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The Relationship between Development Indices and Children's Growth Among Under 12-Month-Old Children in Markazi Province, Iran

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Abstract

Background: The factors affecting children's growth and development have been discussed in various research studies. This study evaluates the association between growth and development of under 12-month-old children in Iran.

Methods: This cross-sectional study uses the Ages & Stages Questionnaire (ASQ) data and demographic characteristics in the child's health records of 15,885 Iranian children in Arak city up to March 2017. The impact of growth disorder, type of delivery, preterm birth, at birth weight/height/head circumference, gross motor, problem-solving, personal-social, communication, and fine motor on the participants' head circumference/weight/height was assessed. Unadjusted analyses were done using independent sample t-test, Pearson correlation test and one-way analysis of variance. Multiple multivariate regression was utilized for adjusted effects. P-values less than 0.05 were considered statistically significant.

Results: Head circumference was associated with growth disorder, type of delivery, and preterm birth. Children with known and unknown growth disorders had 610.19 and 160.58 grams less weight than those without any growth disorder. Gross motor and personal-social aspects of ASQ were found to be associated with weight at the age of 12-month old. Height at 12-months was affected by growth disorder, gross motor, personal-social, communication, and fine motor.

Conclusion: Results of this study show that cesarean type of delivery, preterm birth, and low birth weight are the impacting factors associated with negative children growth trends and lower developmental status at the age of 12 months.

Key Words: Ages & Stages Questionnaire, Children, Developmental Progress, Growth Disorder.

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1- INTRODUCTION

Managing the health issues related to children is one of the most important indicators of the development of societies. It has been shown that a considerable fraction of children under the age of 5 are at moderate to severe risk of delay in individual and social-behavioral development (1). Due to the need for optimal and exclusive follow-up in children with developmental disorders in the early years of life, it is necessary to determine various factors affecting child health and managing programs concerning maternal health, along with family and child performance (2). Commonly, observing the mother-child interaction and measuring growth indicators are the primary tools for evaluating children's growth and monitoring their development (3, 4).

From 1 to 12 months of age, children grow and develop in physical, cognitive, emotional and social, language, sensory and motor aspects. Controlling other development and growth factors avoids potential problems for the children and the parents. This includes unexpected growth halt, losing skills, negative signs of different issues related to the child's health such as hearing and walking, and future mental and psychological complications (5). It has been widely argued that a 12-month-old child must have different physical and mental capabilities such as weight and height gain, standing and walking ability, playing, following moving objects, saying and understanding simple words, and experiencing separation anxiety (6, 7). It is a fact that receiving appropriate support in the first year, significantly, affects a child's development (8).

Based on literature, the determinants of growth and development mainly are child nutrition and sex, psychological factors, genetic characteristics such as head and chest circumference, height and weight, socioeconomic features, birth order and spacing, and the level of parents' education (9). Children's growth and development indices are measured based on uniform patterns across different regions in Iran (10). In addition, local monitoring of child growth includes measuring weight, height, and head circumference for age (11, 12) and child development is investigated based on the "Ages & Stages Questionnaires (ASQ) (13, 14). It is of the first magnitude to control and improve the indicators of children's growth and development by recognizing its influencing factors. Literature has categorized this case into four main sets, including social, economic, political and cultural aspects.(15) However, other studies have introduced micro factors including age at birth, birth weight, maternal pregnancy diseases, maternal age and smoking habits, nutrition in pregnancy, etc. (16, 17).

Based on previous studies, there are limited similar findings in this field, most of which were designed on small sample sizes. And the issue has not been investigated in Markazi Province, yet. Then, based on the need to improve the condition of children's growth and development, this study aims to evaluate the association between growth and development of under 12-month-old children and to determine their influencing factors.

2- MATERIALS AND METHODS

This study is a cross-sectional study; all methods were carried out in accordance with STROBE guideline (Strengthening the Reporting of Observational Studies in Epidemiology).

This study uses the information of children under 12 months old up to March 2017. Data collection is done through ASQ questionnaire, and demographic characteristics in the child's health record were used. The Ages and Stages

Questionnaire (ASQ) is a parent-completed questionnaire that can be used to evaluate children's development (13). This development screening tool includes 19 intervals, in five areas of personal-social, gross motor, fine motor, problem-solving, and communication. This commonly used instrument has been translated into several languages, including Persian, with a reliability of 0.86 (18). Development indicators are extracted from different ASQ forms collected from health centers and databases and compared with the documentations of the same child's growth indicators available in the national integrated health system. Cases with incomplete information in the national integrated health system and ASQ were excluded from the research. Between birth and 12 months of age, which is assessed in this study, five different forms of the ASQ questionnaire (4, 6, 8, 10 and 12 months) are used, each of which contains about 30 questions and it is suitable for the age of the child. In fact, different forms are used for different ages.

Variables including growth disorder (no/yes/unknown), type of delivery (vaginal/Cesarean), preterm birth (term/preterm), at-birth head circumference (cm), at-birth weight (gr), at-birth height (cm), gross motor, problem solving, personal-social, communication, and fine motor were used as the independent features and 12-month head circumference (cm), 12-months weight (gr), and 12-month birth height (cm) were assumed as the dependent variables.

2-1. Data Analysis

Mean (standard deviation) and frequency (percentage) were used to describe the continuous and categorical variables. Comparing the means of outcome variables across categorical independent variables was done using independent samples t-test and one-way analysis of variance. The association of continuous independent variables and the outcomes were assessed by the Pearson correlation test. Simple linear regression was applied to find the estimated effect size of predictors. Those with a p-value less than 0.20 were entered into the multiple regression model to assess the adjusted impact of multiple predictors on the outcomes. Moreover, multivariate (more than one associated response variables) multiple (more than one predictor) regression was done to take the potential interaction among the outcome variables.

The statistical analysis was preceded by R programming software (https://cran.r-project.org/), and a p-value less than 0.05 was considered statistically significant.

3- RESULTS

Among 15885 children, 10620 (~67%) completed questionnaires were collected. 0.8% of the participants had growth disorders, 59.8% were delivered vaginally, and 6.6% had preterm births. More details about the descriptive characteristics of children under 12 months of age are shown in **Table 1**.

The one-way analysis of variance and Tukey’s multiple comparisons show that children with growth disorder have significantly bigger head circumferences at 12 months, less weight at 12 months and shorter height ($p<0.001$). The independent samples t-test also revealed that vaginally delivered children had a significantly 0.21cm bigger head circumference at 12 months ($p<0.001$). Moreover, preterm cases had a significant 2.47 cm head circumference at 12 months ($p<0.001$). The Pearson correlation test demonstrated that 12-month height and weight of children were statistically associated. It was shown that 12-month head circumference is positively and significantly associated with head circumference (at birth), weight (at birth), height (at birth), gross motor, problem-solving, personal-social, communication, and fine motor. Except for the personal-

social aspect of the ASQ, other variables were associated with 12-month weight. In addition, 12-month head was significantly correlated with weight at birth, gross motor, and problem-solving dimensions of ASQ. More details are demonstrated in **Table 2**.

The unadjusted impact of growth disorder, type of delivery, preterm birth, gross motor, problem solving, personal-social, weight at birth, height at birth, head circumference at birth, communication, and fine motor on the outcome variables was carried out using simple univariate regression models. Based on the results in **Table 3**, 12-month head circumference is statistically affected by each of the independent variables ($p<0.001$). Moreover, except for the type of delivery, preterm birth, and personal social dimension of the ASQ, all other predictors were separately effective on weight and height at 12 months.

The adjusted impact of each predictor on the outcome variables was estimated through multiple regression. To consider the potential interaction between the outcome variables, we fitted multivariate multiple regression as well. As mentioned above, the association between the response variables was insignificant except for the correlation between height and weight at 12 months. After fitting both models, it was revealed that the results of multivariate multiple and univariate multiple regression are the same. Hence, the output of univariate multiple regression is demonstrated in **Table 3**. All independent variables were entered in the univariate multiple regressions regarding the high number of observations.

Table-1: Descriptive characteristics of children under 12 months old

Variables	Category	Mean or Frequency	SD or percentage
Growth disorder	No	10153	95.6%
	Yes	80	0.8%
	Unknown	387	3.6%
Type of delivery	Vaginal	6347	59.8%
	CS	4273	40.2%
Preterm Birth	Term	9914	93.4%
	Preterm	706	6.6%
Head circumference (12 Months)		45.55	1.69
Height (12 Month)		75.5	2.8
Weight (12 Month)		9428.7	1143.7
Head circumference (at birth)		32.6	.8
Height (at birth)		49.1	2.4
Weight (at birth)		3179.3	468.4
Gross motor		54.4	8.3
Problem solving		56.6	5.9
Personal-social		54.6	7.6
Communication		54.7	7.1
Fine motor		56.8	5.7

Table-2: Unadjusted association between the outcomes and independent variables

Independent Variables	Outcome Variables					
	Head circumference (12 Months)		Weight (12 Month)		Height (12 Month)	
Categorical Variables	Mean (SD)	P	Mean (SD)	P	Mean (SD)	P
Growth disorder		<0.001		<0.001		<0.001
No	45.61 (1.61)		9440.5(1134.2)		75.6 (2.8)	
Yes	41.81(2.31)		9000.7(1616.0)		74.5(3.2)	
Unknown	44.63(2.32)		9208.2(1233.9)		75.1(3.1)	
Type of delivery		<0.001		0.919		0.349
Vaginal	45.63(1.58)		9427.8(1144.8)		75.5(2.8	
CS	45.42(1.84)		9430.1(1142.1)		75.6(2.8)	
Preterm Birth		<0.001		0.159		0.432
Term	45.71(1.47)		9432.9(1138.7)		75.5(2.8)	
Preterm	43.24(2.69)		9370.1(1211.1)		75.5(2.9)	
Continuous Variables	r	P	r	P	r	P
Head circumference (12 Months)			0.01	0.064	0.01	.914
Weight (12 Month)					0.59	<0.001
Height (12 Month)						
Head circumference (at birth)	0.34	<0.001	0.05	<0.001	0.03	.001
Weight (at birth)	0.35	<0.001	0.05	<0.001	0.03	.001
Height (at birth)	0.32	<0.001	0.03	.002	0.01	.171
Gross motor	0.17	<0.001	0.07	<0.001	0.05	<0.001
Problem solving	0.24	<0.001	0.03	<0.001	0.02	.022
Personal-social	0.32	<0.001	0.01	.265	-0.01	.510
Communication	0.19	<0.001	0.02	.008	-0.01	.747
Fine motor	0.20	<0.001	0.02	.019	0.00	.731

Table-3: The results of Univariate simple and multiple linear regressions assessing the impact of different predictors on the outcome variables

Outcome	Predictor	Univariate Simple Regression		Multiple Regression	
		Estimate (SE)	P	Estimate (SE)	P
Head circumference (12 Months)	Growth disorder (Yes)	-3.80(0.185)	<0.001	-1.345(0.21)	<0.001
	Growth disorder (Unknown)	-0.97(0.086)	<0.001	-0.023(0.088)	0.794
	Type of delivery (Cesarean)	-0.21(0.033)	<0.001	-0.08(0.031)	0.009
	Preterm Birth (Yes)	-2.46(0.061)	<0.001	-2.048(0.113)	<0.001
	Weight (at birth)	0.001(0)	<0.001	0.002(0)	<0.001
	Height (at birth)	0.226(0.006)	<0.001	0.034(0.009)	<0.001
	Head circumference (at birth)	0.735(0.019)	<0.001	-0.481(0.06)	<0.001
	Gross motor	0.035(0.002)	<0.001	0(0.002)	0.942
	Problem solving	0.07(0.003)	<0.001	0(0.003)	0.928
	Personal-social	0.073(0.002)	<0.001	-0.024(0.005)	<0.001

	Communication	0.045(0.002)	<0.001	-0.005(0.003)	0.039
	Fine motor	0.06(0.003)	<0.001	-0.002(0.003)	0.629
Weight (12 Month)	Growth disorder (Yes)	-439.77(128.2)	0.001	-610.19(155.183)	<0.001
	Growth disorder (Unknown)	-232.31(59.16)	<0.001	-160.587(64.765)	0.013
	Type of delivery	2.301(22.632)	0.919	-4.406(22.645)	0.846
	Preterm Birth (Yes)	-62.795(44.5)	0.159	-242.886(83.402)	0.004
	Weight (at birth)	0.135(0.024)	<0.001	0.22(0.083)	0.008
	Height (at birth)	14.326(4.621)	0.002	4.491(6.958)	0.519
	Head circumference (at birth)	79.341(13.884)	<0.001	202.674(44.339)	<0.001
	Gross motor	10.43(1.335)	<0.001	6.887(1.615)	<0.001
	Problem solving	6.683(1.87)	<0.001	-1.271(2.522)	0.614
	Personal-social	1.626(1.459)	0.265	-27.622(3.385)	<0.001
	Communication	4.123(1.556)	0.008	-1.928(1.901)	0.31
	Fine motor	4.557(1.948)	0.019	-3.031(2.402)	0.207
Height (12 Month)	Growth disorder (Yes)	-1.021(0.314)	0.001	-1.774(0.381)	<0.001
	Growth disorder (Unknown)	-0.411(0.145)	0.005	-0.359(0.159)	0.024
	Type of delivery	2.301(22.632)	0.919	0.037(0.056)	0.508
	Preterm Birth (Yes)	-62.795(44.547)	0.159	0.311(0.205)	0.128
	Weight (at birth)	0.135(0.024)	<0.001	0.001(0)	0.006
	Height (at birth)	14.326(4.621)	0.002	-0.001(0.017)	0.941
	Head circumference (at birth)	79.341(13.884)	<0.001	0.386(0.109)	<0.001
	Gross motor	10.43(1.335)	<0.001	0.014(0.004)	<0.001
	Problem solving	6.683(1.87)	<0.001	-0.001(0.006)	0.834
	Personal-social	1.626(1.459)	0.265	-0.063(0.008)	<0.001
	Communication	4.123(1.556)	0.008	-0.014(0.005)	0.003
	Fine motor	4.557(1.948)	0.019	-0.012(0.006)	0.039

Cases with a growth disorder, Cesarean type of delivery, and preterm birth had 1.34, 0.08, and 2.04 smaller head circumferences, respectively ($p<0.05$). One score increase in personal-social and communication skills is associated with 0.02 and 0.005 smaller head circumference at 12 months ($p<0.05$). Children with known and unknown growth disorder had 610.19 and 160.58 grams less weight than those without growth disorder ($p<0.05$). It was also shown that preterm birth is associated with 242.88 grams less weight at 12 months ($p=0.004$). One score increase in the ASQ's gross motor and personal-social aspects is associated with 6.88 more and 27.62 less weight at 12 months ($p<0.05$). Height at 12 months was, respectively, 1.77 and 0.35 cm less among cases with a known and unknown growth disorder than those without the disorder ($p<0.05$). Further, one unit increase in gross motor, personal-social, communication, and fine motor scores is associated with 0.01 more and 0.06, 0.014, and 0.012 less height at 12 months ($p<0.05$).

4- DISCUSSION

In this study, we used ASQ to assess developmental factors in 12-month-old children. The Ages and Stages Questionnaire is a parent-completed child monitoring system that was developed in 1980 as an alternative screening assessment for infants and young children.

The ASQ is a set of 11 developmental questionnaires composed of three sections: a short set of demographic items; 30 worded questions focusing on infant's or children developmental repertoire; and a brief section asking seven open-ended questions. The 30 items are divided into five domains: communication, gross motor, fine motor, problem-solving, and personal-social. Once an infant or child is identified for screening, a questionnaire appropriate for the child's age (or corrected age) can be mailed to the parents at the following intervals: 4, 6, 8, 12, 16, 18, 20,24, 30, 36, and 48 months. For each item on the questionnaires, a "yes" response indicates that the child performs the behavior, "sometimes" response expresses that the child performs the item on occasion (an emerging behavior), and "not yet" demonstrates that the child does not yet perform the behavior.

The findings of our study show a significant relationship between low birth weight, preterm birth, and mental and motor development. Jaekal et al. (19) reached similar conclusions in their study. In their study, the relationship between head growth and intelligence score between childhood and adulthood in very preterm people (<32 weeks of gestational age) with very low birth weight (less than 1500 gr birth weight) was assessed. Head circumference was measured at five months of age, 20 months and four years of age. In addition, IQ was also obtained by standard tests at 6, 8 and 26 years of age. They showed that very preterm and very low birth weight subjects had a smaller head circumference at birth (27.61 cm vs. 35.11 cm, mean difference of 7.49, 95% confidence interval (7.09–7.90)) and also had a lower intelligence score (88.98 vs. 102.54, mean difference 13.56 (10.59–16.53)) in comparison to the term subjects.

In 2009, Datar et al. (20) designed a study to examine the effect of low birth weight on mental, motor and physical development. They used the z-score of motor development, weight-for-age, weight-for-length and length-for-age parameters measured at nine months and two years of age. The authors investigated the effect of very and moderate low birth weight on monozygotic and dizygotic twins. The results of their study showed that very and moderate low birth weight have a large negative effect on the mental development and motor development of children.

Australian researchers Baumgartel et al. (21) conducted a cohort study in 2020 to examine the risk factors for developmental disorders at 12 months of age in children with fetal growth restriction (FGR), preterm birth, and early-term birth. Similar to our study, they used an ASQ questionnaire to measure gross and fine motor skills, communication adaptability and personal-social development. They revealed that FGR children were at slightly more risk of developmental delay at 12 months. Moreover, preterm and early term children came across poorer developmental status at 12 months.

According to the results of our study, there is a significant relationship between the head size and variables such as type of birth delivery, preterm birth, and growth disorders. Sicard et al. (22) investigated the association between head circumference (HC) growth and neurodevelopmental disorders in preterm infants in 2017. They suggested that poorer head circumference Z-score may cause an increased risk of non-optimal neurodevelopmental outcomes in 2 years. Also, either poor or excessive HC growth increased the risk of non-optimal neurodevelopmental outcomes including fine motor and coordination. Another study was done by Geraedts et al. (23) in order to assess the correlation between head circumference and body size in which a significant association between head circumference and both height standard

deviation scores (SDS) and weight SDS was observed.

There have been controversial outcomes regarding the association between delivery mode and growth. Shafaie et al. (24) studied the relationship between delivery mode and children's growth. In their study, 526 children were included and followed up to assess their weight, height, and head circumference from birth to 6 months. The results showed that weight, height, and head circumference at birth and six months of age were higher in the Natural Vaginal Delivery (NVD) than the Cesarean section group. However, the difference was not statistically significant. In contrast, another study reported an increased risk of being overweight at 12 months of age in children who were born via cesarean delivery. Cai et al. (25) demonstrated that elective cesarean delivery was significantly associated with being overweight at 12 months of age.

5- CONCLUSION

In conclusion, our findings indicate that factors such as cesarean type of delivery, preterm birth, and low birth weight are the effective factors associated with negative children growth trends and lower developmental status at 12 months of age. Also, striking correlations were observed between the other growth variables. Therefore, further studies are suggested in order to achieve a vast understanding of the relationship between growth determinants in children.

6- ETHICAL CONSIDERATIONS

This study was approved by the Ethics Committee of Arak University of Medical Sciences (code: IR.ARAKMU.REC.1397.279). We used the existing registered data in the health deputy of Arak University of Medical Sciences. The used data were recorded in the health centers and, therefore, the Ethics committee of Arak University of Medical Sciences approved the informed consent waiver.

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8- COMPETING INTERESTS

None.

9- AVAILABILITY OF DATA AND MATERIALS

The datasets generated and/or analyzed during the current study are available by request.

10- FUNDING

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11- AUTHORS' CONTRIBUTIONS

Study conception and design: JN, HD, RM and AAH. Data collection, statistical expertise, analysis and interpretation of data: PA, AAH, JN, RM, MN, YK, and HD. Manuscript preparation, supervision, administrative support and critical revision of the paper: PA, AAH, JN, RM, MN, YK, and HD. All authors read and approved the final manuscript.

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