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Original Article

Investigation of maternal smoke exposure and childhood obesity: A cross-sectional study

Gülşen Göney[1*], Cengiz Gazeloğlu[2]

[1]Süleyman Demirel University, Faculty of Pharmacy, Department of Toxicology, 32260, Çünür, Isparta, Turkey
[2]Süleyman Demirel University, Faculty of Arts and Sciences, Department of Statistics, 32260, Çünür, Isparta, Turkey

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Abstract

Introduction: Recent studies suggest that smoking exposure in pregnancy period might be a risk agent for childhood overweight and obesity. We examined associations between maternal smoking in pregnancy period and children's weight and the possible obesogenic effects of maternal smoking.

Methods: The present study was designed as a cross-sectional analysis of a survey. A 31-question survey was administered to mothers to learn the nutrition and smoking habits in Turkey from January to March 2020. Also, a 25-question survey was administered to children to study their diet. Participants were classified as underweight, normal, overweight, or obese. The smoking status of mothers was also recorded. The data were analyzed using SPSS.

Results: The research group consisted of 454 participants (227 mothers, $M_{age}=38.73\pm6.23$ years and 227 children, $M_{age}=10.39\pm4.96$ years). In this study, 60.3% of children were underweight, 27.9% normal, 8.8% overweight, and 2.9% obese. Overall, 6.3% of children had smoking exposure and were overweight, whereas 1.4% were obese. Our results show that the relationship between maternal smoke exposure and body mass index (BMI) was non-significant ($P>0.05$). Children whose mothers did smoke in pregnancy period were at low risk for obesity (odds ratio [OR] = 0.66, 95% CI: 0.07, 6.11) compared with children whose mothers never smoke.

Conclusion: In this study, we found that the BMI of children not increased with maternal smoking exposure. In future, taking into consideration the health of mother and child, new studies should be performed to investigate the relationship between maternal or paternal smoking exposure and childhood overweight or obesity.

Introduction

Obesity and smoking have become a public health crisis, and both are treated as a disease. Between 1975 and 2016, the obesity rate tripled in the world.[1] Researchers agree that too much caloric intake and too little exercise are both important factors in obesity prevalence, but studies suggest that toxic chemicals may also be a factor.[2,3] Obesity risk factors include diet, sedentary lifestyle, physical activity, psychological factors, genetic syndromes, some endocrine diseases, and smoking exposure.[4,5] This study evaluated the possible obesogenic effects of smoking exposure. Cigarette smoke is a source of over 4000 toxic compounds, some of which are anti-obesogenic (chromium and cadmium) and others are obesogenic (Benzo[a]pyrene and $PM_{2.5}$). Studies show that chromium and cadmium supplementation decrease body mass index (BMI) and fat.[6-9] Cigarette smoking causes polycyclic aromatic hydrocarbon (PAH) and particulate matter (PM) exposure. Experimental studies show that these substances may have an obesogenic effect.[2] In experimental studies, PAH exposure blocks lipolysis, resulting in increased BMI. Early lifetime exposure to PM causes mitochondrial detriment and raised accumulation of white adipose tissue relative to metabolically active brown adipose tissue. PM has estrogenic effects, and maternal exposure to environmental estrogens causes lead away obesity in animal bioassays.[10] Importantly, experimental study results have found that early exposure to nicotine might result in accelerated postnatal weight gain, as well as raised visceral adiposity.[10-15]

The worldwide prevalence of overweight and obese children has increased. It is hard to assign the whole mechanism through which maternal smoking might result in raised offspring obesity.[16] Infants of mothers who had a smoke exposure in pregnancy period were lighter at birth than infants of non-smokers, but in adolescence, they had an increased risk of being in the highest decile of BMI. Evaluating epidemiological data supports a favorable relation between maternal smoking exposure and a raised risk of obese or overweight offsprings.[5,17,18] Over the past decade, there have been a large number of studies investigating the possible relationship between paternal/

***Corresponding Author:** Gülşen Göney, Tel: 0246 211 0179/0341, Email: gulsengoney@sdu.edu.tr

maternal smoking and obesity.[12,19] However, in Turkey, no study has analyzed the possible obesogenic effects of cigarette exposure in childhood. The present study aims to fill the lack of scientific data on this subject.

Methods

A web-based survey using google documents was applied in Turkey over the Internet. This study was carried out with 379 woman and 379 children participants (n = 758). The present study was designed as a cross-sectional analysis of the survey. Mothers who were given consent, aged over 18 years old, and did not have an ongoing genetic and metabolic disease were included in this study. Also, children aged 2 to 18 years, whose parents gave consent, were included in the study. Subjects interested in participating received the questionnaire by mail, which collected information on socioeconomic position, demographic data, and several lifestyle parameters, including tobacco and alcohol consumption. The 31-question survey was administered to mothers. Mothers were asked whether they had been exposed to smoke before or after the pregnancy period. Each of these questions was supposed to be answered with "no" or "yes." A 25-question survey was administered to children. In addition, age, sex, level of education, nutrition habits (fat, carbohydrate, protein), body weight, and height information were recorded in both of them. BMI, defined as the weight in kilograms divided by the square of the height in meters, was calculated and subjects were classified as underweight, normal, overweight, or obese according to the WHO criteria.[1]

Statistical analysis

The data were analyzed using the statistical program Statistical Package for the Social Sciences (SPSS). Frequency and percentage analyses were used for analyzing participants' demographic characteristics and mean ± SD scores from the measurement tools. When the sampling error is ± 0.05, the sample volume of 384 is sufficient according to the situation where the volume of the main mass is one million.[20] In this study, we tried to reach a total sample volume of more than 384. The representation of the main volume of the sample volume was exceeded (n = 454). T-test analyses have been performed to compare two related groups in order to determine whether there is a statistically significant difference. *Analysis* of variance (*ANOVA*) is used to check if the means of two or more groups are significantly different from each other. A Chi-square test is used to analyze categorical data. A *P* value less than 0.05 was considered statistically significant. Odds ratios (OR) with 95% confidence interval (CI) were also *measured* to determine associations between the maternal smoke-exposed group and control group in the study population.

Results

This study was carried out from January to March 2020 with 379 woman and 379 child participants (n = 758). However, 304 (152 women, 152 children) subjects were excluded from the study because of missing data (age, height, weight). Finally, 227 women ($M_{age} = 38.73 \pm 6.23$) 18 years old or older, and 227 children ($M_{age} = 10.39 \pm 4.96$) who were ≥2 and ≤18 in Turkey were included. Maternal BMI was found at 19.10 ± 4.42. BMI from 454 participants (227 females and 227 children) are shown in Table 1, which shows that 11.3% of children were overweight or obese. Baseline characteristics of mothers are shown in Table 2. Results show that the relationship between maternal income and maternal smoking is statistically significant ($P = 0.004$). The relationship between maternal education and smoking is also statistically significant ($P = 0.007$). The participants were asked if they thought their child was overweight/obese, and if they thought their child gained weight despite a regular/balanced diet. In addition, we asked the mothers that is their child was weight gain despite a regular/balanced diet. We assessed there was no association ($P > 0.05$). Mother's views on their children's BMI and diet was shown in Table 3. Most mothers (77.4%) thought that their child was overweight or obese. In the present study, 60.3% of children were underweight, 27.9% normal, 8.8% overweight, and 2.9% obese. Overall, 6.3% of children had smoking exposure and were overweight, whereas 1.4% were obese. Characteristics of offspring, according to maternal smoking, are shown in Table 4. According to the results, the association of smoking habits and the children's BMI was statistically non-significant ($P = 0.372$). The association between physical activity and the mother smoking was statistically significant ($P = 0.03$). The association between television watching of children and mother smoking was statistically significant ($P = 0.016$). Table 5 shows the prevalence of maternal smoking and mean BMI in the offspring. The relationship between maternal smoking before pregnancy, during pregnancy, and the postnatal period, and BMI of the child was statistically non-significant ($P > 0.05$). According to the results, children whose mothers smoked during pregnancy had an elevated risk for obesity (pooled adjusted OR = 0.66, 95% CI: 0.073, 6.111) compared with children whose mothers did not smoke during pregnancy (Table 6). We evaluated the relation between maternal cigarette smoking and the child's BMI. The most valuable result of this study is that there were no statistical differences found

Table 1. Characteristics of body mass index from participants

	Study group	Underweight	Normal	Overweight	Obesity class 1	Obesity class 2
Gender						
Mother	226	5 2.2%	104 46.0%	65 28.8%	2 0.9%	9 4.0%
Missing	41, 18.1%					
Child	226	119 52.7%	80 35.4%	18 8.0%	4 1.8%	3 1.5%
Missing	5, 2.2%					

Table 2. Characteristics of mothers*

	Smoking status			
	No. of subjects	Never smoked	Smoked	*P* value
Mother	217	38.64%	39.26%	0.490
Maternal income[a]				
Low	94	56.8%	33.3%	
Medium	34	12.9%	29.8%	0.004
High	61	30.3%	36.8%	
Family income[b]				
Low	18	10.5%	7.1%	
Medium	84	46.6%	39.3%	0.380
High	87	42.9%	53.6%	
Maternal education				
Compulsory school	74	43.9%	19.4%	
High school	45	18%	29.9%	0.007
Graduate	60	26.6%	34.3%	
Postgraduate	27	11.5%	16.4%	

[a] In Euro: low, ≤ €19 600; medium, €19 600–39 200; high, ≥ €39 200.
[b] In Euro: low, ≤ €19 600; medium, €39 200–65 300; high, ≥ €65 300.
* A chi-squared test when the outcome was based on smoking status categories.

Table 3. Mother's views on children

Questions	No. of subjects	Percent
Do you think your child is overweight/obese?		
No	25	11.1
Yes	175	77.4
Do you think your child has a regular/balanced diet?		
No	27	25
Yes	81	75
Do you think your child is gaining weight despite your regular/balanced diet?		
No	181	80.1
Yes	45	19.9

between maternal smoking and BMI ($P > 0.05$).

Discussion

Although smokers tend to have a lower BMI than non-smokers, smoking might support abdominal body fat accumulation. However, no population-based studies have evaluated the association between smoking and body fat composition.[21] Results showed that the relation between cigarettes smoked per day and BMI was non-significant. Besides, over the past decade, there have been a large number of studies investigating the possible relationship between smoking and overweight or obese outcomes.[12,19,22] The population prevalence of overweight and obese children has raised. There are limited studies about maternal/paternal smoke exposure and childhood obesity. Infants of mothers who smoked during pregnancy period had lower birth weight in comparison with the infants of non-smokers, but during adolescence, they had a raised risk of being in the highest decile of BMI.[16] Last epidemiological findings support a favorable relation between maternal smoking exposure and raised risk of obese or overweight offspring.[5,17] Studies report a relationship between maternal smoking in pregnancy period and risk of overweight children at least. Analyzes show that the early influence of maternal smoking on the prevalence of overweight children at age 2 or 3 years is high-risk.[23,24] Interestingly, smoking by adolescents was not related to weight, height, or head circumference of the subjects.[25] However, tobacco smoking causes lower BMI among current smokers,[26] although Lv et al reported that tobacco smoking could be an important risk factor for obesity.[22] Also, epidemiological and experimental research (83 in humans and 18 in animals) related to smoking exposure found a positive association between obesity at any age and exposure.[5] A considerable amount of studies indicate that smoking and obesity are related to adverse pregnancy outcomes, and especially smoking during pregnancy has a relationship with childhood obesity.[27-29] Results show that the prevalence of overweight and obese offspring was greater for those whose mothers had smoked in pregnancy period than those whose mothers had never smoked. Obesity is also significantly related to smoking between 28 and 32 weeks of gestation, with some indication of a dose-response. Researchers suggest that maternal smoking during pregnancy not only directly causes childhood obesity but also affects adolescent obesity.[30]

In this study, we present the first comprehensive study

Table 4. Characteristics of children according to maternal smoking

	No. of subjects	Smoking status		*P* value
		Never smoked	Smoked	
Body mass index				
Underweight	116	60.3%	52.8%	
Normal	75	27.9%	39.4%	0.372
Overweight	15	8.8%	6.3%	
Obese	4	2.9%	1.4%	
Dietary habit				
Vegetables	47	30.8%	20.8%	
Carbohydrate intake	37	17.1%	32.1%	0.072
Protein intake	86	52.1%	47.2%	
Fast food				
Never	66	39.5%	29.2%	
Rarely	81	43.4%	52.1%	0.437
Most days/3 or 4 days per week	31	17.1%	18.8%	
Engaging in sports or exercise (days/week)				
Never	82	48.8%	35.2%	
Rarely	59	33.3%	29.6%	0.03
Most days/2 or 3 days per week	42	17.8%	35.2%	
Television watching (hours/day)				
Never	32	21.5%	6.9%	
1-2	86	40%	58.6%	0.016
3-4	70	38.5%	34.5%	

Table 5. Prevalence of maternal smoking and mean body mass index in child*

	Before pregnancy		Pregnancy period		Postnatal period	
	Mean		Mean		Mean	
	Yes	No	Yes	No	Yes	No
Child BMI	18.05	20.13	18.67	19.03	17.69	19.11
P value	0.576		0.818		0.224	

*Independent samples *t* test

Table 6. Odds Ratio with 95% CI for overweight/obese children, defined by high BMI, by maternal smoking exposure during pregnancy

	Overweight		Obese	
	OR	95% CI	OR	95% CI
Smoking mother	1.5	0.164, 13.749	0.66	0.073, 6.111

OR, odds ratio, CI, confidence interval.

regarding the impact of maternal cigarette smoking on BMI compared with healthy non-smoking mothers in Turkey. Children whose mothers smoked in pregnancy period had a low risk for obesity (pooled adjusted OR = 0.66, 95% CI: 0.07, 6.11) compared with children whose mothers did not smoke. Our findings suggest that smoking exposure in pregnancy period is not a risk factor for being overweight in childhood. According to some views about smoking and obesity, results might support the hypothesis of "fetal origin of adult disease", but the risk of being overweight related with smoking during pregnancy period was independent of intrauterine growth retardation, and may thus be based on particular effects of cigarette smoke.[23,27]

Conclusion

In conclusion, evaluating recent epidemiological data supports a prominent relation between maternal smoking and an increased risk of obese or overweight children. Therefore, prominent findings regarding smoking could indicate a candidate for a new obesogen. Active or passive exposure to smoke is also a significant source of toxic chemical exposure. People should be encouraged never to take up smoking. Moreover, the worldwide prevalence of childhood obesity has raised and considering the health of mother and child, new studies should investigate the relationship between maternal or paternal smoking exposure and childhood weight or obesity to determine the detailed mechanism.

Conflict of Interest

The authors have no conflict of interest to declare.

Ethical Approval

The collection of the questionnaires was based on an official consent confirmed by the Ethical Committee of the Süleyman Demirel University School of Medicine Clinical Research Ethical Committees in Isparta (paper number 2020/48).

Authors' Contribution

GG contributed to the conception and design of the study and literature review. Data were acquired by GG, and CG. Analysis and interpretation of data were performed by CG. All authors reviewed and approved the final version of the article. GG drafted the manuscript.

Study Highlights

What is current knowledge?

- Childhood overweight or obesity could be related with maternal smoking during pregnancy period.

What is new here?

- Smoking exposure in pregnancy period is not a risk factor for being overweight/obesity in childhood.

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References

1. World Health Organization (WHO). Health Topics Obesity 2019. Available from: https://www.who.int/topics/obesity/en/. Updated May 12, 2020. Accessed May 2020.
2. Grün F, Blumberg B. Environmental obesogens: organotins and endocrine disruption via nuclear receptor signaling. Endocrinology. 2006;147(6 Suppl):S50-5. doi: 10.1210/en.2005-1129.
3. Newbold RR, Padilla-Banks E, Jefferson WN. Environmental estrogens and obesity. Mol Cell Endocrinol. 2009;304(1-2):84-9. doi: 10.1016/j.mce.2009.02.024.
4. Amisola RV, Jacobson MS. Physical activity, exercise, and sedentary activity: relationship to the causes and treatment of obesity. Adolesc Med. 2003;14(1):23-35.
5. Behl M, Rao D, Aagaard K, Davidson TL, Levin ED, Slotkin TA, et al. Evaluation of the association between maternal smoking, childhood obesity, and metabolic disorders: a national toxicology program workshop review. Environ Health Perspect. 2013;121(2):170-80. doi: 10.1289/ehp.1205404.
6. Banihani SA, Jaradat SA, Khader YS. Serum chromium level is ıncreased in Jordanian smokers, decreased in Jordanians with prediabetes and type 2 diabetes, but not altered in Jordanians with hypertension, with obesity, or with family history of diabetes. Int J Prev Med. 2019;10:145. doi: 10.4103/ijpvm.IJPVM_137_18.
7. Tsang C, Taghizadeh M, Aghabagheri E, Asemi Z, Jafarnejad S. A meta-analysis of the effect of chromium supplementation on anthropometric indices of subjects with overweight or obesity. Clin Obes. 2019;9(4):e12313. doi: 10.1111/cob.12313.
8. Onakpoya I, Posadzki P, Ernst E. Chromium supplementation in overweight and obesity: a systematic review and meta-analysis of randomized clinical trials. Obes Rev. 2013;14(6):496-507. doi: 10.1111/obr.12026.
9. Johnson MD, Kenney N, Stoica A, Hilakivi-Clarke L, Singh

B, Chepko G, et al. Cadmium mimics the in vivo effects of estrogen in the uterus and mammary gland. Nat Med. 2003;9(8):1081-4. doi: 10.1038/nm902.
10. Wenger D, Gerecke AC, Heeb NV, Schmid P, Hueglin C, Naegeli H, et al. In vitro estrogenicity of ambient particulate matter: contribution of hydroxylated polycyclic aromatic hydrocarbons. J Appl Toxicol. 2009;29(3):223-32. doi: 10.1002/jat.1400.
11. Irigaray P, Ogier V, Jacquenet S, Notet V, Sibille P, Méjean L, et al. Benzo[a]pyrene impairs beta-adrenergic stimulation of adipose tissue lipolysis and causes weight gain in mice. A novel molecular mechanism of toxicity for a common food pollutant. FEBS J. 2006;273(7):1362-72. doi: 10.1111/j.1742-4658.2006.05159.x.
12. Sun M, Jiang Y, Sun C, Li J, Guo X, Lv Y, et al. The associations between smoking and obesity in northeast China: a quantile regression analysis. Sci Rep. 2019;9(1):3732. doi: 10.1038/s41598-019-39425-6.
13. Xu X, Liu C, Xu Z, Tzan K, Zhong M, Wang A, et al. Long-term exposure to ambient fine particulate pollution induces insulin resistance and mitochondrial alteration in adipose tissue. Toxicol Sci. 2011;124(1):88-98. doi: 10.1093/toxsci/kfr211.
14. Yan Z, Zhang H, Maher C, Arteaga-Solis E, Champagne FA, Wu L, et al. Prenatal polycyclic aromatic hydrocarbon, adiposity, peroxisome proliferator-activated receptor (PPAR) γ methylation in offspring, grand-offspring mice. PLoS One. 2014;9(10):e110706. doi: 10.1371/journal.pone.0110706.
15. McConnell R, Gilliland FD, Goran M, Allayee H, Hricko A, Mittelman S. Does near-roadway air pollution contribute to childhood obesity? Pediatr Obes. 2016;11(1):1-3. doi: 10.1111/ijpo.12016.
16. Sunday S, Kabir Z. Impact of carers' smoking status on childhood obesity in the growing up in Ireland cohort study. Int J Environ Res Public Health. 2019;16(15). doi: 10.3390/ijerph16152759.
17. Ginawi IA, Bashir AI, Alreshidi YQ, Dirweesh A, Al-Hazimi AM, Ahmed HG, et al. Association between obesity and cigarette smoking: a community-based study. J Endocrinol Metab. 2016;6(5):149-53. doi: 10.14740/jem378e.
18. Power C, Jefferis BJ. Fetal environment and subsequent obesity: a study of maternal smoking. Int J Epidemiol. 2002;31(2):413-9.
19. Courtemanche C, Tchernis R, Ukert B. The effect of smoking on obesity: evidence from a randomized trial. J Health Econ. 2018;57:31-44. doi: 10.1016/j.jhealeco.2017.10.006.
20. Yazıcıoğlu Y, Erdoğan S. SPSS Uygulamalı Bilimsel Araştırma Yöntemleri. Ankara: Detay Yayıncılık; 2004. [Turkish].
21. Clair C, Chiolero A, Faeh D, Cornuz J, Marques-Vidal P, Paccaud F, et al. Dose-dependent positive association between cigarette smoking, abdominal obesity and body fat: cross-sectional data from a population-based survey. BMC Public Health. 2011;11:23. doi: 10.1186/1471-2458-11-23.
22. Lv J, Chen W, Sun D, Li S, Millwood IY, Smith M, et al. Gender-specific association between tobacco smoking and central obesity among 0.5 million Chinese people: the China Kadoorie Biobank Study. PLoS One. 2015;10(4):e0124586. doi: 10.1371/journal.pone.0124586.
23. Oken E, Levitan EB, Gillman MW. Maternal smoking during pregnancy and child overweight: systematic review and meta-analysis. Int J Obes (Lond). 2008;32(2):201-10. doi: 10.1038/sj.ijo.0803760.
24. Adams AK, Harvey HE, Prince RJ. Association of maternal smoking with overweight at age 3 y in American Indian children. Am J Clin Nutr. 2005;82(2):393-8. doi: 10.1093/ajcn.82.2.393.
25. Fried PA, James DS, Watkinson B. Growth and pubertal milestones during adolescence in offspring prenatally exposed to cigarettes and marihuana. Neurotoxicol Teratol. 2001;23(5):431-6. doi: 10.1016/s0892-0362(01)00161-1.
26. Winsløw UC, Rode L, Nordestgaard BG. High tobacco consumption lowers body weight: a Mendelian randomization study of the Copenhagen General Population Study. Int J Epidemiol. 2015;44(2):540-50. doi: 10.1093/ije/dyu276.
27. Toschke AM, Koletzko B, Slikker W Jr, Hermann M, von Kries R. Childhood obesity is associated with maternal smoking in pregnancy. Eur J Pediatr. 2002;161(8):445-8. doi: 10.1007/s00431-002-0983-z.
28. von Kries R, Toschke AM, Koletzko B, Slikker W Jr. Maternal smoking during pregnancy and childhood obesity. Am J Epidemiol. 2002;156(10):954-61. doi: 10.1093/aje/kwf128.
29. Stone CD, Diallo O, Shyken J, Leet T. The combined effect of maternal smoking and obesity on the risk of preeclampsia. J Perinat Med. 2007;35(1):28-31. doi: 10.1515/jpm.2007.003.
30. Reilly JJ, Armstrong J, Dorosty AR, Emmett PM, Ness A, Rogers I, et al. Early life risk factors for obesity in childhood: cohort study. BMJ. 2005;330(7504):1357. doi: 10.1136/bmj.38470.670903.E0.