropometric measures, including weight, height, BMI, arm circumference (AC), waist circumference (WC), and hip circumference (HC) in early school-aged children. Based on a review of existing literature, we hypothesized that there would be a negative association between body weight, BMI, AC, WC, and HC and children's IQ scores [10, 14–17], while a positive association was anticipated with height [9, 17].

Methods

Design, setting, and participants

A cross-sectional survey was conducted on 7–8-year-old children in the 17th district of Tehran, Iran, from February to March 2020. Participants for this study were selected utilizing an available sampling method from four primary schools in the designated region. The exclusion criteria comprised individuals with (a) mental retardation, (b) psychiatric disorders including major depressive disorder, anxiety disorders, attention-deficit hyperactivity disorder, autism spectrum disorders, and conduct disorder, (c) developmental disabilities (d) cerebral palsy (e) any chronic medical conditions such as asthma, type 1 diabetes, anemia, and malignancies (f) genetic disorders such as cystic fibrosis, Down's syndrome, fragile x syndrome, and Turner syndrome. Furthermore, children resulting from multiple pregnancies were not considered for inclusion in this study.

Ethical considerations

Prior to participation, verbal and written informed consent from parents and verbal agreement from students were obtained, following a detailed presentation of the study's purpose and comprehensive explanations regarding the information sought in the questionnaire. The involvement of school children and their parents in this survey was entirely voluntary, allowing them to withdraw from the study at any point without consequence. The research protocol received approval from the Institutional Review Board (IRB) and Ethics Committee of Tehran University of Medical Sciences, under the reference number IR.TUMS.1394.1016. All aspects of the study adhered to the guidelines outlined in the Declaration of Helsinki [18]. We also followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [19].

Data collection

Demographic characteristics, including age, sex, and parents' educational level, were gathered for each participant. Body weight measurements were taken with children wearing light clothing and no shoes or socks, utilizing a standard and calibrated electronic balance scale (Model GR-300, San Jose, CA, USA) with an accuracy of 0.01 g. The scale was calibrated before each measurement session to ensure precision. Height measurements were obtained without shoes, in a standing position, using a stadiometer with a precision of 0.5 cm, ensuring the shoulders were in a normal state. AC at the humerus middle was assessed with the arm slightly elevated and internally rotated, without contracting the biceps muscle. WC was measured to the nearest 0.1 cm using an elastic-band meter, with children in a standing position at the distal third of the distance from the xiphoid process to the umbilicus. HC was determined at the maximum protuberance of the buttocks, measured with a tape measure to the nearest 0.1 cm. All measurements were conducted by trained personnel following a standardized protocol to minimize variability and ensure consistency.

BMI was calculated by dividing weight (in Kg) by the square of the assessed height (in m). According to the BMI classifications from the Centers for Disease Control and Prevention (CDC) growth charts (accessible at https://www.cdc.gov/growthcharts/clinical_charts.htm), children were categorized as underweight (< 5^{th} percentile), normal (5^{th}-85^{th} percentile), overweight (85^{th}-95^{th} percentile), obese (95^{th}-99^{th} percentile), and severely obese (≥ 99^{th} percentile).

Outcome measures

To assess the children's intelligence level, we administered the Persian-translated version of Raven's Standard Progressive Matrices (RSPM), a tool for evaluating non-verbal reasoning skills [20, 21]. The RSPM consists of five sets (A, B, C, D, and E) of 12 items each, with increasing difficulty as the test progresses. The test requires participants to identify the missing element in a series of geometric patterns. Children choose the correct missing piece from six options in sets A and B, and eight options in sets C, D, and E, within a 45-min time limit. This test is designed to measure logical problem-solving and clear thinking without relying on language. Previous research has demonstrated favorable internal consistency (Cronbach's alpha = 0.827) and criterion validity (correlation coefficient = 0.73) for the Persian-translated version of the RSPM in assessing IQ scores among Iranian populations [22].

The main outcome of the study was the children's IQ scores, which were derived from their performance on the RSPM and standardized based on their age according to the guidelines outlined in the Raven's Manual [23].

Statistical analysis

The statistical analysis was performed using IBM® SPSS® program version 25.0. Categorical data were expressed as numbers and percentages, while continuous data were presented as mean ± standard deviation. The independent t-test and one-way Analysis of Variance (ANOVA) were employed to compare the mean IQ scores among children based on sex, age groups, and the educational levels of both mothers and fathers. These factors were considered potential confounders following a review of the existing literature [21, 24–26]. The *P*-value derived from Levene's test was interpreted to account for the homogeneity of variances. A *P*-value < 0.05 was set as the statistical significance level.

We conducted linear regression analyses to evaluate the association between various anthropometric variables (weight, height, BMI, AC, WC, and HC) and children's IQ scores. Initially, we assessed key assumptions of the regression model: the Durbin-Watson statistic was used to evaluate the independence of errors, a scatterplot was examined to assess homoscedasticity, the histogram of residuals was checked to verify the normality of residuals, and the Variance Inflation Factor (VIF) and tolerance values were inspected to assess multicollinearity. Subsequently, univariate (unadjusted) linear regression analyses were performed for each predictor variable, calculating the β along with the corresponding 95% confidence interval (CI), *P*-values, t-values, and R^2 values. Statistical significance was set at *P*-value < 0.05. Furthermore, multivariable linear regression analyses were performed to adjust the results of our univariate analyses for potential confounders, including age, sex, and parental educational level, across all studied anthropometric indices.

Moreover, a subgroup analysis was also conducted using univariate linear regression to assess the association between each anthropometric index and children's IQ within male and female cohorts separately. Then, multivariable linear regression analyses were performed to adjust the univariate results for potential confounders, including age and parental educational level, across all anthropometric indices examined.

Results

Participants' characteristics

A total of 160 students were included in the study, comprising half males and half females. The mean age of the participants was 7.5 ± 0.6 years. The predominant educational background among parents was at the high school diploma level, with 50.6% of mothers and 41.3% of fathers holding this qualification. Other prevalent educational levels included education below the high school diploma level (35.6% of mothers and 38.8% of fathers), bachelor's degree (8.8% of mothers and 11.9% of fathers), associate degree (3.8% for both mothers and fathers), master's degree (0.6% of mothers and 3.8% of fathers), and doctorate (0.6% for both mothers and fathers).

The mean weight of the children was 27.7 ± 6.5 kg, and their mean height was 1.2 ± 3.4 m. Consequently, the mean BMI was 17.9 ± 3.4 kg/m^2. To provide further detail, 2 (1.3%) children were underweight, 90 (56.3%) had normal weight, 26 (16.3%) were overweight, 16 (10.0%) were obese, and 26 (16.3%) were severely obese. The mean AC, WC, and HC of the population were 20.7 ± 2.8, 56.4 ± 6.4, and 68.1 ± 6.6 cm, respectively. Furthermore, the participants exhibited a mean IQ score of 106 ± 16.6 (Table 1).

In examining the relationship between baseline demographic characteristics and children's IQ scores, we observed that males had significantly higher mean IQ scores compared to females (111.9 ± 13.7 vs. 100.0 ± 17.1; *P*-value < 0.001). Additionally, we observed that children younger than 7.5 years had significantly higher IQ scores compared to those aged 7.5 years and older (110.4 ± 15.9 vs. 102.6 ± 16.4; *P*-value = 0.003). However, no statistically significant differences in mean IQ scores were found based on maternal or paternal education levels (*P*-values = 0.285 and 0.974, respectively) (Table 2).

Table 1 Demographic and anthropometric characteristics of the study participants[a]

Variables	Groups	
Sex	Male	80 (50.0)
	Female	80 (50.0)
Age, years		7.5 ± 0.6 (6.5–9.0)
Mother's education	Below high school diploma	57 (35.6)
	High school diploma	81 (50.6)
	Associate degree	6 (3.8)
	Bachelor's degree	14 (8.8)
	Master's degree	1 (0.6)
	Doctorate	1 (0.6)
Father's education	Below high school diploma	62 (38.8)
	High school diploma	66 (41.3)
	Associate degree	6 (3.8)
	Bachelor's degree	19 (11.9)
	Master's degree	6 (3.8)
	Doctorate	1 (0.6)
Arm circumference, cm		20.7 ± 2.8 (16.0–29.0)
Waist circumference, cm		56.4 ± 6.4 (45.0–77.0)
Hip circumference, cm		68.1 ± 6.6 (56.0–90.0)
Weight, Kg		27.7 ± 6.5 (17.0–48.0)
Height, m		1.2 ± 0.1 (1.05–1.43)
BMI, Kg/m^2		17.9 ± 3.4 (13.0–33.4)
BMI category	Underweight	2 (1.3)
	Normal	90 (56.3)
	Overweight	26 (16.3)
	Obese	16 (10.0)
	Severely obese	26 (16.3)
IQ score		106 ± 16.6 (71.0–137.0)

Abbreviations: *BMI* Body Mass Index, *IQ* Intelligence Quotient

[a] Categorial data are presented as numbers (percentage), and continuous data are presented as mean ± standard deviation (range)

Association of anthropometric indices with children's IQ scores

Based on the results of our linear regression analyses, we found no significant associations between children's IQ scores and body weight (*P*-value = 0.153, β = 0.288 [-0.108, 0.684]). However, there was a negative association with height (*P*-value = 0.048, β = -31.685 [-63.142, -0.228]), which was no longer significant after adjusting for sex, age, and parental education (*P*-value = 0.784) (Table 3).

Additionally, a significant positive association emerged between participants' BMI and their IQ scores (*P*-value = 0.001, β = 1.265 [0.524, 2.006]), but this association diminished after adjusting for covariates (*P*-value = 0.067) (Table 3). Moreover, no significant differences in mean IQ scores were observed across different bodyweight categories, with values of 101.5 ± 27.5, 102.9 ± 17.2, 106.9 ± 14.7, 107.6 ± 14.6, and 115.0 ± 13.8 for

Table 2 Examining the association of baseline demographic features and IQ scores of the children[a]

Variables	Groups	IQ score	*P*-value
Sex	Male	111.9 ± 13.7	< 0.001[b*]
	Female	100.0 ± 17.1	
Age, years	< 7.5	110.4 ± 15.9	0.003[b*]
	≥ 7.5	102.6 ± 16.4	
Mother's education	Below high school diploma	103.1 ± 15.7	0.285[c]
	High school diploma	106.4 ± 16.4	
	Associate degree	107.5 ± 21.1	
	Bachelor's degree	112.7 ± 18.5	
	Master's degree	130.0 ± 0.0	
	Doctorate	105.0 ± 0.0	
Father's education	Below high school diploma	100.9 ± 15.7	0.974[c]
	High school diploma	108.0 ± 16.5	
	Associate degree	116.6 ± 17.1	
	Bachelor's degree	108.7 ± 16.0	
	Master's degree	113.0 ± 16.8	
	Doctorate	126.0 ± 0.0	

Abbreviations: *IQ* Intelligence Quotient

[*] Statistically significant (*P*-value < 0.05)

[a] Continuous data are presented as mean ± standard deviation

[b] Independent t-test

[c] ANOVA

Table 3 Findings of the linear regression analyses on the association of different anthropometric indices with children's IQ scores in the entire cohort ($n = 160$)

Variables	Unadjusted analysis				Adjusted analysis[a]		
	β [95% CI]	*P*-value	t	R^2	β [95% CI]	*P*-value	t
Weight	0.288 [-0.108, 0.684]	0.153	1.436	0.013	0.195 [-0.179, 0.570]	0.305	1.030
Height	-31.685 [-63.142, -0.228]	0.048*	-1.989	0.024	-4.935 [-40.444, 30.574]	0.784	-0.275
BMI	1.265 [0.524, 2.006]	0.001*	3.373	0.067	0.628 [-0.93, 1.348]	0.087	1.720
AC	0.051 [-0.870, 0.972]	0.913	0.110	< 0.001	0.168 [-0.683, 1.018]	0.697	0.390
WC	0.542 [0.147, 0.937]	0.007*	2.711	0.044	0.289 [-0.094, 0.672]	0.138	1.490
HC	0.484 [0.102, 0.866]	0.013*	2.504	0.038	0.334 [-0.032, 0.699]	0.073	1.804

Abbreviations: *AC* Arm Circumference, *BMI* Body Mass Index, *CI* Confidence Interval, *HC* Hip Circumference, *WC* Waist Circumference

[*] Statistically significant (*P*-value < 0.05)

[a] Adjusted for children's sex, age, as well as mother's and father's educational level as potential confounders

the underweight, normal weight, overweight, obese, and severely obese groups, respectively (*P*-value = 0.180).

There was also no significant association between AC and IQ scores (*P*-value = 0.913, β = 0.051 [-0.870, 0.972]). In contrast, positive associations were identified for WC (*P*-value = 0.007, β = 0.542 [0.147, 0.937]) and HC (*P*-value = 0.001, β = 0.484 [0.102, 0.866]) with IQ scores; however, these associations disappeared after adjusting for sex, age, and parental education (*P*-values = 0.138 and 0.073, respectively) (Table 3).

Subgroup analysis based on the children's sex

Male cohort

Our univariate linear regression analyses revealed no significant associations between children's IQ scores and any of the following anthropometric measures: body weight (*P*-value = 0.717, β = 0.084 [-0.374, 0.541]), height (*P*-value = 0.627, β = 14.092 [-43.391, 71.576]), BMI (*P*-value = 0.732, β = 0.155 [-0.744, 1.055]), AC (*P*-value = 0.519, β = -0.365 [-1.487, 0.758]), WC (*P*-value = 0.778, β = 0.067 [-0.404, 0.538]) or HC (*P*-value = 0.403, β = 0.198 [-0.272, 0.669]). Moreover, after adjusting for the potential confounders of children's age and parental educational levels, none of these measures showed significant associations with IQ scores (*P*-values > 0.05) (Table 4).

Female cohort

In the univariate analysis, a significant positive association was found between children's IQ scores and BMI (*P*-value = 0.004, β = 1.742 [0.580, 2.904]), while no significant associations were observed for body weight (*P*-value = 0.492, β = 0.217 [-0.408, 0.842]), height (*P*-value = 0.052, β = -36.531 [-73.333, 0.270]), AC (*P*-value = 0.878, β = 0.581 [-0.736, 1.898]), WC (*P*-value = 0.059, β = 0.622 [-0.023, 1.266]), and HC (*P*-value = 0.137, β = 0.435 [-0.141, 1.012]). After adjusting for children's age and parental educational levels, significant positive associations were observed between IQ scores and BMI (*P*-value = 0.028, β = 1.241 [0.138, 2.344]) and WC (*P*-value = 0.046, β = 0.597 [0.011, 1.183]), with no significant associations found for body weight, height, AC, or HC (*P*-values > 0.05) (Table 4).

Discussion

During our investigation, we observed noteworthy associations between various anthropometric measures (e.g., BMI) and IQ in school-aged children. However, these associations lost significance upon adjusting the analyses for cofounders. This suggests that, contrary to our initial hypothesis, there are no robust associations between anthropometric indices and the IQ scores of children at early-school age.

The relationship between IQ and BMI in children remains a subject of conflicting evidence. In accordance with our own findings, certain studies have reported no significant associations between BMI and IQ, even among children with obesity [12, 27]. In line with this, numerous studies demonstrated no correlations between the children's BMI and their cognitive performance [13, 28]. These findings support a growing body of literature suggesting that intelligence performance in early-school-aged children is not necessarily linked to anthropometric measures [12, 27]. Instead, cognitive performance in this population is likely more influenced by genetic and sociodemographic factors than by physical growth patterns [29, 30].

However, there are studies that reported a negative association between children's BMI and IQ, suggesting a lower intelligence level in obese children [10, 16]. Notably, a study focusing on 233 children aged 5–8 years found that a higher weight-to-height ratio is associated with lower IQ scores [31]. On the other hand, Sandjaja et al. (2013) presented a different perspective, indicating

Table 4 Findings of the linear regression analyses on the association of different anthropometric indices with children's IQ scores in the male ($n=80$) and female ($n=80$) cohorts

Variables	Unadjusted analysis				Adjusted analysis[a]		
	β [95% CI]	*P*-value	t	R^2	β [95% CI]	*P*-value	t
Males							
Weight	0.084 [-0.374, 0.541]	0.717	0.363	0.002	0.112 [-0.367, 0.591]	0.642	0.467
Height	14.092 [-43.391, 71.576]	0.627	0.488	0.003	27.578 [-36.272, 91.427]	0.392	0.860
BMI	0.155 [-0.744, 1.055]	0.732	0.344	0.002	0.152 [-0.780, 1.084]	0.746	0.326
AC	-0.365 [-1.487, 0.758]	0.519	-0.647	0.005	-0.358 [-1.533, 0.817]	0.546	-0.607
WC	0.067 [-0.404, 0.538]	0.778	0.283	0.001	0.092 [-0.404, 0.589]	0.712	0.370
HC	0.198 [-0.272, 0.669]	0.403	0.840	0.009	0.249 [-0.249, 0.748]	0.322	0.997
Females							
Weight	0.217 [-0.408, 0.842]	0.492	0.691	0.006	0.415 [-0.183, 1.013]	0.171	1.384
Height	-36.531 [-73.333, 0.270]	0.052	-1.976	0.048	-10.317 [-58.922, 38.389]	0.674	-0.423
BMI	1.742 [0.580, 2.904]	0.004*	2.985	0.103	1.241 [0.138, 2.344]	0.028*	2.306
AC	0.581 [-0.736, 1.898]	0.383	0.878	0.010	0.868 [-0.372, 2.107]	0.167	1.394
WC	0.622 [-0.023, 1.266]	0.059	1.919	0.045	0.597 [0.011, 1.183]	0.046*	2.344
HC	0.435 [-0.141, 1.012]	0.137	1.503	0.028	0.469 [-0.066, 1.003]	0.085	1.748

Abbreviations: *AC* Arm Circumference, *BMI* Body Mass Index, *CI* Confidence Interval, *HC* Hip Circumference, *WC* Waist Circumference

* Statistically significant (*P*-value < 0.05)

[a] Adjusted for children's age and mother's and father's educational level as potential confounders

that children with low BMI-for-age have a significantly increased likelihood (3.5 times) of obtaining a non-verbal IQ score lower than 90 [11]. Additionally, a study conducted in central Nigeria found a significant positive association between BMI and IQ in children aged 6–12 years, suggesting that malnourished children with lower BMI had poorer cognitive performance compared to those with better nutrition and higher BMI [32]. A similar association was observed in a study on school-aged children in Nepal [33]. These findings suggest that in low- to middle-income regions, the relationship between BMI and IQ may differ significantly from that seen in other regions. In areas with a higher prevalence of malnutrition, a greater proportion of children with lower BMI suffer from malnutrition, which is a risk factor for reduced IQ and cognitive function in children [34, 35]. Thus, a positive association between BMI and IQ scores is expected, as reflected in our unadjusted analysis, given that the children in our study were recruited from a region in Tehran where a great proportion of the families face socioeconomic challenges [36]. Although this association disappeared after adjusting for confounders, it is noteworthy that the initial findings may reflect the socioeconomic conditions of our study population.

We believe that disparities in findings across studies on the BMI-IQ relationship primarily stem from differences in the populations studied, particularly in terms of socioeconomic status and geographic location. Also, many studies have not adjusted for the effects of key confounders. Prior research has demonstrated the significant influence of sociodemographic factors—such as parental education, living conditions, and family income—on children's cognitive performance [37–39]. Moreover, certain studies have highlighted distinct patterns of associations between anthropometric measures and intelligence in children from diverse socioeconomic backgrounds [40–42]. This highlights the need for further large-scale studies worldwide that utilize robust analytic approaches to adjust for multiple sociodemographic factors, providing more definitive conclusions on the relationship between anthropometric indices and children's intelligence.

It is noteworthy that our subgroup analysis by sex revealed interesting findings. While no significant associations between anthropometric measures and IQ scores were found in the male cohort, a significant positive association emerged between BMI and WC with IQ in the female cohort. The distinct associations observed between anthropometric measures and IQ across male and female children in our study emphasize that, beyond their differing neurodevelopmental trajectories and IQ scores [39, 43, 44], the relationship between intelligence and anthropometric measures also varies by sex [45].

Furthermore, our adjusted analyses found no significant associations between height and IQ in school-aged children, challenging the widely held belief of a direct link between the two. A substantial body of evidence has previously reported a positive correlation between children's height and cognitive performance, with large-scale cohort studies suggesting that taller students often perform better academically [11, 46]. One suggested explanation is that growth hormone, naturally produced in higher quantities in taller children, may enhance brain function [47]. However, more recent studies suggest that this positive association weakens over time, emphasizing the potential impact of sociodemographic factors on cognitive abilities [48]. Our findings align with this view, indicating that height is not necessarily a predictor of cognitive abilities. Similar results have been reported in other studies, including one that found no significant association between height and IQ in a population of eight-year-olds, comparable to our study cohort [49]. This suggests that, contrary to the traditional assumption that taller students perform better academically, various sociodemographic factors may substantially moderate the relationship between height and intelligence. Additionally, while some studies have reported a positive link between height and IQ, much of this association may be attributed to shared genetic factors rather than a direct causal relationship [50]. This reinforces the idea that although height and IQ may appear correlated in many studies, the observed relationship is likely influenced by underlying genetic factors rather than reflecting a true direct link.

Our study is subject to certain limitations. Its cross-sectional design precludes the establishment of a causal relationship between anthropometric measures and IQ scores in children. Additionally, potential selection bias and errors in measurement tools may have impacted the results, warranting cautious interpretation. The sample size is limited, drawn from schools in a specific region of Tehran predominantly inhabited by medium-to-low and low-income families, which restricts the generalizability of our findings. Furthermore, due to limitations in our data collection process, we were unable to gather information on several important sociodemographic factors known to significantly interact with children's IQ scores, such as parental IQ, living environment, and family income. Given the recognized influence of various socioeconomic factors on both the neurodevelopment of children and the growth of their anthropometric indices [41, 51], failing to account for these variables as potential confounders may introduce bias into our findings. Consequently, further research employing longitudinal designs, larger sample sizes, and meticulous control for multiple sociodemographic parameters is warranted to elucidate the precise association between different anthropometric indices and IQ in school-aged children.

Conclusions

Our study suggests that there is no strong association between various anthropometric indices (such as BMI) and IQ in school-aged children. This finding indicates that genetic and sociodemographic factors may exert a more significant influence on intelligence levels in these children than their nutritional status and body growth patterns. Consequently, the anthropometric growth patterns observed during early-school-aged childhood may not accurately reflect their neurodevelopmental and cognitive status. Nonetheless, there is still a need for future research to elucidate the precise association between body anthropometric indicators and IQ scores in early-school-aged children.

Abbreviations

AC	Arm Circumference
ANOVA	Analysis of Variance
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CI	Confidence interval
HC	Hip Circumference
IQ	Intelligence Quotient
RSPM	Raven's Standard Progressive Matrices
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
VIF	Variance Inflation Factor
WC	Waist Circumference

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Not applicable.

Authors' contributions

KM conceptualized the study, ME gave technical support and conceptual advice, RT and ME designed the study, RT, SEM, KM, and AI collected data, MP analyzed and interpreted study data, MP, KM, and AI wrote the manuscript, and RT, SYM, ME, and MP revised and edited the manuscript. All authors read and approved the final manuscript.

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Data availability

The data analyzed in this paper will be available in terms of reasonable request to the corresponding author.

Declarations

Ethics approval and consent to participate

All stages of this study were performed in studies involving human participants in accordance with the Declaration of Helsinki. Prior to enrollment, the study protocol was approved by the Institutional Review Board (IRB) and ethics committee of the Tehran University of Medical Sciences with the reference number IR.TUMS.1394.1016. Prior to participation, verbal and written informed consent from parents and verbal agreement from students were obtained, following a detailed presentation of the study's purpose and comprehensive explanations regarding the information sought in the questionnaire.

Consent for publication

After explaining the purpose of the study, verbal and written informed consent was obtained from the parents of the students for the anonymous publication of their children's data.

Competing interests

The authors declare no competing interests.

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