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ORIGINAL ARTICLE

Relation of the Mediterranean diet with the incidence of gestational diabetes

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BACKGROUND/OBJECTIVES: Some studies document relationships of the incidence of gestational diabetes mellitus (GDM) with individual components of the diet, but studies exploring relationships with patterns of eating are lacking. This observational study aimed to explore a possible relationship between the incidence of GDM and the Mediterranean diet (MedDiet) pattern of eating.
SUBJECTS/METHODS: In 10 Mediterranean countries, 1076 consecutive pregnant women underwent a 75-g OGTT at the 24th–32nd week of gestation, interpreted both by the ADA_2010 and the International Association of the Diabetes and Pregnancy Study Groups (IADPSG)_2012 criteria. The dietary habits were assessed by a previously validated questionnaire and a Mediterranean Diet Index (MDI) was computed, reflecting the degree of adherence to the MedDiet pattern of eating: a higher MDI denoting better adherence.
RESULTS: After adjustment for age, BMI, diabetes in the family, weight gain and energy intake, subjects with GDM, by either criterion, had lower MDI (ADA_2010, 5.8 vs 6.3, $P=0.028$; IADPSG_2012, 5.9 vs 6.4, $P<0.001$). Moreover, the incidence of GDM was lower in subjects with better adherence to the MedDiet (higher tertile of MDI distribution), 8.0% vs 12.3%, OR = 0.618, $P=0.030$ by ADA_2010 and 24.3% vs 32.8%, OR = 0.655, $P=0.004$ by IADPSG_2012 criteria. In subjects without GDM, MDI was negatively correlated with both fasting plasma glucose and AUC glucose, $P<0.001$ for both.
CONCLUSIONS: Adherence to a MedDiet pattern of eating is associated with lower incidence of GDM and better degree of glucose tolerance, even in women without GDM. The possibility to use MedDiet for the prevention of GDM deserves further testing with intervention studies.

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INTRODUCTION

Gestational diabetes mellitus (GDM) confers significant risks for the mother, the foetus and the newborn, while appropriate therapeutic interventions during pregnancy may decrease these risks.[1] Prevention is always better than treatment and in this context recognising factors associated with the development of GDM could possibly help to diminish its incidence and its consequences. Nutritional factors are associated with an increased predisposition for the development of type 2 diabetes (DM2); however, the relationship between nutritional parameters and the development of GDM remains elusive and conflicting.

High energy intake leading to obesity is associated with increased incidence of DM2;[2] however, there is still controversy regarding the role of the qualitative composition of the diet in the development of glucose intolerance.[3,4] Cross-sectional and follow-up studies show either no association or an association with some individual nutrients, that is, negative with vegetable fat or fibre and positive with total or animal fat.[5–13] Intervention studies show that high carbohydrate (CHO) and high monounsaturated fat diets improve insulin sensitivity and glucose disposal.[14] The large prospective DM2 prevention studies show that energy intake restriction with the accompanying weight loss, decrease of total and saturated fat intake, increase of vegetables and fibre intake and exercise reduce the incidence of DM2 in subjects with impaired glucose tolerance. However, the contribution of each individual intervention in these studies was not assessed.[3,15,16]

Regarding the relation of GDM with nutritional factors, the findings of various studies are conflicting. A positive correlation between GDM incidence and saturated fat intake, including cholesterol and egg intake, has been described,[17–19] while a further association was noted with a combination of higher intake of fat and lower intake of CHO.[20] The role of fibre seems controversial, as in two studies high intake of fibre is associated with lower risk of GDM, while in another two studies such association is absent.[17,21–23] A prospective study shows that high glycaemic load increases the risk of GDM.[23] The type of fat seems

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to be important, as polyunsaturated fat decreases, while saturated fat increases the risk of GDM.[17,21]

The role of the pattern of eating and specifically of the Mediterranean type of diet in the development of GDM has not yet been explored. The present study, carried out within the context of the 'Gestational Diabetes in the Mediterranean Region Study', sponsored by the Mediterranean Group for the Study of Diabetes (MGSD), investigates the association of the Mediterranean Diet (MedDiet) with the incidence of GDM in Mediterranean countries.

SUBJECTS AND METHODS

This is a prospective, observational, non-interventional, multicentre study, performed in 10 centres, in 10 Mediterranean countries, namely Algeria, France, Greece, Italy, Lebanon, Malta, Morocco, Serbia, Syria and Tunisia. All participating centres were hospital-based obstetric departments caring for non-selected populations of pregnant women.

Assuming an incidence of GDM 5–15%, the number of subjects needed to give adequate power to the study was 900; thus we aimed to recruit at least 100 subjects at each centre. In total, 1076 consecutive pregnant women were studied between 1 January 2010 and 31 July 2011. Women with a known history of diabetes (type 1, type 2 or MODY) in the non-pregnant state were excluded from the study, although a history of previous GDM was not an exclusion criterion. All other pregnant women, in whom an OGTT was performed, were included in the study. The management and interventions were done according to the protocols of each individual centre.

An OGTT was performed during the 24th–32nd week of gestation, with 75 g of glucose. Venous plasma glucose was measured, fasting, 1 and 2 h after the glucose load. Diagnostic cutoff points were defined as: fasting $\geqslant$5.3, 1-h $\geqslant$10.0 and 2-h $\geqslant$8.6 mm/l. The diagnosis of GDM required two or more of the cutoff points to be met or exceeded according to the American Diabetes Association (ADA) 2010 guidelines.[24] Furthermore, the OGTT was also assessed by the recent criteria of the International Association of the Diabetes and Pregnancy Study Groups (IADPSG), which had not been published at the time the study was performed.[25] According to these, the cutoff points are set at: fasting $\geqslant$5.1, 1 h $\geqslant$10.0 and 2 h $\geqslant$8.5 mm/l. One glucose value equal to or above any cutoff point is enough for the diagnosis of GDM. The area under the glucose curve (AUC) during the OGTT was calculated by the trapezoid method. Both total and incremental areas were calculated.

The dietary habits were assessed by a dietary history method that has been used and validated in previous studies in the Mediterranean region.[26] A dietary questionnaire comprising 78 questions was administered by a specially trained person (dietician, nurse or physician). The questions referred to the daily or weekly consumption of various foodstuffs or groups of foodstuffs, before the OGTT was performed and any dietary intervention was done. Estimation of the amounts consumed was based on common household measures. The questionnaires were centrally analysed with a specially constructed computer program. Each participating centre provided information regarding the composition of local foodstuffs. Total CHO intake was further divided into starch and sugars (mono- and di-saccharides) intake. Total fat intake was also further divided into fat of animal or plant origin. The ratio of plant to animal fat intake was calculated. Alcohol intake was zero in 881 participants from the 1003 participants of the study, less than 1 ml/day in 66 and 1–5 ml/day in the remaining 56. Thus, alcohol could not be included in the analysis of the data.

The dietary questionnaire has been previously validated in 104 subjects from eight Mediterranean countries in comparison with the 3 Day Diet Diary (3DDD), which is considered the reference method for the assessment of dietary habits.[27] Dietary intakes, as calculated by both methods, were compared by Student's *t* test and Pearson's bivariate correlation.[26] The mean values were not different by the Student's *t*-test, except for CHO and fibre, which were higher by the questionnaire. The correlation coefficients (*r*-values) between the various macronutrient intakes measured by each assessment method were: 0.3630 for CHO, 0.4520 for protein, 0.6140 for fat and 0.6270 for energy intake, $P<0.001$ for all. These values are better than those of a recent comparison of a food frequency questionnaire and 10 days of food record intakes in pregnant women, where the corresponding *r*-values were: 0.4900, 0.5500, 0.4800 and 0.2400.[28]

The nutrient intake was compared among eight Mediterranean countries and no differences were found. Certain foodstuffs were used in some but not other countries (that is, couscous, bulgur), but their nutrient composition was known and, moreover, they could be incorporated into major foodstuff groups (cereals, etc). Thus, the combined analysis of data from all centres is justified in the present study.

The questionnaires were also analysed according to foodstuff categories, as described in the MedDiet Pyramid, in order to evaluate the degree of adherence to the Mediterranean type of diet.[29] In order to evaluate the degree of adherence to the MedDiet pattern of eating, various Mediterranean Diet Indices (MDIs) have been invented, which express arithmetically the adherence to this pattern. For this purpose, in the present study we calculated a MDI by scoring according to the consumption of various foodstuffs, in a way that the higher the score the greater the adherence.[30] We used 12 food groups, as defined in the first publication of the seven-country study (bread, cereals, legumes, vegetables, fruits, meat, fish, eggs, the ratio of olive oil to animal fat, potatoes, cheese and dairy products).[31] We calculated the median intake for each group and for each subject we scored 1 if the intake was above the median for the healthy foods (that is, vegetables, legumes and so on) or below the median for the less healthy foods (that is, meat, eggs and so on).[30]

Statistics

Data are presented as mean + s.e.m., compared by Student's *t*-test. As age, BMI and the presence of diabetes in parents or siblings (family history), known risk factors for the development of diabetes, differed between the GDM-positive and GDM-negative subjects, all further comparisons were done after adjustment for age, BMI and family history. Adjustments were also done for energy intake and body weight gain during pregnancy, where appropriate. To avoid multiplicity errors, all *P*-values were adjusted for multiple comparisons according to Bonferroni. Continuous variables with skewed distribution were log-transformed before statistical analysis. A model of binary logistic regression was used for evaluation of the relation of GDM incidence with those factors that differed significantly in the univariate analysis. Categorical variables were evaluated with the χ^2 test, Yate's correction. All statistical tests were two-tailed and a *P*-value$\leqslant$0.05 was considered significant. The statistical analysis was performed with the SPSS statistical package, version 17.1 (Chicago, IL, USA).

RESULTS

From the 1076 subjects who participated in the study, 73 were excluded from further analysis, as anthropometric, biochemical or nutrition data were incomplete.

The incidence of GDM was 9.5% by the ADA 2010 criteria (GDM_ADA) and 29.0% by the new criteria of the IADPSG (GDM_IADPSG). Comparing GDM-positive with GDM-negative subjects, using raw data, Table 1, we found significant differences for age, BMI and family history, which were higher in the GDM-positive (by either criterion) subjects, and also for energy intake and weight gain during pregnancy, which were higher only in GDM_IADPSG-positive subjects. Therefore, all further analysis was done after adjustment for age, BMI, family history, weight gain, energy intake and multiple comparisons.

The contribution of total fat intake to the energy intake was higher in both GDM_ADA-positive subjects (34.6% vs 33.0%, $P<0.05$) and GDM_IADPSG-positive subjects (34.8% vs 32.5%, $P<0.001$).

The comparison of various foodstuffs and foodstuff groups, as originally described in the seven-countries study,[31] in relation to the concept of the MedDiet, between GDM_ADA and GDM_IADPSG-positive and GDM_ADA and GDM_IADPSG-negative subjects, is shown in Table 2. Cheese and olive oil intake was higher, both in the GDM_ADA-positive subjects ($P=0.031$ and $P=0.003$) and in the GDM_IADPSG-positive subjects ($P<0.001$). On the contrary, potatoes and cereal (cereals + rice + pasta + bread) intake was lower, both in the GDM_ADA-positive ($P=0.030$ and $P=0.042$) and GDM_IADPSG-positive subjects ($P=0.006$ and $P<0.001$). Furthermore, the MDI, a measure of adherence to the MedDiet, was significantly lower (poor adherence) in the GDM_ADA- and GDM_IADPSG-positive subjects in comparison

Table 1. Comparison of various parameters between subjects with and without GDM by ADA and IADPSG criteria

	GDM_ADA negative	P *(two-tailed)*	*GDM_ADA positive*	*GDM_IADPSG negative*	P *(two-tailed)*	*GDM_IADPSG positive*
Age	29.9 + 0.1	0.001	31.9 + 0.5	29.6 + 0.2	<0.001	31.5 + 0.3
BMI	24.4 + 0.2	0.001	26.7 + 0.6	24.2 + 0.2	<0.001	25.8 + 0.3
family history (%)	26.8	0.026	38.5	24.0	<0.001	38.1
BW gain (kg)	9.2 + 0.2	0.729	9.3 + 0.7	9.0 + 0.2	0.017	9.9 + 0.3
Height (cm)	1.62 + 0.2	0.212	1.61 + 0.7	1.62 + 0.2	0.503	1.62 + 0.4
(kcal/day)	2449 + 28	0.050	2271 + 80	2492 + 32	<0.001	2287 + 43
CHO (g/day)	305.2 + 3.7	0.027	278.4 + 11.3	313.0 + 4.3	<0.001	278.0 + 6.0
Protein (g/day)	102.8 + 1.4	0.061	94.2 + 4.1	104.7 + 1.7	0.002	95.5 + 2.2
Fat (g/day)	90.6 + 1.2	0.328	86.7 + 3.4	91.2 + 1.4	0.213	88.0 + 1.9
CHO % energy	49.9 + 0.2	0.111	48.6 + 0.9	50.4 + 0.28	<0.001	48.2 + 0.45
Protein %energy	16.8 + 0.1	0.576	16.6 + 0.4	16.8 + 0.13	0.942	16.8 + 0.21
Fat % energy	33.2 + 0.2	0.047	34.8 + 0.9	32.8 + 0.26	<0.001	34.9 + 0.44

Abbreviations: BMI, body mass index; BW, body weight; CHO, carbohydrate; GDM_ADA, ADA 2010 criteria for the diagnosis of GDM; GDM_IADPSG, IADPSG criteria for the diagnosis of GDM.

Table 2. Comparison of the intake of various foodstuffs and the Mediterranean Diet Score between subjects with and without GDM by ADA and IADPSG criteria[a]

Daily intake (g/day)	*GDM_ADA negative*	P *(two-tailed)*	*GDM_ADA positive*	*GDM_IADPSG negative*	P *(two-tailed)*	*GDM_ IADPSG positive*
Dairy	411.6 ± 10.2	0.711	386.6 ± 31.8	406.8 ± 11.3	0.547	388.4 ± 17.8
Cheese	36.1 ± 1.2	0.031	42.7 ± 3.9	33.2 ± 1.4	<0.001	44.3 ± 2.2
Olive oil	14.1 ± 0.5	0.003	19.9 ± 1.5	13.8 ± 0.5	<0.001	17.7 ± 0.8
Vegetables	325.4 ± 7.3	0.607	336.4 ± 22.7	323.5 ± 8.1	0.705	307.8 ± 12.7
Legumes	43.7 ± 2.1	0.791	40.9 ± 6.7	45.7 ± 2.4	0.701	35.9 ± 3.7
Fruits	436.8 ± 12.1	0.226	485.7 ± 37.7	426.5 ± 13.3	0.257	446.6 ± 20.9
Potatoes	87.8 ± 2.6	0.030	81.3 ± 8.2	90.9 ± 2.9	0.006	76.0 ± 4.6
Cereals[b]	265.7 ± 5.4	0.042	229.3 ± 16.7	274.7 ± 5.8	<0.001	223.5 ± 9.1
Meat	134.2 ± 3.0	0.946	131.9 ± 9.6	135.0 ± 3.4	0.711	127.4 ± 5.3
Eggs	12.0 ± 0.4	0.402	12.0 ± 1.4	11.9 ± 0.5	0.105	12.2 ± 0.8
Fish	38.7 ± 1.4	0.137	31.2 ± 4.4	40.4 ± 1.5	0.056	29.6 ± 2.4
Sugar	45.3 ± 1.4	0.052	39.1 ± 4.3	46.7 ± 1.5	0.001	38.6 ± 2.4
MedDiet score	6.3 ± 0.1	0.028	5.8 ± 0.2	6.4 ± 0.1	<0.001	5.9 ± 0.1

Abbreviations: GDM_ADA, ADA 2010 criteria for the diagnosis of GDM; GDM_IADPSG, IADPSG criteria for the diagnosis of GDM; MedDiet, Mediterranean diet. [a]Values are mean ± s.e.m. Comparisons were adjusted for age, body mass index, family history of diabetes, weight gain during pregnancy, energy intake and multiple comparisons (Bonferroni). [b]Cereals + pasta + rice + bread, as originally described in the seven-countries study.

with the GDM_ADA- and GDM_IADPSG-negative subjects ($P = 0.028$ and $P < 0.001$, respectively).

In Table 3 the indices of the degree of glucose tolerance during the OGTT are compared between the lower tertile (poor adherence) and the upper tertile (good adherence) of the MDI. Better glucose tolerance is documented in the group with good adherence to the MedDiet, as glucose at 1 h and both total and incremental areas under the glucose curve are lower in this group. Moreover, the incidence of GDM is lower in the upper tertile (good adherence) of the MedDiet Score by 38% ($P = 0.030$) with the GDM_ADA criteria and by 34% ($P = 0.004$) with the GDM_IADPSG criteria.

Indices of the degree of glucose tolerance (fasting, 1-h, 2-h glucose levels, incremental and total area under the glucose curve during the OGTT) showed negative correlation with the MDI ($P < 0.001$). The above correlations remained significant when subjects with GDM were removed from the analysis.

Finally, all parameters that showed a statistically significant correlation with the incidence of GDM in the univariate analysis were entered in a model of binary logistic regression, with dependent variable the development of GDM, by either criterion. Age, BMI and olive oil intake showed positive correlation with the incidence of GDM, while the MDI showed negative correlation, $P < 0.05$ for all associations.

DISCUSSION

The present study has examined the association of nutrient intake, individual foodstuff intake and especially the MedDiet pattern of eating with the risk of GDM. The diagnosis of GDM was based on the results of an OGTT performed with 75 g of glucose, instead of the classical 100 g used in most studies. It was interpreted both by the ADA and the new IADPSG criteria, which are more stringent and require only one abnormal glucose value, instead of two, for the diagnosis. Thus, women with GDM in the present study have less degree of glucose intolerance than those in previous studies.

The association of high total fat intake with the risk of both DM2 and GDM found in many studies[32–34] has been confirmed by our findings.

However, attention has been given to the role of eating patterns and not individual nutrients or foodstuffs in the risk of DM2. Dietary patterns have the advantage of taking into account the complex interactions and cumulative effects of multiple nutrients within the entire diet. Nutrients are not consumed in isolation in everyday life and thus the effect of dietary habits on health is the resultant of the interplay of an array of dietary factors, ranging from the macronutrient to the micronutrient content of the diet, trace elements, antioxidants, and so on. Various epidemiological studies have shown a significant decrease of the incidence of DM2 in subjects adhering to the MedDiet. In a prospective study of a cohort of 1380 university graduates in

Table 3. Comparison of plasma glucose values, total and incremental area under the glucose curve during the OGTT and incidence of GDM between subjects with low (poor adherence) and high (good adherence) Mediterranean Diet Index

	MedDiet Index low (poor adherence) (4.3 ± 0.05)	*MedDiet Index high (good adherence) (8.5 ± 0.05)*	P *(two-tailed)*
Fasting plasma glucose (mmol/l)	4.6 ± 0.1	4.5 ± 0.1	0.169
Plasma glucose 1 h post-load (mmol/l)	8.0 ± 0.1	7.7 ± 0.1	0.016
Plasma glucose 2 h post-load (mmol/l)	6.8 ± 0.1	6.6 ± 0.1	0.066
Incremental glucose area (mmol*min)	270.0 ± 7.8	255.6 ± 5.4	0.034
Total glucose area (mmol*min)	823.1 ± 10.0	793.3 ± 7.0	0.016
Incidence of GDM_ADA	12.3%	8.0%	0.030 Odds ratio = 0.618 CI (0.401–0.950)
Incidence of GDM_IADPSG	32.8%	24.3%	0.004 Odds ratio = 0.655 CI (0.495–0.867)

Abbreviations: CI, confidence interval; GDM_ADA, ADA 2010 criteria for the diagnosis of GDM; GDM_IADPSG, IADPSG criteria for the diagnosis of GDM; OGTT, oral glucose tolerance test.

Spain, the risk of DM2 was decreased by 83% in those following the MedDiet.[35]

In the ATTICA Study, adherence to the MedDiet was associated with lower odds of having DM2.[36] A prospective study in 8291 patients with myocardial infarction showed that after 3–5 years of follow-up the incidence of DM2 was 33% less in those adhering to the MedDiet.[37]

PREDIMED, the only intervention RCT comparing two types of MedDiet, one enriched with extra virgin oil and the other with nuts, with a control diet, over a period of 4 years has shown 50% lower incidence of DM2 in the two intervention groups.[38]

Regarding GDM, only in the Nurses Health Study the pattern of a ‘prudent diet’ (more vegetables, legumes, fruits and poultry) compared with a ‘westernised’ diet, rich in red and processed meat, was associated with less risk of GDM,[39] as was also the case for an alternate MedDiet.[40] However, it must be noted that the diagnosis of GDM in those studies was not done by OGTT but by self-reporting, and that the dietary assessment was done some years before the pregnancy. There are no other studies in the literature examining the relation of dietary patterns and especially MedDiet with GDM.

MedDiet is an eating pattern considered as the prototype of healthy diet and the MedDiet Pyramid is widely accepted as the guide for healthy nutrition. However, the MedDiet Pyramid conveys only a general sense of the relative proportions and frequency of servings of foods and food groups that contribute to this dietary pattern.[29] MDI is a good and validated arithmetic index of the degree of adherence to the MedDiet. Higher values (better adherence) were associated with lower CHD morbidity and mortality in various studies.[30,41,42] However, it has to be stressed that the methods used for the calculation of the MDI differ greatly among studies. The main differences concern the number and kind of foodstuffs considered in the calculation and the way the cutoff points are defined. In this context, the Index used in the PREDIMED study, which has shown a decrease in the incidence of DM2, was quite different from the one we used and has shown a decrease in the incidence of GDM. Pre-defined cutoff points were used in the PREDIMED, whereas in the present study the cutoff point for each food was defined in relation to the median of the intake of all the subjects of the study, as this method has been well validated in studies that examined the relation of MedDiet with CHD and mortality.[27] The differences in the computation of the MedDiet Index among studies make any comparison difficult. However, MedDiet in most studies proves to be beneficial either for DM2 or for CHD prevention. This means that the various methods for computation of the MedDiet Index reflect satisfactorily the adherence to the MedDiet. For the computation of the MedDiet Index, we have chosen to use the food groups described in the seven-country study, except alcohol, as its consumption was practically absent in the population of the study.[31]

We found higher MDI in subjects without GDM compared with those with GDM. Moreover, in subjects without GDM adherence to the MedDiet was associated with better glucose tolerance, as MDI showed negative correlations with all glucose tolerance indices during the OGTT.

The above observations can be considered as evidence of a protective role of the MedDiet against the development of GDM. In support to this hypothesis is the finding of lower incidence of GDM in the upper tertile (good adherence) of the MDI distribution (38% less for GDM_ADA and 34% for GDM_IADPSG). Moreover, in a model of multiple logistic regression, after adjustment for various confounding factors, it was shown that the higher the MDI (good adherence), the lower the incidence of GDM.

MedDiet is the only eating pattern that is associated with lower incidence of CHD, DM2 and as documented in the present study, lower incidence of GDM. However, the mechanisms underlying the protective effects of the MedDiet are not clear. A reduction in circulating inflammatory biomarkers observed in subjects adhering to the MedDiet could be one of the mechanisms, as chronic low-grade inflammation is considered a pathogenetic factor both in CHD and DM2.[43] The high ratio of monounsaturated fatty acids to saturated fatty acids, the low content of trans fatty acids and the high content of fibre, antioxidants, polyphenols and magnesium may contribute to the anti-inflammatory properties of the MedDiet.[44]

The strengths of the present study are: (1) the more accurate diagnosis of GDM, as an OGTT was performed in all participants and not selectively after a screening test; (2) the use of the 75-g OGTT, interpreted by the most recent, more stringent criteria (both the ADA 2010 and the IADSPG 2012), thus diagnosing GDM subjects having less degree of glucose intolerance, in comparison with previous studies; (3) the questionnaire used for the assessment of the dietary habits was administered by specially trained personnel and had been validated by comparison with the 3-Day Diet Diary, widely accepted as the reference method, with absolutely comparable results, although in most studies self-administered questionnaires are used.

The limitation of the study is the collective analysis of data from various populations having in common the ‘Mediterranean Basin’, but differing in ethnicity, socio-economic status, religious practices and everyday habits. Relatively small numbers from each country do not allow analysis of the data by centre and multiple comparisons.

In summary, the present study explored, in Mediterranean populations, associations of individual nutrients, and especially of a MedDiet pattern of eating with the incidence of GDM, diagnosed by a 75-g OGTT, interpreted by the more recent, more stringent, diagnostic criteria.

A new finding is not only the association of the adherence to a MedDiet pattern of eating with lower incidence of GDM, but also with better degree of glucose tolerance in pregnant women without GDM. These results put forward the hypothesis that in pregnancy MedDiet can improve glucose tolerance and decrease to some extent the incidence of GDM, which of course deserves further testing with intervention studies.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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APPENDIX

All participating investigators are listed, by country:

The MGSD-GDM study group was composed of key investigators in each collaborating country, including: Algeria (M Bachaoui, F Kolli, Z Benghanem); France (M Marre); Greece (B Karamanos, E Anastasiou); Italy (A Lapolla, M G Dalfra, A Filippi, A Barison, R Valentini); Lebanon (C Saab); Malta (C Savona-Ventura, J Vassallo, J Craus); Morocco (H El Ghomari, F Louda, H Addi, M Joubij, A Chraibi); Serbia (A Jotic, N M Lalic, A Ljubic, M Gojnic, T Milicic, L Lukic, J Seferovic, M Macesic); Syria (N Albache, A Jalek, K Kebbewaer, M Albache); and Tunisia (C Ben Slama).