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ABSTRACT

Introduction: the prevalence of overweight and obesity showed and increasing trend over the past few years. The burden of this epidemic represents a public health issue worldwide. Spain, and especially the Canary Islands, are not exempt. Pregnancy is a situation of weight gain, and the amount of such increase during gestation can affect the health status of both

the mother and her baby. Thus, an optimal dietary style becomes of importance.

Aim: given the benefits of the Mediterranean diet (MD) on various health outcomes, we aimed to study the adherence to this dietary pattern in a sample of Canarian pregnant women, and to investigate its association with their newborn's weight.

Methods: adherence to MD as well as clinical history and anthropometrics were assessed in a sample of pregnant women followed at a Canarian hospital. Similarly, their newborn characteristics were studied.

Results: our findings showed an overall low adherence to MD, with no association between this trend and birthweight.

Conclusions: in conclusion, specific tools should be tailored to the target population to assess adherence to MD, and further efforts should be made to promote a healthy eating pattern and lifestyle among the pregnant population.

Keywords: Overweight. Obesity. BMI. Pregnancy. Mediterranean diet. Newborn’s health.

RESUMEN

Introducción: la prevalencia del sobrepeso y la obesidad presentó una tendencia al alza en los últimos años. La carga de esta epidemia supone un problema de salud pública en todo el mundo. España, y especialmente las Islas Canarias, no es una excepción. El embarazo es una situación en la que se gana peso y la cantidad de peso que se gana durante la gestación puede afectar al estado de salud tanto de la madre como del niño. Por tanto, adquiere importancia seguir un tipo de dieta óptimo.

Objetivo: dados los beneficios de la dieta mediterránea (DM) sobre varios resultados de salud, nos propusimos estudiar la adherencia a este patrón dietético en una muestra de embarazadas canarias e investigar su asociación con el peso neonatal.

Métodos: la adherencia a la DM, al igual que la historia clínica y la antropometría, se evaluó en una muestra de mujeres embarazadas seguidas

en un hospital canario. También se estudiaron las características de los neonatos.

Resultados: nuestros hallazgos mostraron una adherencia general baja a la DM, sin ninguna asociación entre esta tendencia y el peso al nacer.

Conclusiones: en conclusión, se deben adaptar a la población objeto de este estudio herramientas específicas que sirvan para evaluar la adherencia a la DM, y se deben realizar nuevos esfuerzos para fomentar un patrón alimenticio y un estilo de vida saludables entre la población gestante.

Palabras clave: Sobrepeso. Obesidad. IMC. Embarazo. Dieta mediterránea. Salud del neonato.

INTRODUCTION

The World Health Organization (WHO) defines overweight and obesity as an abnormal or excessive fat accumulation that represents a risk to health, as well as an ascertained risk factor for chronic noncommunicable diseases (NCD) such as diabetes, cardiovascular diseases and cancer. In 2016, approximately 39% of adults over 18 years of age were overweight, and 13% were obese (1).

In Spain, in the Canary Islands, the prevalence of obesity represents a public health issue, as outlined by epidemiological studies over the last decade (2). In 2004, the DORICA study found in the Spanish adult population aged 25-60 years a prevalence of obesity of 15.5% (13.2% in men and 17.5% in women) (3,4), and the highest prevalence was recorded in the south and north-east of Spain, and in the Canary Islands (14.21% in men and 22.22% in women) (5). The ENRICA study, conducted between the years 2008 and 2010, observed that about 36% (32% of men and 39% of women) of the Spanish population aged 18 years or more had abdominal obesity, with a higher prevalence of obesity in the Canary Islands and in the south of Spain (6). Data collected between May 2014 and May 2015 showed that in the Spanish population aged 25 to 64 years the prevalence of overweight and obesity was 39.3% and 21.6%, respectively (7).

The burden of this epidemic affects not only the adult but also the pregnant population, as the number of women who are overweight or obese at the

moment of conception is increasing. According to a study conducted at the Maternal and Child University Hospital of the Canary Islands, Spain, on a sample of women who gave birth at the same center during 2008 (n = 6,693) the prevalence of overweight and obesity prior to gestation was 25.0% and 17.1%, respectively (8).

Pregnancy is an inevitable situation of weight gain, and the amount of such a ponderal increase during gestation can affect the immediate and future health of both the mother and her baby. The available scientific evidence supports the association between excessive weight gain during pregnancy and increased weight of the newborn, and between inadequate weight gain during pregnancy and reduced birth weight (9). For this reason, in 1990 the Institute of Medicine (IOM) developed guidelines for recommended ranges of gestational weight gain, in order to optimize fetal growth as well as maternal and infant consequences. In 2009 the recommendations were revised according to the body mass index (BMI) cut-off points established by the WHO (10,11).

An elevated BMI during pregnancy implies an increased risk of developing gestational hypertension and diabetes, preeclampsia, spontaneous abortion, episiotomy, or cesarean section (12). In the newborn, maternal obesity increases the probability of congenital anomalies, macrosomia, and appearance of obesity during childhood (13-15).

An appropriate nutritional intake not only allows to enhance a woman's health status and prevent gestational diseases, but is also related to the health of the baby. In this regard, published data (16) show that the habitual consumption of foods representative of the Mediterranean diet (DM) may have beneficial effects on gene expression, normal intrauterine growth, respiratory function, allergies, neural tube defects, and preterm birth.

The aim of the present study was to investigate, in a Canarian sample of pregnant women, the possible associations between adherence to MD and the birthweight of their babies.

MATERIALS AND METHODS

A retrospective cross-sectional study on a sample of 218 women and their newborns was conducted at Hospital Insular Materno Infantil de Gran Canaria (HIMIGC), Spain. Eligible participants were healthy women who gave birth in

the HIMIGC between November the 1st and December the 31st, 2018. The subjects had singleton pregnancies and expressed their will to voluntarily participate in the study providing a written informed consent. Women with any clinical condition other than type 1 or 2 diabetes mellitus (DM) or hypertension, who had high-risk pregnancies, who carried a multiple pregnancy, and who gave birth to children with any pathological condition were considered to be not eligible for the study.

The participants' anthropometric characteristics (weight and height) were assessed at the beginning of pregnancy and at the end. The other variables investigated in the present study were assessed trough a questionnaire the women were provided with, and filled out in the presence of the investigator. Mother-related variables included age, nationality, educational level, employment status, marital status, family history of DM, obesity and/or hypertension, personal history of DM, hypertension, gestational diabetes and hypertension, preeclampsia, smoking, alcohol and drug use, and physical activity. The corresponding Metabolic Equivalents of Task (METs) were calculated by assigning to mild exercise (i.e., walking) a value of 2.5 METs, and to moderate exercise (i.e., weight lifting, running) a value of 4 METs (17,18).

The newborn characteristics investigated in the present study were: gestational age (and subsequent classification in pre-term, at term, and post-term), gender, birthweight (in grams), birth-height (centimeters), and cranial circumference (in centimeters).

In order to estimate the mothers' dietary habits, and in particular their degree of adherence to MD, a survey validated by the PREDIMED study (Prevención con Dieta MEDiterránea) (19-21) was used. It consists of 14 items, known as the Mediterranean Diet Adherence Screener (MEDAS) (22). Each item scores one point in case of a positive answer or does not score otherwise. The total value has a range of 0-14. The items included in the questionnaire are reported in Fig. 1.

The study has been performed in accordance with the ethical standards of the Declaration of Helsinki, and was approved by the referent Ethics Committee of Hospital Insular Materno-Infantil de Gran Canaria, Spain. The participants expressed their will to voluntarily participate in the study by providing their

written informed consent. All subject-related data were coded to preserve confidentiality.

Statistical analysis

The statistical analysis was performed using the R (www.r-project.org) and SPSS, version 25 (IBM) software packages. Tests for assessing the normal distribution of continuous variables were performed, as well as a test for detecting outliers. The sample was divided into three groups according to the MEDAS punctuation. The first group (score from 0 to 4) corresponded to a low adherence to MD, the second (ranging from 5 to 8) to an average adherence, and the third group (from 9 to 13) represented the best adherence to MD.

A descriptive analysis was performed according to the women's adherence to MD, with the objective of describing the sample according to their nutritional habits. The p-value was calculated using Student's t-test and a chi-square analysis or Fisher's test for continuous and discrete variables, respectively, in order to verify the existence of between-group statistically significant differences (p-value ≤ 0.05).

To analyze the possible associations between the independent variable "mother adherence to MD" and newborn weight, a linear model of multiple regression was fitted to our data.

According to the available evidence, the adjustment covariates that were included in the model, due to their relationship with newborn weight, were: mother's age, BMI before pregnancy and gestational weight gain, smoking status, physical exercise, diabetes and gestational hypertension, and gestational age of the newborn.

RESULTS

The MEDAS showed a mean of 6.61 out of 13 points, indicative of an overall low adherence to MD. Table I reports the anthropometric characteristics of the 218 pregnant women according to MD adherence groups. The mean age of the study sample was 32 years, ranging from a minimum of 17 to a maximum of 51 years of age. A statistically significant difference in age was observed across the three MD adherence groups. Before pregnancy, the women with lower adherence to MD were characterized by having normal weight, while the other

groups were classified as overweight. However, these differences were not found to be statistically significant. The differences between weight gains during pregnancy were not significant either, although the average weight gain of the whole sample (12.6 ± 7.44 kg) is in line with the recommendations of the IOM for normal-weight women (increase by 11.3 - 15.9 kg throughout the whole pregnancy).

Table II lists the clinical and sociodemographic characteristics of the pregnant women in the study, as well as their personal clinical history. A majority of subjects were European, with the minority including women from Asia, South America and Africa. The educational level across the three groups of MD adherence was statistically significant ($p < 0.001$), with most subjects in the basic education and high school groups. Similarly, the differences in employment status bbetween the three groups turned out to be significant. Tobacco smoking and alcohol consumption were investigated and, although positive results only applied to a restricted number of women, statistically significant differences were found between the three groups of MD adherence ($p = 0.042$ and $p = 0.001$, respectively).

The practice of some sort of physical activity, whether of mild or moderate intensity, was assessed by the questionnaires, and yielded statistically significant differences ($p = 0.037$) between the three groups, with mild exercise being the most practiced modality. Mean MET values per week were 1254.78 ± 919.60 and 2640 ± 2336.15 METs for the mild- and moderate-intensity exercise groups, respectively.

Neither blood hypertension, defined by values of systolic and diastolic blood pressure higher than 140/90 mmHg, nor gestational hypertension showed significant differences between the three groups of MD adherence. The same observation was made for diabetes mellitus.

Table III shows the newborns' characteristics according to their mother’s MD adherence group. The sample was represented by the same number of males and females. The estimated mean birthweight was 3282.52 (± 554.26) grams, mean length was 50.07 (± 2.40) centimeters, and mean cranial circumference was 34.09 (± 1.8) centimeters. The association between gestational age and MEDAS was found to be statistically significant ($p = 0.047$), as well as the association between length at birth and MEDAS ($p = 0.011$).

Table IV describes the results obtained with the multiple linear regression model fitted to our data. Of all the covariates analyzed in the model, a mother's BMI before pregnancy was found to be statistically significant ($p = 0.001$), as well as weight gain during pregnancy ($p = 0.020$). Finally, gestational age was statistically associated with the weight of the newborn ($p < 0.001$).

DISCUSSION

Overweight and obesity represent well established risk factors for NCDs such as type-2 diabetes, cardiovascular diseases and cancer, and their burden has been increasing over the last few years (1). Such conditions represent a risk factor also in the pregnant population, and could possibly influence the intrauterine growth of the fetus and the health outcome of the newborn.

Nutrition during pregnancy plays an important role in the evolution of gestation and in the health of the newborn. An adequate nutritional intake not only allows to enhance the health of the woman and to prevent gestational diseases, but is also associated with the health of her baby.

A systematic review conducted by Amati et al. (16) examining 22 published papers on the issue, showed that adhering to MD during pregnancy has a beneficial role on a wide range of outcomes, including gestational diabetes in the mother and congenital defects in the offspring. Similar findings were observed in a recent case-control study by Olmedo-Requena et al., where the authors concluded that strict adherence to MD prior to pregnancy was associated with a lower risk for developing gestational diabetes (23).

Moreover, various authors observed that adherence to a Mediterranean dietary pattern was associated, among other things, with fewer congenital defects and better clinical outcomes, with a reduced risk of gastroschisis (24) and spina bifida in the newborn (25).

The beneficial effects of adherence to MD during pregnancy on the health status of both the mother and the offspring are well known and supported by a growing body of evidence (26). Nevertheless, in our study, an overall low adherence to MD was observed, the value obtained being lower than expected. In other words, the population examined did not follow an optimal diet even in that period of life in which it would be more desirable: pregnancy.

Two hypotheses can be advanced in order to explain this observation. The first one is that dietary habits among the Canarian population have changed over the last few years. This is possibly due to the adoption of a western-style diet in the nineties, paralleling an increased number of tourists in these areas (27). The second hypothesis is that the MEDAS does not fit with our study's population, particularly because it is not addressed to pregnant women. In fact, as reported by Schroder et al., the Mediterranean Diet Adherence Score was validated in Spanish older men and women at high risk for chronic heart disease (22). Although successfully utilized in many trials, such as the PREDIMED study, we consider that the MEDAS is unable to provide exhaustive information on diet quality in a population of pregnant women. Moreover, the MEDAS assesses diet quality but does not take into account daily calorie intake or the intake of other kinds of foods that could negatively affect the health of the subjects.

Therefore, among the limitations of the present study, we have to highlight that the MEDAS questionnaire was not accompanied by a food frequency questionnaire, which could have allowed us to compare the MEDAS punctuation with a reference method, as done by other authors (28).

Another important limitation is that the MEDAS questionnaire was administered just once during the whole pregnancy, wheras a dual (or multiple) administration, i.e., at the beginning and at the end of the gestation period, would have provided more detailed information about MD adherence. All these reasons may be invoked to explain why, in our study, a mother's adherence to MD during pregnancy is not significantly associated with her newborn's weight.

Moreover, we have to consider a presumable selection bias as the subjects enrolled in this study were volunteers, even if, given the results obtained in our population sample, an overestimation of MD adherence seems unlikely.

Growing evidence suggests that practicing physical activity on a regular basis is associated with improved physiological, metabolic and psychological outcomes. This observation is valid also for pregnant women, where exercise provide benefits not only to the mother (i.e., improvement of cardiovascular function, limited gestational weight gain, less limb edema) but also to the newborn (i.e., reduced fat mass or improved stress tolerance) (29,30). Nevertheless, despite the beneficial role of physical activity during pregnancy,

a significant number of women stop exercising when they realize they are pregnant. In our sample, the proportion of participants who practiced physical activity of low or moderate intensity was higher in the groups with better adherence to MD. These findings are possibly due to a more health-conscious lifestyle, as supported by a low prevalence of smoking and alcohol intake, and a high prevalence of higher education among these groups.

In the present study, in order to investigate the association between mother adherence to MD and newborn weight, a multiple linear regression model was fitted to the data. We adjusted the model for the covariates known to be associated with birthweight. The observed significant association between such covariates and the outcome variable is in agreement with the available evidence.

According to our data, BMI before pregnancy is significantly associated with birthweight. This finding is in line with the available evidence according to which intrauterine exposure to obesity and diabetes mellitus may even represent a risk factor for the development of type-2 diabetes mellitus and hypertension during childhood (14)(31).

A mother's weight gain during pregnancy is associated with some maternal and fetal outcomes (32,33); for this reason, the optimal weight gain for pregnant women has been established by the Institute of Medicine, US, according to BMI prior to gestation (10). As weight gain during pregnancy reflects fetus development, this explain the significant association between such covariable and birthweight that was observed in the present study.

Gestational age is extremely associated with birthweight as these two features represent the degree of development of the fetus and define its capability to survive in an extrauterine environment. This explains the results we observed in the present study relative to gestational age and birthweight.

CONCLUSIONS

In conclusion, after adjusting for the covariates known to play a role in the offspring's birthweight, the mother's adherence to MD, assessed by mean of the MEDAS, does not seem to be associated with birthweight. These findings confirm the need to use a combined questionnaire assessing both diet quality and quantity when investigating MD adherence in a sample of subjects, and to

pave the way for the implementation of questionnaires with better capabilities to characterize the eating habits of the pregnant population. Nevertheless, a healthy lifestyle, especially among pregnant women in the Canary Islands, should be further promoted in order to improve health outcomes for both mothers and newborns.

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Fig. 1. The 14-point Mediterranean Diet Adherence Screener (MEDAS)

	Frequency*
1. Do you use olive oil as the principal source of fat for cooking?	Yes
2. How much olive oil do you consume per day (including that used in frying, salads, meals eaten away from home, etc.)?	≥ 4 tbsp[1]
3. How many servings of vegetables do you consume per day? **Count garnish and side servings as 1/2 point; a full serving is 200 g**	≥ 2
4. How many pieces of fruit (including fresh-squeezed juice) do you consume per day?	≥ 3
5. How many servings of red meat, hamburger, or sausages do you consume per day? A full serving is 100-150 g.	< 1
6. How many servings (12 g) of butter, margarine, or cream do you consume per day?	< 1
7. How many carbonated and/or sugar-sweetened beverages do you consume per day?	< 1
8. Do you drink wine? How much do you consume per week?	≥ 7 cups[2]
9. How many servings (150 g) of pulses do you consume per week?	≥ 3
10. How many servings of fish/seafood do you consume per week? **(100–150 g of fish, 4–5 pieces or 200 g of seafood)**	≥ 3
11. How many times do you consume commercial (not homemade) pastry such as cookies or cake per week?	< 2
12. How many times do you consume nuts per week? (1 serving = 30 g)	≥ 3

13. Do you prefer to eat chicken, turkey or rabbit instead of beef, pork, hamburgers, or sausages?	Yes
14. How many times per week do you consume boiled vegetables, pasta, rice, or other dishes with a sauce of tomato, garlic, onion, or leeks sautéed in olive oil?	≥ 2

*Criterion to score 1 point. Otherwise, 0 recorded. [1]1 tablespoon = 13.5 g. [2]1 cup = 100 mL.

Table I. Anthropometric characteristics of the sample according to Mediterranean Diet Adherence Score (MEDAS) group

	Low adherence (0-4) n = 44		Average adherence (5-8) n = 122		High adherence (9-13) n = 52		p-value
	n	Mean (SD)	n	Mean (sd)	n	Mean (SD)	
Age (years)	44	28.9 (5.9)	122	32,4 (6.3)	52	34.6 (5.5)	< 0.001*
Weight at baseline (kg)	44	63.69 (17.70)	120	69.58 (18.20)	50	67.67 (12.69)	0.145*
Weight at the end (kg)	44	77.38 (16.59)	121	81.71 (17.15)	50	79.54 (11.59)	0.282*
Weight increase (kg)	44	13.69 (5.53)	121	12.70 (8.79)	52	11.41 (5.04)	0.321*
BMI (kg/m^2) before pregnancy	44	24.22 (6.71)	120	25.78 (6.45)	50	25.65 (4.94)	0.346*
BMI (kg/m^2) after pregnancy	44	29.40 (6.02)	121	30.29 (6.08)	50	30.15 (4.46)	0.673*

*p-value obtained by ANOVA.

Table II. Sociodemographic and clinical characteristics of the sample according to Mediterranean Diet Adherence Score (MEDAS) group

	Low adherence (0-4) n = 44	Average adherence (5-8) n = 122	High adherence (9-13) n = 52	p-value
	n (%)	n (%)	n (%)	
European nationality	37 (84.1)	106 (86.9)	43 (82.7)	0.759
Education				<
- Primary	27 (61.4)	40 (32.8)	17 (32.7)	0.001*
- High school	15 (34.1)	43 (35.2)	14 (26.9)	
- University	2 (4.5)	39 (32.0)	21 (40.4)	
Occupation				0.036*
- Unemployed	18 (40.9)	30 (24.6)	7 (13.5)	
- Employed	18 (40.9)	71 (58.2)	35 (67.3)	
- Housewife	8 (18.2)	21 (17.2)	10 (19.2)	
Civil status (married/couple)	39 (88.6)	116 (95.1)	50 (96.2)	0.238
Smoking				0.042*
- Non-smoker	26 (59.1)	87 (71.3)	44 (84.6)	
- Smoker	11 (25.0)	15 (12.3)	5 (9.6)	
- Ex-smoker	7 (15.9)	20 (16.4)	3 (5.8)	
Alcohol (occasionally)	24 (54.5)	37 (30.3)	11 (21.2)	0.001
Physical activity	16 (36.4)	66 (54.5)	33 (63.5)	0,037
- Mild	3 (6.8)	3 (2.5)	3 (5.8)	
- Moderate				
1st gestation	16 (36.4)	50 (41.0)	16 (30.8)	0.438

Arterial hypertension	1 (2.3)	4 (3.3)	1 (1.9)	1.000
Diabetes	0 (0)	1 (0.8)	0 (0)	1.000
Gestational hypertension	8 (18.2)	11 (9.0)	4 (7.7)	0.188
Gestational diabetes	2 (4.5)	24 (19.7)	36 (16.5)	0.054
Preeclampsia	0 (0)	6 (4.9)	4 (7.7)	0.201

*p-value obtained by Fisher's exact test. The other p-values have been obtained according to the chi-square test

Table III. Characteristics of the newborns according to their mothers' Mediterranean Diet Adherence Score (MEDAS) group

	Low adherence (0-4) n = 44	Average adherence (5-8) n = 122	High adherence (9-13) n = 52	p-value
	n (%)	n (%)	n (%)	
MALE GENDER	28 (63.6)	55 (45.1)	26 (50)	0.109
At term/post-term	43 (97.7)	109 (89.3)	51 (98.1)	0.047
	Mean (SD)	Mean (SD)	Mean (SD)	
Birthweight (g)	3275.98 (501.74)	3251.94 (598.82)	3380.31 (498.41)	0.378 *
Lenght at birth (cm)	50.36 (2.20)	49.67 (2.61)	50.81 (1.81)	0.011 *
Cranial circumference at birth (cm)	34.51 (1.53)	33.95 (2.00)	34.14 (1.54)	0.217 *

*p-value obtained by ANOVA. The other p-values have been obtained according to the chi-square test.

Table IV. Multiple linear regression model

	Coefficient	Signif.
Low vs. average MD adherence group	5.79	0.950
High vs. average MD adherence group	61.91	0.465
Mother’s age (years)	-2.07	0.718
BMI before pregnancy	22.10	0.001
Weight gain during pregnancy	14.43	0.020
Smoker vs. non-smoker	-125	0.206
Ex-smoker vs. non-smoker	-103.50	0.304
Gestational diabetes	174.78	0.068
Gestational hypertension	-136.21	0.234
At term/post-term vs. pre-term	708.60	< 0.001

MD: Mediterranean diet; BMI: body mass index.