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Original Article

The Effects of Maternal Cigarette Smoking on Infant Anthropometric Measurements

*F Sahin Mutlu [1], *U Ayranci [2], K Ozdamar [1], S Yazici [3]*

[1]*Dept. of Biostatistics, Medical Faculty, Osmangazi University, 26480 Meselik-Eskisehir/Turkey*
[2]*Medico-Social Center, Osmangazi University, 26480 Meselik-Eskisehir/Turkey*
[3]*Pediatric Clinic, Public Hospital, 26090 Eskisehir/Turkey*

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Abstract

Background: The association between maternal smoking and poor pregnancy outcome, which is well established in medical literature, has also been corroborated by the results of this study conducted in a Turkish hospital. Our objective was to investigate the effects of cigarette smoking during pregnancy on infant head circumference, height, weight, and body mass index (BMI).

Methods: In this retrospective study, the data was collected from the Medical Live Birth Registry in a maternity hospital with the largest capacity of births in a city of northwest Turkey during 2002.

Results: We found that 16.4% (1040/6332) of mothers investigated had smoked during their pregnancy, with a mean of 5 cigarettes per day. Head circumference, height, weight and BMI values of male infants whose mothers smoked were found to be less than those of infants whose mothers did not smoke ($P > 0.05$, for each one). Head circumference, height, weight and BMI values of female infants whose mothers smoked were less than those whose mothers did not smoke ($P > 0.05$, $P < 0.01$, $P < 0.05$ and $P > 0.05$, respectively). According to analysis of variance, infant head circumferences, heights and weights in all infants decreased as the rate of the mother's smoking increased ($P > 0.05$, $P < 0.001$ and $P > 0.05$, respectively).

Conclusions: The results support that maternal smoking during pregnancy was associated with a linear reduction of height measurement, and the infants appeared to be more susceptible to the growth retarding effects of cigarette smoking on height. Thus, if cessation-of-smoking programs are initiated before conception, many of the harmful effects of smoking on fetal growth might be prevented.

Keywords: *Growth retardation, Intrauterine growth, Low birth weight, Maternal smoking, Turk*ey

Introduction

Studies have demonstrated that infants born to smoking mothers have a reduction in birth weight of between 100 and 300 g (1-3). Some researchers have suggested a generalized reduction in neonatal size represented proportionally in fat mass and lean body mass (4, 5).

Maternal smoking during pregnancy has been recognized as a risk factor for fetal growth retardation since the 1950s (6). Of all known risk factors for low birth weight, smoking carries the highest attributable risk, being responsible for as many as 22 to 36% of the cases, assuming a smoking prevalence of 20 to 40% in women of childbearing years (2). The high prevalence of smoking among young women highlights not only smoking-related risks of adverse pregnancy outcomes, such as spontaneous abortions, stillbirth, preterm birth, and fetal growth restriction (7). Some studies have shown that cigarette smoking during pregnancy is associated with a decrease of birth weight and a worsening of the general condition of newborns immediately after delivery (8, 9). Several studies have reported a positive association between maternal smoking and small head circumference in infants (10-13). A positive association between maternal smoking and premature closure of one or more of the cranial sutures may explain the specific negative effect of maternal smoking on head growth (14, 15).

***Corresponding to author:** Tel: +90 222 2401817, E-mail: unalayrancioglu@yahoo.com

Birth weight, chest circumference, and abdominal circumference showed a dose-response effect as the reported number of cigarettes smoked per day by the mother increased. The mean birth weight of infants born to women having smoked 20 or more cigarettes per day was reduced an average of 6.8% compared to the mean birth weight of infants of nonsmokers. Chest circumference was reduced by 1.7% and abdominal circumference by 2.8%. Head circumference, and crown-heel, arm, and femur lengths showed similar reductions regardless of the number of cigarettes smoked per day (16). In a study conducted in Belgrade hospitals, significant reductions in birth weight, head circumference and chest circumference were found to be associated with average daily smoking during pregnancy (17). Various data collected during follow-ups on children born to mothers who smoked during pregnancy suggest that the deficits at birth may remain in childhood and possibly even into adulthood (18, 19). Sexton and Hebel (1984) (20) and Fox et al. (19) suggested that weight deficits at birth in children born to mothers who had smoked during pregnancy might remain throughout life. However, this long-term effect has not been reported by other authors (21, 22).
Being small at birth and remaining small during childhood is of concern because stunting is associated with reduced cognitive outcomes, school achievement and adult work capacity, increased risk of lower respiratory illnesses, childhood asthma, gastrointestinal or dermatological symptoms (23-26). Furthermore, it may also predispose growth-retarded infants to hypertension, diabetes, coronary heart disease, hemorrhagic stroke, and neurodevelopment disorders later in life (27, 28).
Prior to the study, we hypothesized that maternal smoking during pregnancy would result in a reduction in fetal head circumference, weight, height and BMI. Our objective was to investigate the effects of cigarette smoking during pregnancy on head circumference, height, birthweight and body mass index (BMI) of infants born to mothers who smoked during pregnancy.

Materials and Methods

The registry information of all births for 2002 was obtained from the live birth registration lists. The data referred to all births recorded on the maternity ward of a secondary healthcare hospital in the city of Eskisehir, North-west Turkey and was retrospectively scanned in this study. The maternity hospital in which the study was conducted has the largest capacity of births when compared with the other four hospitals in Eskisehir, with more than 25% of all deliveries in the city occurring at this facility. The city has a total population of 600,000 and includes two universities. The socio-economic level is judged to be average. The population reflects the general characteristics of Turkey.
The birth registration lists contained medical information on all deliveries such as the mother's age, smoking habit, number of births, as well as the infant's sex, head circumference, height and weight at birth. The baby's weight was measured upon delivery on a beam balance scale and heights/lengths were taken with the measure mounted on the same scale to the nearest half-inch.
Standardized record forms of births are used at all antenatal clinics, and all delivery units in both the city and the other cities. The information collected on these forms is sent to the health authority of the city involved, where they are computerized and then sent onto the Ministry of Health located in the capital of Turkey, Ankara.

Study design

We conducted a retrospective study based on the live birth records of the largest maternity hospital in the city of Eskisehir. Of the total 6,669 live birth registries entered (2002), we excluded non-singleton births (63 records), and birth records where a mother's smoking status (67 records), as well as the infants' head circumference (46 records), height (28 records) or weight (12 records) was unknown. Records were also excluded if the mother had an existing chronic illness on birth records (56 records), a record of baby death (12 records), congenital malformations (7 records), or hospitalization (41 records). The cohort there-

fore consisted of 6332 normal singleton term pregnancy registrations of infants. Eligible newborns were those who were born in that period. Maternal smoking status was based on the reported number of cigarettes smoked recorded on the registry

Statistical analysis

Statistical differences were analyzed using the Pearson's chi-square test (x^2) and *t* tests where appropriate by means of SPSS 11.0 package program. These are the tests frequently used when examining whether there is a difference between the registry information of two independent groups of respondents. For demographic variables and fetal measurements, the level of significance was set at 5% ($P< 0.05$). The results were given as means with standard errors (s.e.) of means.

After standardizing the reference values, median values from the National Center for Health Statistics (NCHS) (29) were used to compare our study data of the infants. For variance analyses application, according to groups, variables were controlled by the Normality Shapiro-Wilk Test. For data that showed normality, variance analysis was performed.

We coded the mother's smoking habit variable as 0 and 1 and also this was put as independent variable. On the other hand, infant birth weight, height and head circumference variables were put separately as dependent variables. For those, Linear Regression Model was used.

All of the hospitals manifested similar characteristics in terms of the types of infants registered and the places of settlement.

We grouped the infant weights, head circumferences and heights into three categories, and BMI values into four categories according to Turkish infants' normal values (30).

Informed consent

The local health authority approved this study and consent from the head doctor of the hospital was received.

Results

The average age of the 6332 infants' mothers included in the study was 24.99±0.07 (ranging from 15 to 44). The rates of male and female infants were 50.1% (n= 3175) and 49.9% (n= 3175), respectively.

The average head circumference, average height and average weight of all the infants was 34.83± 0.02 (mean±s.e) 49.93±0.03 and 3.34±0.04, respectively. It was found that 16.4% (1040/ 6332) of the mothers had smoked during their pregnancy, with a mean of 5 cigarettes per day.

It was found that 16.4% (1040/6332) of the mothers had smoked during their pregnancy, with a mean of 5 cigarettes per day, which was greater than the rate of smoking in women in general population.

Table 1 presents the demographic characteristics of the study population. In view of the rate of cigarettes smoked by both male and female infants' mothers per day; although the smoking proportion of mothers was higher in the male infants' than female infants (51.4 vs. 48.6%, respectively) it revealed no difference ($P= 0.397$).

Fig. 1 indicates the comparison of the percentiles of male and female infants by NCHS percentiles. In view of the NCHS percentiles, compared to median values (50^{th} percentiles), the study male infants' average head circumferences were more. The study male infants' height was less than the NCHS percentile, whereas the study male infants' weight was more than NCHS'. In view of the NCHS percentiles, compared to median values (50^{th} percentiles), the study female infants' average head circumference was more. The study female infants' height was higher than the NCHS percentile, whereas the study female infants' weight was lower than NCHS'

Table 2 shows the distribution of average head circumferences, heights, weights and BMI values of male and female infants whose mothers smoked during pregnancy. Head circumference, height, weight and BMI values of male infants whose mothers smoked were less than those delivered to mothers who did not smoke ($P> 0.05$, for each one). Head circumference, height, weight and BMI values of female infants whose mothers smoked were less than those whose mothers did

not smoke ($P > 0.05$, $P < 0.01$, $P < 0.05$ and $P > 0.05$, respectively).

Fig. 2 shows the distribution of average head circumferences, heights, weights and BMI values of male and female infants, irrespective of whether or not the mothers smoked.

Table 3 indicates the relationships of the head circumferences, heights, weights of the infants by the mothers' smoking variable. In this table, mothers' smoking did not reveal any difference in terms of head circumstances ($P > 0.05$). There was an important relationship between mothers' smoking and the infants' heights ($P < 0.05$). The mothers' smoking did affect the infants' weights ($P > 0.05$). We coded the mother's smoking habit as independent variable. On the other hand, infant birth weight, height and head circumference variables were put separately as dependent variables. In result, linear regression analysis was not important for each model. In addition, in the result of the analysis, the results of beta coefficients of infant birth weight, height and head circumference variables were given as *t* test for each analysis.

Table 4 shows the evaluation of head circumferences, heights and weights of all the infants. According to analysis of variance results, when considering all of the infants, infant head circumferences, heights and weights decreased as mother's smoking increased ($P > 0.05$, $P < 0.001$ and $P > 0.05$, respectively). We performed a Tukey Post Hoc Test in order to investigate in more detail the relationship with smoking of the difference between mother's smoking and baby height. There were significant differences both between nonsmoking and heavy smoking and light smoking and heavy smoking. In view of all the male infants, infant head circumferences, heights and weights decreased as the mother's smoking increased, but revealed no difference ($P > 0.05$, each one). For all the female infants, infant head circumferences, heights and weights decreased as the mother's smoking increased ($P > 0.05$, $P < 0.001$ and $P < 0.05$, respectively). According to the Tukey Post Hoc Test, there was a difference both between nonsmoking and heavy smoking and light smoking and heavy smoking for the relationship between the mother's smoking and baby height. Similarly, according to the Tukey Post Hoc Test, a difference did exist between nonsmoking and light smoking for the relationship between mother's smoking and baby weight.

Table 1: Demographic characteristics of study subjects

	Males 3175(50.1%)	**Females 3157(49.9%)**	**Total n= 6332 (100%)**
Mother's parity	χ^2=3.921, df=5, p=0.561		
1	1231(50.0)	1230(50.0)	2461(38.9)
2	996(50.5)	976(49.5)	1972(31.1)
3	505(48.0)	546(52.0)	1051(16.6)
4	229(53.0)	203(47.0)	432 (6.8)
5	125(52.5)	113(47.5)	238 (3.8)
≥6	89(50.0)	89(50.0)	178 (2.8)
Mother's parity	χ^2=0.024, df=1, p=0.877		
1	1231(50.0)	1230(50.0)	2461(38.9)
≥2	1944(50.2)	1927(49.8)	3871(61.1)
Mother's smoking during pregnancy/day*	χ^2=0.716, df=1, p=0. 397		
No	2645(49.9)	2647(50.1)	5292(83.6)

Table 1: Continued…

Yes	530(51.4)	510(48.6)	1040(16.4)
Weight (gr) for girls and boys	χ^2=7.682, df=2, *P*= 0.021		
<2.500	47(51.1)	45(48.9)	92 (1.5)
≥2.500 - <4.000	2921(49.7)	2957(50.3)	5878(92.8)
≥4.000	207(57.2)	155(42.8)	362 (5.7)
Head circumference (cm)	χ^2=1.560, df=2, *P*= 0.458		
<33.0	124(50.6)	121(49.4)	245 (3.9)
≥33 - <38	3007(50.1)	3003(49.9)	6010(94.9)
≥38.0	44(57.2)	33(42.8)	77 (1.2)
Heights (cm)	χ^2=7.960, df=2, *P*= 0.019		
<47	130(46.3)	151(53.7)	281 (4.4)
≥47-<54	2894(49.9)	2896(50.1)	5790(91.5)
≥54	151(57.8)	110(42.2)	261 (4.1)
BMI values (kg/m^2)	χ^2=7.78, df=3, *P*= 0.051		
Underweight (<11)	132(49.6)	134(50.4)	266 (4.2)
Normal weight (≥11 - <14)	2248(49.1)	2327(50.9)	4575(72.6)
At risk of overweight (≥14 - ≤15)	549(53.4)	480(46.6)	1029(16.3)
Overweight (>15)	230(53.2)	202(46.8)	432 (6.9)

*The number of cigarettes smoked during pregnancy ranged from 4 to 21, with mean of 5.08±1.2. mean±s.e.

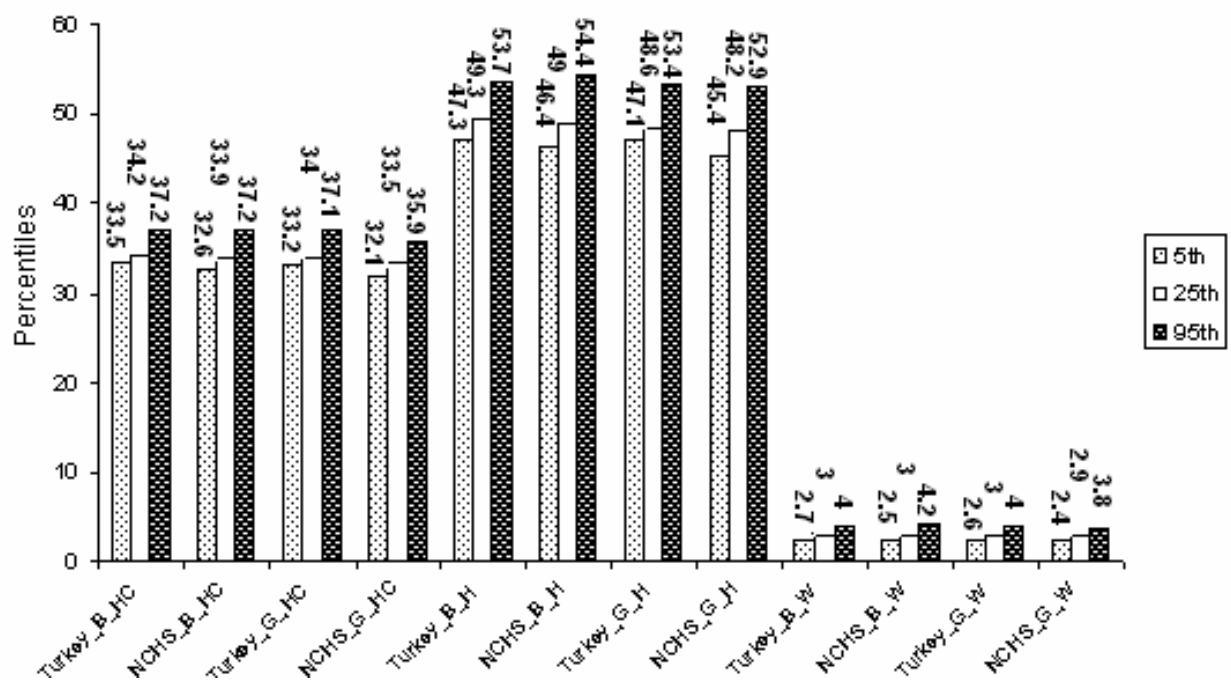

Fig. 1: The comparison of the percentiles of male and female infants by NCHS percentiles

Table 2: Distribution of average head circumference, heights, weights and BMI values of male and female infants whose mothers smoked during pregnancy

	males whose mother smoked mean±s.e	**males whose mother did not smoke mean±s.e**	**Females whose mother smoked mean±s.e**	**Females whose mother did not smoke mean±s.e**
	t=0.666, DF=3173, *P*= 0.505	*t*=1.033, DF =3155, *P*= 0.302		
Head circumference (cm)	34.79±0.07	34.84±0.03	34.69±0.06	34.76±0.02
	t=1.399, DF =3173, *P*= 0.162	*t*=2.978 DF =3155, *P*= 0.003		
Height (cm)	49.99±0.08	50.15±0.05	49.46±0.11	49.79±0.04
	t=.787, DF =3173, *P*= 0.431	*t*=2.419 DF =3155, *P*= 0.016		
Weight (kg)	3.25±0.018	3.44±0.10	3.18±0.02	3.28±0.02
	t=0.723, DF =3173, *P*= 0.470	*t*=1.454 DF =3155, *P*= 0.146		
BMI (kg/m2)	13.01±0.05	13.73±0.43	12.99±0.07	13.24±0.07

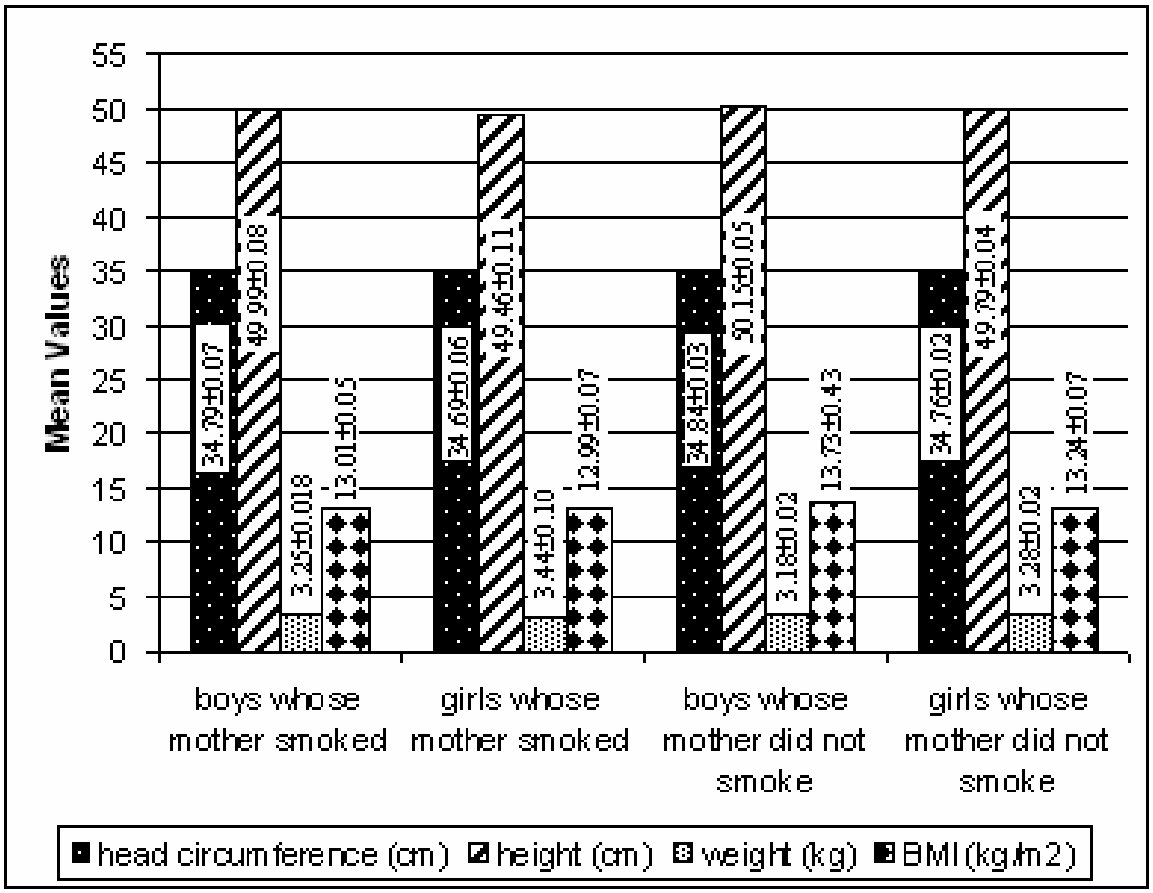

Fig. 2: Male and female infants' anthropometrical values according to mother's smoking

Table 3: The relationships of the head circumferences, heights, weights of the infants by the mothers' smoking during pregnancy/day

All infants Dependent variables	Independent variables	B	S.E.	t	*P*
The head circumference of infants whose mother did not smoke and smoke (cm)	Constant*	34.82	0.023	1544.36	<0.001
	Mother's smoking during pregnancy/day	0.023	0.058	0.404	0.686
The height of infants whose mother did not smoke and smoke (cm)	Constant*	49.97	0.032	1584.437	<0.001
	Mother's smoking during pregnancy/day	-0.252	0.081	-3.12	0.002
The weight of infants whose mother did not smoke and smoke (cm)	Constant*	3.36	0.046	72.89	<0.001
	Mother's smoking during pregnancy/day	-0.141	0.118	-1.20	0.232

*****Variables effect of which is unknown such as insufficient food, environment in which baby lives, financial status, and it indicates the sum of constant and beta coefficients

Table 4: Evaluation of head circumstance, heights and weights of all the infants, male infants, female infants whose mothers smoked or not during pregnancy

All babies	n	mean±s.e.	95% CI	Tukey Post Hoc Test		
				No smoker	Light smoker	Heavy smoker
Height (cm)			F(2:6329)= 9.073, *P*<0.001			
No smoking	5292	49.97±0.03	49.91-50.04			
Light smoker	943	49.80±0.07	49.67-49.94	ns		
Heavy smoker	97	49.07±0.20	48.67-49.48	*	*	
Males						
Females						
Height (cm)			F(2:3154)= 7.620 *P*< 0.001			
No smoking	2647	49.79±0.04	49.71-49.88			
Light smoker	465	49.53±0.11	49.33-49.74	ns		
Heavy smoker	45	48.71±0.34	48.03-49.40	*	*	
Weight(kg)			F(2:3154)= 4.095 *P*< 0.05			
No smoking	2647	3.28±0.02	3.25-3.32			
Light smoker	465	3.17±0.02	3.14-3.21	*		
Heavy smoker	45	3.12±0.07	2.97-3.26	ns	Ns	

ns: not significant *:*P*< 0.05

Discussion

This study indicates a cause-effect relationship between cigarette smoking by women during pregnancy and newborns' anthropometrical measurements, such as head circumference, weight and height.

We found that 16.4% of the mothers had smoked during their pregnancy, with a mean of 5 cigarettes per day. This proportion and number is less compared to other studies in another country; in a study conducted on Mexican-American mothers, it was found that 24% of the mothers had smoked during their pregnancy, with a mean of 11 cigarettes per day (31). In another study by Young (1983) (32), smokers during pregnancy comprised 46.1% of the mothers and approximately 20% to 25% of American women had smoked cigarettes during pregnancy (29). In our study, a possible reason for the low smoking incidence rate observed could be that Turkish women are generally unemployed, and live under religious norms, traditions and customs were such actions could be regarded as a sin or blame (33, 34). However, the proportion of smoking cigarette during pregnancy was more compared to other studies showing that the smoking proportion in general population ranged between 3-13.4% in Turkey (35-37), which may be related to stress the pregnancy causes.

Mother's smoking per day during pregnancy had decreased significantly all infants' weight, male infants' weight and female infants' weight ($P< 0.001$, $P< 0.05$ and $P< 0.05$, respectively). Our findings are in accordance with results from other studies (8, 17, 38, 39).

When considering male infants and female infants, the infants' anthropometrical measurements such as head circumference, height, weight and BMI values were observed to be more in infants whose mother did not smoke than in those whose did. However, it did not reveal any difference between male infants. Conversely, mother's smoking significantly decreased female infants' height and weight. This shows that mother's smoking during pregnancy affects female infants' anthropometrical measurements such as height and weight more so than it does males. Thus, maternal smoking cessation is very important for female infants' growth in particular.

In this study, smoking had less of an effect on the head circumference, height and weight of all the infants, male infants and female infants of women who were light smokers during their pregnancies compared to the infants of women who were heavy smokers. This finding is in agreement with earlier studies (13, 16, 17, 40). This result shows that smoking cessation intervention prior to pregnancy will minimize or reduce the risk of smoking to the developing fetus. In the present study, infant head circumference decreased in line with increased rate of mother's smoking for both female infants and male infants and all the infants. The specific negative effect of maternal smoking on head growth could perhaps be related to a positive association between maternal smoking and premature closure of one or more of the cranial sutures (craniosynostosis), which has been reported by two independent investigations (14,15). It could be speculated whether the smoking-related premature closure is the primary event, or if it occurs secondary to a retarded head growth. This shows that given the evidence, maternal smoking specifically affects head growth, and until contradictory evidence is found, it seems reasonable to assume that maternal smoking during pregnancy affects brain development in a bad way negatively (13).

According to the results of our study, when all anthropometrical measurements are considered, infants born to non-smokers were heavier, longer, and possessed larger head circumferences than those born to light and heavy smokers. In other words, cigarette smoking during pregnancy has also been shown to be an independent predictor of infant birth weight. The more women smokes during pregnancy, the lighter her baby is likely to be. This is consistent with many studies (18, 20, 40). This suggests that mothers might prevent some of the harmful effects of smoking on

fetal growth, such as decreasing the number of cigarette smoked daily.

The consistent decreases in infant anthropometrical measurements in this population indicate that maternal smoking affects overall fetal growth, thereby reducing length and circumference measurements. This especially becomes evident when the number of cigarette smoked by mother daily increases. The fact that much of the negative effect of maternal smoking appears to occur during pregnancy provides hope that smoking cessation intervention either prior to pregnancy or in the first trimester will minimize the risk to the developing fetus. Our data indicates that cessation-of-smoking programs should be initiated before conception.

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