MEDITERRANEAN DIET ADHERENCE SCORE, NUTRITIONAL PROFILE AND INCIDENCE OF GESTATIONAL DIABETES IN PREGNANT WOMEN FROM THE PROVINCE OF SAFI (MOROCCO)

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Abstract

Objectives. The nutrition of pregnant women is one of the challenges of the Moroccan health authorities. A healthy and balanced diet based on the principles of the Mediterranean diet (MD) is a potential way to prevent several dietary deficiencies and avoid risks, particularly in women with gestational diabetes (GD). This work aims were to examine the association between adherence to the (MD) and nutritional status, among diabetic pregnant women in the city of Safi in Morocco.
Material and methods. A cross-sectional, correlational and analytical study conducted over a period of 17 months, from October 2018 to February 2020, targeted 401 pregnant women attending antenatal consultation (ANC) services in eight health centers (HCs). MD adherence was assessed by the MDS-P score, based on the simplified MD score in addition to the specific needs for Iron (Fe), Calcium (Ca) and folic acid during pregnancy. Results were processed using statistical operations such as correlations, comparison, and ANOVA analysis of variance.
Results. The study shows that adherence to the MD was low in 33.9%, moderate in 65.1%, and high in 1% only. The data also revealed that the MD adherence score was not significantly associated with the incidence of GD ($p>0.05$), while a significant association was found with nutritional status in the majority of cases ($p<0.001$).
Conclusions. Maintaining the Mediterranean dietary model in Morocco plays a crucial role in the public health as it protects against gestational diabetes and several metabolic diseases.

Keywords: Mediterranean diet Adherence score, Gestational diabetes, Nutritional status, Nutrition.

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Introduction

Like other developing countries, Morocco has experienced a series of transitions in recent decades, including the nutrition transition with consequences for health (Popkin, 1998; Benjelloun, 2002). The current health picture is indeed characterized by a continuous and progressive increase in chronic and degenerative diseases replacing infectious diseases and undernutrition as the main causes of death. This situation has been accompanied by problems of overweight and obesity associated with nutrient deficiency diseases (Belahsen, 2014). In fact, globalization, economic development and urbanization have affected including dietary habits and the level of physical activity (Benjelloun, 2002; Batal, Steinhouse, & Delisle, 2018; Chadli, Taqarort, El Houate & Oulkheir, 2018). These changes have led to the emergence of some chronic diseases such as obesity, diabetes, hypertension, stroke, hyperlipidemia, coronary heart disease and cancer (Belahsen, 2014). To respond to this critical situation, it was necessary the adoption of a healthy lifestyle characterized by a healthy, balanced diet that takes into account the respect towards the environment, the food sustainability and the appropriate physical activity which has been recommended (Dernini, Berry, Bach-Faig, Belahsen, Donini, Lairon, Serra-Majem, & Cannella, 2012; Barakat Chamlal, El Fane, El-Jamal, Elayachi & Belahsen, 2022).

According to FAO & UNESCO (2010), The Mediterranean diet (MD), declared as a sustainable diet model (Burlingame & Dernini, 2018), has attracted the interest of researchers around the world (Keys, Menotti, Aravanis, Blackburn, Djordevič, Buzina, Dontas, Fidanza, Karvonen, Kimura, 1984), because of its association with multiple health benefits. These include a reduced risk of premature death, cardiovascular disease, metabolic syndrome, cancer, liver disease, type 2 diabetes (Trichopoulou, Costacou, Bamia & Trichopoulos, 2003; Yngve, 2009; Dernini, Berry, Bach-Faig, Belahsen, Donini, Lairon, Serra-Majem & Cannella, 2012).

The traditional MD is characterized by a high consumption of vegetables, legumes, fruits and nuts, and grains that were largely unrefined in the past, and a high consumption of olive oil but a low consumption of saturated fats, moderately high consumption of fish, low to moderate consumption of dairy products (then mainly in the form of cheese or yogurt), low consumption of meat and poultry, and regular but moderate consumption of alcohol, mainly in the form of wine and usually with meals (Trichopoulou, Costacou, Bamia & Trichopoulos, 2003). However, the dietary habits have changed among Mediterranean populations, becoming gradually rich in protein foods sources, saturated fats and refined sugars, whose consumption exceeds the daily requirement. The resulting situation is an apparent well-being with increased life expectancy accompanied by increased risk of obesity, metabolic syndromes, cardiovascular diseases and cancers (Dernini, Berry, Bach-Faig, Belahsen, Donini, Lairon, Serra-Majem & Cannella, 2012). Pregnant women are not spared from this observation, the diet of diabetic pregnant women includes several aberrations and errors which influence the pregnancy leading to some maternal-fetal complications (Fah, Klotoé, Dougnon, Koudokpon, Fanou, Dandjesso & Loko, 2013). Extensive literature has, indeed, revealed alarming figures in pregnant women regarding the rates of anemia, hypocalcemia, vitamin D deficiency, obesity and diabetes (Sofi, Macchi, Abbate, Gensini & Casini, 2014; Chamlal, Mziwira, Ayachi & Belahsen, 2020).

Admittedly, an appropriate diet is essential throughout the childbearing period and during pregnancy with the aim to ensure a proper development of the foetus. The diet must

provide adequate food quantity and variety of necessary nutrients in accordance with the pillars of MD (Mariscal-Arcas, Rivas, Monteagudo, Granada, Cerrillo & Olea-Serrano, 2009). The adherence to MD in Pregnancy (MDS-P) is based on the traditional Mediterranean diet (DeKoning & Anand, 2004) and meeting the specific requirements of pregnancy for iron, calcium and folic acid (Mariscal-Arcas, Rivas, Monteagudo, Granada, Cerrillo & Olea-Serrano, 2009). The MDS is calculated based on the compliance with eight typical components of the Mediterranean diet: high consumption (median intake) of vegetables, fruits and nuts, legumes, cereals, fish, high MUFA/SFA ratio and low consumption of meat and dairy products and moderate alcohol consumption not exceeding 12g (Sofi, Macchi, Abbate, Gensini, & Casini, 2014). Dietary intakes of selected micronutrients (folic acid, Fe and Ca) were also assessed against the recommended daily allowance (RDA), considering two-thirds of the RDA for pregnancy as the cut-off point (Mariscal-Arcas, Rivas, Monteagudo, Granada, Cerrillo & Olea-Serrano, 2009). The purpose of this study is to examine the association of nutritional status and adherence to MD in pregnant women with incidence of gestational diabetes in the city of Safi in Morocco.

Material and methods.

Study type and setting

This is a cross-sectional, correlational and analytical study and it was conducted over a period of 17 months, from October 2018 to February 2020. It targeted pregnant women attending prenatal consultation services (PNC) in eight selected health centers (HCs). The study population included all pregnant women over the age of 18. The study was supported by the Moroccan Ministry of Higher Education and Research and the Moroccan Ministry of Health and protection social.

Sample

The sampling protocol was carried out in two phases. The initial phasis consisted in the selection of HCs that are frequented by pregnant women in the province of this study, these were selected according to the rate of prenatal consultation which is higher than 80% of births expected per semester, their geographical location that covers the representative majority of the province and their distribution between urban and rural areas. In the second phasis, the sampling of pregnant women attending the designated health centers were randomly selected. Were excluded from the study sample, the pregnant women with history of gestational diabetes, pre-existing diabetes, other chronic disease, high-risk pregnancy and the lack of follow-up records. The final sample size was 401 pregnant women.

Collection of data

A questionnaire was used in order to collect the information concerning mainly data on patient characteristics (age, gender, places of residence, monthly income and level of education).

Data on dietary intake are collected using two 24-hour dietary recalls. Dietary intakes were converted to energy and nutrient intakes by BILNUT – NUTRISOFT software version 2.01 using a food composition database compiled and modified to accommodate the diet specificity and intakes were expressed as grams per day. The values obtained were then compared to the reference nutrient intakes.

The anthropometric measurements were carried out according to the WHO (1995) recommendations. A mechanical person scale (SECA 761 - Class IIII), with an accuracy of 0,1kg was used for to measure weight. Height was measured using a wall height chart (STANLEY)

with measurement range from 0 to 200 cm. All the measurements are undertaken in respect of techniques in force (World Health Organization, 1995).

Preconception body mass index (BMI) was calculated by dividing pre-pregnancy weight (kg) by the height in meter square (m^2). Weight status was defined according to the World Health Organization (WHO) criteria as normal weight if 18.5≤ BMI ≤24.9 kg/m^2, overweight by 25≤ BMI ≤30 kg/m^2 and obesity overall by a BMI>30 kg/m^2 (Rasmussen &Yaktine, 2009).

The diagnosis of gestational diabetes was made by the oral glucose test 75g/l (OGT) according to the criteria of the International Association of Diabetes and Pregnancy Groups (IADPSG), the World Health Organization (WHO) and according to Hanson, Bardsley, De-Regil, Moore, Oken, Poston, & Morris (2015). Measurements were performed by three well-trained investigators (2 midwives and dietitians) with the aim to reduce subjective errors.

Adherence to the MDS-P Mediterranean diet was determined using an overall 10-point scale (from zero to nine, indicating greater adherence with increasing score) designed a priori in order to incorporate nine important components of the traditional Mediterranean diet. A binary value was assigned based on the relative consumption of the presumed beneficial or harmful components (Mariscal-Arcas, Rivas, Monteagudo, Granada, Cerrillo, & Olea-Serrano, 2009; Sofi, Macchi, Abbate, Gensini, & Casini, 2014).

The **beneficial components** are Vegetables, Pulses, Fruits and nuts, Cereals, Fish and MUFA/SFA assigned the score 0 or 1 as follows:

Vegetables: frequency of consumption per day of an amount of 100g; <1 serving/d =0; >1 portion/day =1

Pulses: frequency of consumption per week in an amount of 70g; <1 serving/wk=0; >1 serving/wk=1

Fruits and nuts: frequency of consumption per day of an amount of 150g; <1 serving/day =0; >1 portion/day =1

Cereals: frequency of consumption per day in an amount of 130g; <1 serving/day =0; >1 portion/day =1

Fish: frequency of consumption per week of an amount of 100g; <1 serving/wk=0; >1 serving/wk=1

MUFA/SFA: frequency of seasonal or frequent consumption of olive oil; low =0; high =1.

For the **harmful Components** (Meat and poultry, Dairy products, Alcohol)

Meat and poultry: frequency of consumption per day of an amount of 80g; <1 serving/day =1; >1 serving/day =0

Dairy products frequency of consumption per day in an amount of 180g; <1 portion/day =1; >1 serving/day =0

Alcohol: frequency of consumption per day in an amount of 12g; <1 portion/day=1; >1 serving/day =0

The score of adherence to Mediterranean diet is the sum of the allocated values to the nine components (beneficial and harmful), in addition to the specific needs in Iron (Fe), Calcium (Ca) and folic acid during the pregnancy. The MDS-P was calculated by assessing compliance with eight components typical of MD and a moderate alcohol consumption, also typical of the MD. The alcohol was not taken into account in the study context for the calculation of the index in the pregnant studied women, who reported not consuming alcohol because of their pregnancy. Dietary intakes of the selected micronutrients (folic acid, Iron and Calcium) were assessed against the recommended daily allowance (RDA), considering two-thirds of the RDA for pregnancy as the cut-off point (Mariscal-Arcas, Rivas, Monteagudo, Granada, Cerrillo, & Olea-Serrano, 2009). Three categories of MD adherence score are defined as it follows: Low adherence to MD: ≤4, Medium adherence to MD: [5-8], High adherence to MD: ≥9.

Data analysis

Data were entered into Excel® software and analyzed using SPSS (Statistical Package for Social Sciences) Version 23.0 software. Quantitative variables were expressed as means ± standard deviations. Qualitative variables were expressed as frequency and proportions. In addition, Correlation, the Student's t test for an independent sample, the 1-way ANOVA test and the Chi2 test were used for the analysis of the results. The significance threshold was set at $P<0.05$.

Ethical aspects

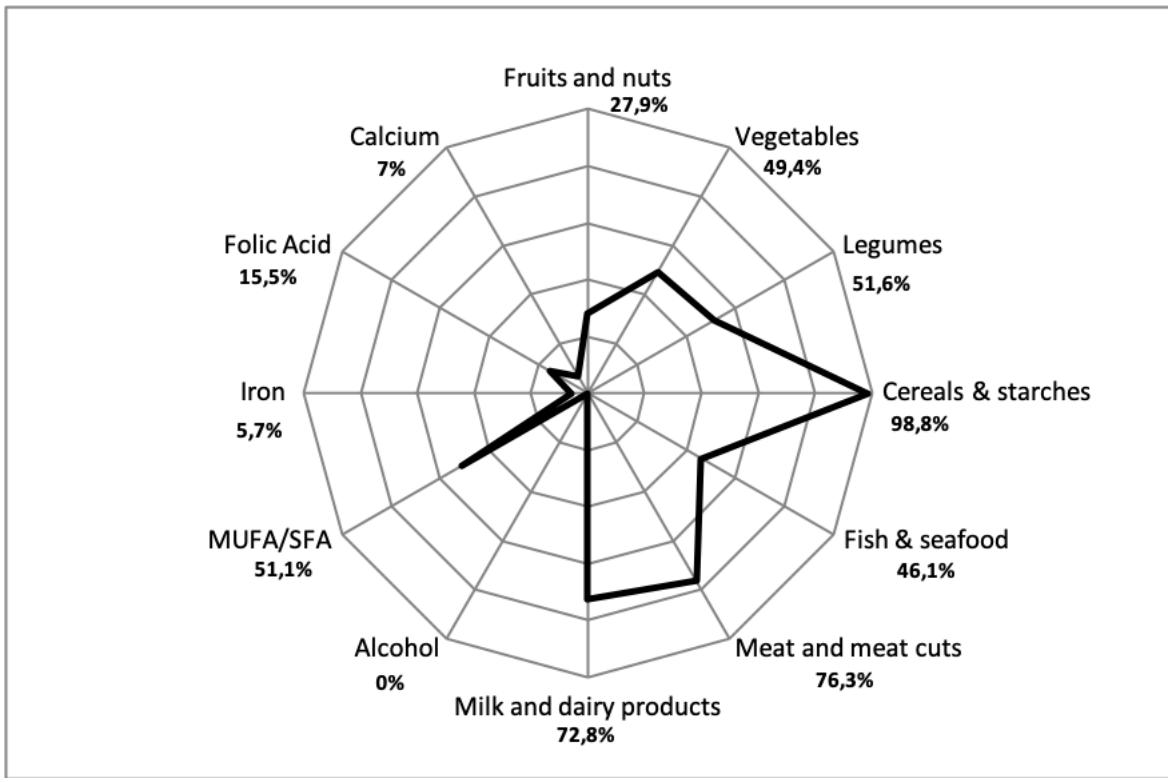
The study protocol was previously authorized by the health authorities of the province of Safi. The participants were informed about the detailed objective of the study and the data collection tool. A consent was systematically requested and anonymity, self-determination and fair and equitable treatment were guaranteed.

Results

Typology of Moroccan pregnant women

The figure below describes a dietary profile characterized by high consumption of cereals and starchy foods (98.8%), meat (76.5%), milk and dairy products (72.8%), an average consumption of legumes (51.6%), vegetables (49.4%), fish (46.1%), and low fruit consumption (27.9%). Concerning micronutrients, the monounsaturated fatty acids to saturated fatty acids ratio was 51.1% while iron (5.7%), folic acid (15.3%) and calcium (6.9%) were very low in their dietary consumption.

Figure 1
Food typology of pregnant women (n=401)



Adherence to MD in pregnant women (MDS-P) according to their characteristics

Table 1 shows that socio-economic status is the only parameter significantly associated with the score of adherence to MD in the study about the Moroccan pregnant women.

Table 1

Comparison of adherence to MD score in pregnant women (MDS-P) according to their characteristics

Characteristics		N	%	MDS-P		*P*
				M	*SD*	
Age	<35 yrs	315	78.6	5.04	1.4	0.603
	≥35 yrs	86	21.4	4.95	1.3	
Origin	Rural	209	52.1	4.91	1.4	0.088
	Urban	192	47.9	5.15	1.3	
Education level	<7yrs	304	75.8	4.99	1.3	0.409
	≥7yrs	97	24.2	5.12	1.5	
SES (income in MAD/month)	Low (<3000)	191	47.6	4.88	1.3	0.020
	Medium (3000-5000)	196	48.9	5.08	1.4	
	High (>5000)	14	3.5	6.21	1.1	
Pre-conception BMI	<18.5	15	3.7	4.67	1.2	0.632
	[18.5-25[	227	56.6	5.01	1.3	
	[25-30[	128	31.9	5.11	1.4	
	≥30	31	7.7	4.90	1.6	

MDS-P: MD compliance score in pregnant women; Continuous variables presented as mean ± SD, qualitative variables in frequency and in percentage, Student's t test. The significance level at $P<0.05$.

Association of GDM and the Mediterranean diet adherence score in pregnant women (MDS-P)

As shown in the Table 2, the score of adherence to the Mediterranean diet and the food groups consumed are not significantly associated with the incidence of GDM $P>0.05$ while, in the majority of the cases $P<0.001$ these are significantly associated with the categories of adherence to the Mediterranean diet.

Table 2

Association of food groups with gestational diabetes and Mediterranean diet adherence score in pregnant women (MDS-P) (n=401)

Food groups	Low MDS-P		Medium MDS-P		High MDS-P		***P***	Without GDM		With GDM		***P***
	N	%	N	%	N	%		N	%	N	%	
	136	33.9	261	65.1	4	1		326	81.3	75	18.7	
MDS-P Mean ± SD	3.51	±0.7	5.75	±0.8	9	±0.0	<0.001	4.97	±1.37	5.24	±1.4	0.132
Fruits and nuts	22	16.2	86	33	4	100	<0.001	84	25.8	28	37.3	0.044
Vegetables	42	30.9	153	58.6	3	75	<0.001	164	50.3	34	45.3	0.437
Legumes	56	41.2	147	56.3	4	100	0.002	163	50.0	44	58.7	0.176

Food groups	Low MDS-P		Medium MDS-P		High MDS-P		*P*	Without GDM		With GDM		*P*
	N	%	N	%	N	%		N	%	N	%	
Cereals et starches	133	97.8	259	99.2	4	100	0.459	322	98.8	74	78.7	0.940
Fish and Sea Food	35	25.7	146	55.9	4	100	<0.001	148	45.8	37	49.3	0.538
Meat and meat products	79	58.1	223	85.4	4	100	<0.001	245	75.2	61	81.3	0.256
Milk and dairy products	68	50.0	220	84.3	4	100	<0.001	232	71.2	60	80	0.121
MUFA/SFA	37	27.2	164	62.8	4	100	<0.001	172	52.8	33	44.0	0.171
Iron (mg/d)	0	0.0	21	8.0	2	50	<0.001	19	5.8	4	5.3	0.868
Folic Acid (µg/d)	3	2.2	57	21.8	2	50	<0.001	49	15	13	17.3	0.619
Calcium (mg/d)	3	2.2	24	9.2	1	25	0.013	23	7.1	5	6.7	0.905

MDS-P: Mediterranean Diet Adherence Score in Pregnant Women; the continuous variables represented as mean ± SD, the qualitative variables represented in number and percentage, one-factor ANOVA test, Student's t test and the Chi2 test. The degree of significance is less than 0.05.

Association of nutritional intake with Mediterranean diet adherence score in pregnant women (MDS-P) and gestational diabetes

Table 3 shows that energy intake was significantly correlated with the Mediterranean diet adherence score $P<0.001$ and that it is significantly different in diabetic pregnant women compared to non-diabetic pregnant women $P=0.048$. For the other nutrients, no significant differences were found between the intakes of women with or without diabetes $P>0.05$. On the other hand, the nutrient intakes were significantly associated with MDS-P in most cases.

Table 3

Nutrient intakes according to MDS-P categories and GD in pregnant women

Nutrient intakes	MDS-P	MDS-P categories						*P*	Without GD 326(81.3%)		With GD 75(18.7%)		*P*
	p	Low		Medium		High							
		M	SD	M	SD	M	SD		M	SD	M	SD	
Energy (kcal/d)	<0.001	1781	486	1935	525	2057	421	0.015	1860	517	1990	497	0.048
Proteins (g/d)	0.192	55.1	17	58.1	36	60.1	18	0.648	56.8	33	58.4	18	0.681
Proteins (%)	0.006	12.5	3.2	11.5	2.7	11.6	2.5	0.006	11.9	3	11.7	2	0.606
Carbohydrates (g/d)	<0.001	253.9	73	277.7	74	304.8	88	0.007	267	74	282	75	0.101
Carbohydrates (%)	0.437	57.4	8.7	58.2	8.4	58.5	5.4	0.692	58	8.6	57.4	7.9	0.574
Lipids (g/d)	0.003	60.6	25	66.5	28	66.4	10	0.117	63.4	27	69.1	26	0.103
Lipids (%)	0.853	30	8.7	30	8.4	29	7	0.963	30	8.5	30.8	8.3	0.450
CT (mg/d)	0.508	176	216	130	192	66.5	54	0.069	146.1	205	143.4	184	0.915
SFA (%)	<0.001	30.7	9.2	25.8	7.9	23.5	4.8	<0.001	27	8.2	29.3	10.1	0.070
MUFA (%)	<0.001	44.9	10	50.2	10	55.6	6.6	<0.001	48.7	10.9	47.4	10.7	0.366
PUFA (%)	0.723	24.3	13	23.8	11	20.8	10.6	0.810	24.2	12.3	22.9	12.3	0.433
Vitamin C (mg/d)	<0.001	24	26	36.5	32	95.5	35	<0.001	33.6	33	29.4	26.9	0.309
Magnesium (mg/d)	0.004	218	87	236	104	258	46	0.190	227.9	98.5	241.6	99.8	0.278
Vitamin E (mg/d)	0.037	3.3	2.1	4.9	7.6	4.9	1.5	0.057	4.4	6.9	4.2	2.6	0.744
Iron (mg/d)	<0.001	8.1	3.1	11.9	11.8	17.9	8.3	<0.001	10.4	9.5	11.7	11.6	0.312
Folic Acid (µg/d)	<0.001	177	49	207	64	279	84	<0.001	198	62.2	197.8	61.5	0.937
Calcium (mg/d)	0.015	376	209	404	252	575	289	0.171	391.4	245.1	420.1	212.9	0.351
Fiber (g/d)	0.004	13.9	8.8	16.3	11.4	16.9	10.3	0.111	15.28	10.6	16.5	10.4	0.341

MDS-P: Score of adherence to MD in pregnant women; continuous variables presented as mean ± SD, Correlation test; One-way ANOVA test and Student's t test. The threshold of significance is set at *P* value <0.05.

Discussion

The Mediterranean diet is a dietary model integrating a lifestyle that includes an interaction of specific foods, health, culture and people. It is a model of sustainable diet. However, its sustainability is questioned today as it is declining in the Mediterranean basin. This fact emphasizes the change in the way of eating in the Mediterranean countries leading to the emergence of health problems associated to overweight and obesity.

In this study, the pregnant women diet is characterized by a high consumption of cereals and starchy foods (98.8%), meat (76.5%), milk and dairy products (72.8%), an average consumption of legumes (51.6%), vegetables (49.4%), fish (46.1%), and low consumption of fruit (27.9%). Concerning micronutrients in the food consumed, the monounsaturated fatty acid to saturated fatty acid ratio was (51.1%) while it was very low for iron (5.7%); folic acid (15.3%); Calcium (6.9%). The traditional Mediterranean diet is characterized by a high consumption of whole grains, legumes, vegetables, fruits and nuts, low to moderate consumption of dairy products, low consumption of meat and poultry and moderate consumption alcohol during meals, a high consumption of olive oil and low consumption of saturated fatty acids (SFA) (Trichopoulou, Costacou, Bamia & Trichopoulos, 2003). The comparison of the present study sample diet to the traditional MD highlights the imbalance concerning the consumption of the food groups of milk and dairy products, meat and meat products and saturated fatty acids in addition to low contents in micronutrients whose deficiency is widespread in most Moroccan women (Mahjoub, Gammoudi, Amrouche, Lahmar, Chouchéne, Gaigi & Blouza, 2010; Mziwira, Ayachi, Lairon, & Belahsen, 2015; Ouzennou, Tikert, Belkedim & Jarhmouti, 2018).

Data on adherence to the Mediterranean diet revealed low MDS-P in 33.9%, medium in 65.1%, and high in 1% of the pregnant studied women. These results reflect the nutritional balance status and the evolution of pregnancy in this population category. Furthermore, in their study, Mziwira, El ayachi, Lairon & Belahsen (2015) reported a change in the dietary habits of the Moroccan population compared to the Mediterranean recommendations and drew attention to the need to promote people's adherence to the traditional Mediterranean diet in the goal of providing them with an adequate nutritional intake (Mziwira, El ayachi, Lairon & Belahsen, 2015).

The present data found also that the socio-economic level of the study sample, was significantly associated with the MDS-P P=0.020. Indeed, in this population the increased standard of living is associated with a negative influence on the adherence to the Mediterranean diet. This result could be explained by some factors such as: the emergence of globalization, the economic development and the urbanization which would have led to changes in dietary habits (Belahsen, 2014; Barakat, Chamlal, El Fane, El-Jamal, El ayachi & Belahsen, 2022). In fact, food choices were influenced by the individual, cultural, social, economic and environmental factors. In contrast, the unhealthy eating habits not only affect the low-income people, but are also widespread in high-income populations (Drewnowski & Kawachi, 2015; Maillot, Vieux, Delaere, Lluch & Darmon, 2017).

Certainly, the Mediterranean diet is considered one of the healthiest and a sustainable dietary patterns and a strong adherence to this diet has been shown to be linked to several benefits upon the health and environment, including the reduced obesity, the protection against diabetes and the cardiovascular problems (Bouzas, Bibiloni, Julibert, Ruiz-Canela, Salas-Salvadó, Corella, Zomeño, Romaguera, Vioque, Alonso-Gómez, Wärnberg, Martínez, Serra-Majem, Estruch, Tinahones, Lapetra, Pintó, García Ríos, Bueno-Cavanillas &Tur, 2020), it is also respectful towards the environment (Serra-Majem, Tomaino, Dernini, Berry, Lairon, Ngo de la Cruz, Bach-Faig, Donini, Medina, Belahsen, Piscopo, Capone, Aranceta-Bartrina, La Vecchia & Trichopoulou, 2020). However, while the consumed food groups and the nutrients intakes were significantly associated with MDS-P, they are not associated with GD incidence. In this

study population, MDS-P was not associated with GD. This result reveals that the adherence to the Mediterranean diet in pregnancy could protect the women against gestational diabetes.

Study Limitations

Challenges in maintaining follow-up with postpartum patients, particularly those from the rural areas, where access to healthcare services may be limited.

Significant loss to follow-up the women patients, which hinders comprehensive data collection and continuity of care.

Conclusions

In Morocco, despite progress in public health, gestational diabetes remains a major challenge in the context of the epidemiological and nutritional transitions. Improved education and the adoption of the Mediterranean diet among pregnant women are the recommended solutions in order to prevent this condition and promote a healthy fetal development.

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Competing interests
The authors declare no competing interests.

Consent to participate
Informed written consent was obtained from each participant at the time of recruitment. The subjects were informed that they could withdraw from the study at any stage, and they were assured of confidentiality.

Author Contributions: all the authors contributed to the design, the execution of the work, the interpretation of the data and the writing of this article.

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