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Adherence to the Mediterranean diet during pregnancy is associated with lower odds of excessive gestational weight gain and postpartum weight retention: results of the Mother-Infant Study Cohort

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Abstract

During the first 1000 d of life, gestational weight gain (GWG) and postpartum weight retention (PPWR) are considered critical determinants of nutritional status. This study examined the effect of adherence to the Mediterranean diet (MD) during pregnancy on GWG and PPWR at 2 and 6 months among women in the United Arab Emirates (UAE), using data from the Mother-Infant Study Cohort. The latter is a prospective study, for which pregnant women were recruited (*n* 243) during their third trimester and were followed up for 18 months. Data on socio-demographic characteristics and anthropometric measurements were obtained. An eighty-six-item FFQ was used to examine dietary intake during pregnancy. Adherence to the MD was assessed using the alternate MD (aMED) and the Lebanese MD (LMD). Adherence to the MD, $PPWR_2$ (2 months) and $PPWR_6$ (6 months) were considered high if participants belonged to the third tertile of the respective measures. Results indicated that 57·5 % of participants had excessive GWG while 50·7 % and 45 % retained ≥ 5 kg at 2 and 6 months postpartum, respectively. After adjustment, adherence to both MD scores was associated with lower odds of excessive GWG (aMED, OR:0·41, 95 % CI:0·18, 0·93; LMD, OR:0·40, 95 % CI: 0·16, 0·98). Adherence to MD was also associated with $PPWR_2$ (aMED: OR: 0·23, 95 % CI: 0·06, 0·88) and $PPWR_6$ (aMED OR:0·26; 95 % CI:0·08–0·86; LMD, OR:0·32; 95 % CI: 0·1, 0·98). The findings of this study showed that adherence to the MD may reduce GWG and PPWR and, hence, underscored the importance of promoting the MD for better health of the mother and infant.

Key words: **Mediterranean diet: Gestational weight gain: Gestational weight retention: Dietary intake: Cohort: United Arab Emirates**

During the first one thousand days of life, from conception until the end of the second year, adequate nutritional status has been shown to be critical for both maternal health as well as optimal child's growth, development and health later in life[1–3]. Among indicators for nutritional status, accumulating evidence suggested that excessive gestational weight gain (GWG) is a risk factor for many adverse pregnancy outcomes such as gestational diabetes mellitus (GDM), pre-eclampsia, gestational hypertension, depression and cesarean birth[4,5]. The negative consequences of excessive GWG seem to reach beyond the period of pregnancy and contribute to transgenerational obesity. For instance, women who exceed the recommended weight gain during pregnancy are more likely to enter the next pregnancy with a higher BMI, to deliver heavier babies, who in turn may have higher odds to become overweight or obese adults later in life[6,7]. GWG was also found to be a strong determinant to postpartum weight retention (PPWR)[8–10], the latter postulated to affect the long-term weight trajectory in women of

Abbreviations: aMED, alternate MD; GWG, gestational weight gain; LMD, Lebanese MD; MISC, Mother and Infant Study Cohort; MD, Mediterranean diet; PPWR, postpartum weight retention; UAE, United Arab Emirates.

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childbearing age hence increasing the risk of overweight and obesity[11,12]. Together excessive GWG and PPWR constitute potential risk factors for obesity-related disorders including insulin resistance, metabolic syndrome and cardiovascular diseases[13–15]. In view of such adverse effects of excessive GWG and PPWR on the health of the mother and child, prevention programmes and public health nutrition interventions were geared towards the promotion of adequate weight gain during gestation[16]. To that end, such interventions mainly targeted lifestyle behaviours and dietary patterns during pregnancy as these were shown to be important modifiable risk factors directly linked to GWG and PPWR[17,18].

Amongst the various dietary patterns, the Mediterranean diet (MD) has been heralded as one of the healthiest diets in the world[19]. This pattern reflects the eating habits of populations living in countries located around the Mediterranean basin[20]. Despite variations in what foods/ food groups constituted a typical MD, such a pattern is generally characterised by high intakes of fruits, vegetables, whole grains, olive oil and legumes; moderate to high consumption of fish; a limited amount of red meat and processed meat and red wine[21]. Available evidence indicated a multitude of health benefits of the MD including lower risk of obesity[22], diabetes and associated metabolic abnormalities[23], preventions of certain cancers[24] and more recently a decrease in the risk of mental disorders, including cognitive decline and depression[25]. Among the health benefits cited for the MD are those related to pregnancy outcomes and the health of mother and child. More specifically, a higher adherence to the MD was associated with the prevention of GDM[26,27], decreasing the risk of compromised fetal growth, prematurity, neural tube defects, asthma, allergy as well as a decrease in the cardio-metabolic risks for both mother and child[28,29]. Pregnancy has been considered as a physiological low-grade systemic inflammatory status with the placenta producing a range of inflammatory cytokines[30]. The protective effect of the MD against metabolic abnormalities during pregnancy could be due to the fact that this pattern is rich in antioxidants nutrients (vegetables and fruits) or antioxidant phenols (olive oil and red wine). Further, these antioxidant compounds render adherence to MD to be inversely associated with inflammatory markers (interleukin-6, tumor necrosis factor-α and C-reactive protein)[31]. This aspect of the MD is speculated to protect against gestational metabolic disorders and improve maternal health and neonatal outcomes[32]. In addition, a few studies have addressed the association of adherence to the MD during pregnancy with GWG and PPWR, and their results suggested a protective effect of this dietary pattern[33–35]. It is important to note that these studies were carried out among women living in various countries in Europe; therefore, their findings may not be directly extrapolated to other contexts and settings such as countries of the Middle East.

Following the discovery of the oil, the United Arab Emirates (UAE), similar to many Gulf Cooperation Council countries in the Middle East, experienced rapid economic growth that precipitated drastic shifts in diet and lifestyle habits[36,37]. Such shifts were characterised by increased consumption of energy-dense, high fat and high sugar foods coupled to high rates of sedentary and physical inactivity. Concomitant to these lifestyle changes are surging rates of obesity and non-communicable diseases in the Gulf Cooperation Council countries[38–41]. A cross-sectional study of 3064 adults, in the UAE, showed that the prevalence of overweight and obesity were 43·0 and 32·3 %, respectively, with women having significantly higher obesity rates than males (36·5 % *v.* 31·4 %)[42]. This alarming situation calls for evidence-based and culture-specific interventions aiming to prevent obesity, especially among women. In this context, GWG and PPWR seem to present plausible targets especially among women of childbearing age. In the UAE, limited evidence existed on GWG, PPWR and their associated factors.

Given the significant adverse effects of excessive GWG and PPWR on maternal and child health and the potential protective effect of the MD, this study aims to explore the associations of the MD with GWG and PPWR among women in the UAE. Using data from a prospective 2-year mother and child nutrition cohort conducted in the UAE (the Mother and Infant Study Cohort (MISC)[43], the specific objectives of this study are to (1) examine adherence to the MD during pregnancy, (2) characterise GWG and PPWR and (3) investigate the associations between adherence to the MD during pregnancy with GWG and PPWR.

Materials and methods

Study design

This work was part of the Mother and Infant Study Cohort (MISC) in the UAE. Details about the protocol and data collection of this cohort were described elsewhere[43,44]. The MISC cohort was a 2-year longitudinal prospective study, during which pregnant women were recruited in their third trimester, between December 2015 to December 2017. Over the duration of the study, data collection was conducted at six time points (visits): third trimester, at delivery and 2, 6, 12 and 18 months postpartum. The protocols used in the MISC cohort were reviewed and approved by the Research Ethics Committee, University of Sharjah (REC/14/01/1505) and by Al Qassimi Clinical Research Centre Ethical Research Committee (REC Reference Number: 215 12015–03), by the Ministry of Health Ethical Research Committee(R02) and by Dubai Health Authority (DSREC-0/ 2016). Moreover, the protocol of the research study was registered at ClinicalTrials.gov, identifier # NCT03578094. All MISC participants provided a written signed consent form. Subjects were reassured of anonymity and confidentiality, that they can withdraw at any time and that their participation in this study/ lack of will not affect their medical care.

For the purpose of this study, data were used from the following time points: visit 1 (third trimester, after the 27th week of gestation, *n* 243), visit 2 (hospital medical records, *n* 243), visit 3 (2 months postpartum, *n* 150) and visit 4 (6 months postpartum, *n* 131).

Study population

Subjects were recruited using a convenient sampling approach by trained research assistants from three main public governmental hospitals and were followed up in seven Primary Health Care clinics and Mother and Child Centers in the Emirates of Sharjah, Dubai and Ajman. To be eligible to

participate, women aged 19 to 40 years and pregnant during their third trimester, with a singleton, and not suffering from any chronic conditions.

Study protocol and data collection

During visit 1, information about the following characteristics was collected: age (in years), nationality (Emirati or Arab), occupation (employed *v.* housewife), education (intermediate or less, high school/technical diploma and university), parity (primiparous *v.* multiparous), income (< 10 000 Arab Emirates Dirham (AED) or ≥ 10 000 AED), presence of GDM, number of children (0, 1 or 2, > 2), maternity Leave (49 d (~ 1·5 months), 70 d (~ 2·5 months), > 3 months, Do not know/not applicable. From the medical charts of the participants (visit 2), information regarding pre-pregnancy weight (kg), gestational age (weeks), weight at delivery (kg) and GDM (yes, no) were obtained. For the diagnosis of GDM, the National Institute for Health and Care Excellence Diabetes in Pregnancy criteria were used[45]. At visit 3 (2 months postpartum) and visit 4 (6 months postpartum), mothers were asked whether their infants were breast-feeding (yes, no). During these two visits (3 and 4), the height and weight of the mother were obtained following standard protocols, using Seca 220 Telescopic Measuring Rod for Column Scales. Measurements were recorded to the nearest 0·1 cm and 0·1 kg for height and weight, respectively.

GWG was calculated as the difference between the pre-pregnancy weight of the mother and the last weight recorded before delivery, both of which were extracted from the medical records. GWG was classified into three categories (insufficient, adequate or excessive) taking into account the participants' prepregnancy BMI as specified by the Institute of Medicine in 2009[46]. Gestational weight gain rate (GWGR, kg/week) is defined as the rate of weight gain per week following week 12 of gestation[46]. Given that, in this study, there was no information available regarding weight gain at 12 weeks, it was assumed that women have gained 1 kg during their first trimester. This assumption was based on the Institute of Medicine weight gain recommendation of 0·5–2 kg over the first trimester[46]. Accordingly, the GWGR was calculated using the pre-pregnancy weight, gestational age and weight before delivery, as per the following equation:

$$\text{GWGR} = \frac{(\text{weight before delivery (kg)} - 1) - \text{pre pregnancy weight (kg)}}{\text{gestational age (weeks)} - 12}$$

PPWR at 2 months ($PPWR_2$, kg) was calculated as the difference between the mother's weight measured at visit 3 (2 months postpartum) and pre-pregnancy weight (kg) (*n* 150). Similarly, PPWR at 6 months postpartum ($PPWR_6$, kg) was calculated as the difference between the weight obtained at visit 4 (6 months postpartum) and pre-pregnancy weight (kg) (*n* 131).

Assessment of dietary intake

Maternal dietary intake was examined during the third trimester (at visit 1), using a culture-specific semi-quantitative FFQ. The FFQ assessed habitual intake over the three months prior to visit 1. Within the FFQ, the food list consisted of eighty-six items and included single food items as well as composite (mixed) traditional recipes. Subjects were asked to indicate the number of times each food item was consumed either per day, per week, per month or never. In order to estimate the portion size, the participants were asked to estimate the amount of the food eaten either in grams or in comparison with reference portion sizes listed for each item. A two-dimensional visual aid[47] as well as pictures of common household measures, measuring cups and spoons were also used to assist the participants in estimating the portion size[48]. The indicated frequency of each consumed food and beverage was converted to daily intake. The food composition database of the Nutritionist Pro. software (Axxya Systems LLC, Sta_ord) was then used to compute the total energy intakes of participants. A copy of the FFQ used in this study is presented in appendix A.

Mediterranean diet scores

In order to examine the adherence of study participants to the MD, scores for two MD indexes were calculated: the alternative Mediterranean Diet (aMED) and the Lebanese Mediterranean Diet (LMD) scores. In this study, no specific questionnaire was used for the assessment of adherence to the MD. Rather, data derived from the FFQ, obtained during visit 1, were used to examine various food groups intakes and to calculate the MD sores. More specifically, for each of the food groups included in the selected MD scores, corresponding items of the FFQ were identified and their dietary intakes were summed to obtain the food group's intake. For example, for the food group 'Whole Grains', the intakes of the following items were added 'Whole wheat bread, bran or whole grain breakfast cereals, burghul'. The detailed description of food groups and their corresponding FFQ items is presented in Supplementary Table 1. Following the estimation of the food groups intakes, the scores of the MD were calculated as per their corresponding references[49,50] and as described in the next paragraph.

The aMED, a widely used score for the MD, was adapted from the traditional MD score developed by Trichopoulou *et al.*[49]. It consisted of eight components: whole grains, MUFA:SFA ratio, fruits, vegetables, legumes, nuts, fish and sea food and red and processed meats. The daily intake of each component was divided into two groups based on the median cut-off. For the first seven components, 0 or 1 points were given for participants consuming below or above the median, respectively. For red and processed meats, a presumed harmful food, a reverse scoring was assigned. Total aMED score was computed by adding the points obtained from the eight components. A higher score indicates higher adherence. In addition to the aMED, the LMD score was used to examine adherence to the MD. The LMD is an index for a variant of the MD which originated from Lebanon[50], a country belonging to the same region (Middle East) as the UAE, where the study is conducted. The LMD score consisted of nine components: whole grains/bulgur, olive oil, fruits, dried fruits, vegetables, starchy vegetables, legumes, eggs, as well as milk and dairy products. For each component, women whose consumption was in the first, second and third tertile were assigned 1, 2 and 3 points, respectively. Points are summed to

obtain the total LMD score whereby higher scores simply better adherence to the MD Pattern.

Statistical analysis

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS) software version 25 for Windows. Descriptive statistics were presented as frequency and percentage for categorical variables and mean ± standard error (SE) for continuous variables. Adherence to the MD scores was classified as low or high based on the upper tertile cut-off. Similarly, high and low PPWR correspond to PPWR above or below the upper tertile cut-off, respectively. Simple and multiple multinomial logistic regression analyses were conducted to examine the associations between adherence to the MD (as per the aMED and LMD scores) with GWG and GWGR. As for the associations of adherence to the MD with $PPWR_2$ and $PPWR_6$, simple and multiple logistic regression analyses were used. In all regression analyses, adherence to the MD was considered as independent variable, while GWG, GWGR, $PPWR_2$ and $PPWR_6$ were the dependent variables. For the analysis, the sample of 243 participants was used to examine adherence to the MD during pregnancy, the sample of 150 women who attended visit 3 was used to examine PPWR at 2 months and its association with MD and the sample of 131 women who attended visit 4 was used to examine PPWR at 6 months and its association with MD. Statistical significance was considered at *P*-values lower than 0·05.

Results

Table 1 describes the baseline characteristics of the study population, including age, education level, employment status, income, nationality, maternity leave, presence of GDM and breast-feeding at 2 and 6 months. (Table 1).

The main outcomes of this study including GWG, GWGR, $PPWR_2$ and $PPWR_6$ are described in Table 2. In the total sample, mean GWG was 12·0 kg ± 0·5 with over half of the populations belonging to the excessive GWG category, 18·3 % had adequate GWG and 24·2 % had insufficient GWG. For GWGR, the mean was 0·5 kg/week ± 0·02. GWGR was classified as insufficient, adequate and excessive for 35 %, 25·4 % and 39·6 % of participants, respectively. Mean $PPWR_2$ was 5·4 kg ± 0·7 and decreased at 6 months postpartum with mean $PPWR_6$ at 3·8 kg ±0·7. The percentage of women retaining any weight at 2 months postpartum was 76·7 % and those retaining at least 5 kg was 50·7 %. These figures at 6 months postpartum were 73·3 % and 45 %, respectively. (Table 2).

Figure 1 illustrates the association between GWG and PPWR at 2 and 6 months postpartum. Positive correlations were observed at both points in time where higher GWG was associated with higher PPWR (age-adjusted $R^2 = 0{\cdot}21$ and 0·22, respectively, at 2 and 6 months postpartum, *P*-values < 0·001). (Fig. 1).

Table 3 describes adherence to the MD in the study population as per the aMED and LMD scores. Common components between aMED and LMD scores include whole grains/bulgur, vegetables and legumes. Considering both scores, the main contributors to higher adherence to the MD were vegetables and olive oil/(MUFA/SFA). On the other hand, legumes and whole grains were among the lowest contributors. The distribution of the total aMED and LMD scores in the study population followed a bell-shaped curve as presented in Fig. 2.

Table 1. Baseline characteristics of the study population (Numbers and percentages, *n* 243)

	n	%
Age		
18–24·9	55	22·6
25–34·9	125	51·4
≥ 35	63	25·9
Education		
Intermediate and less	32	13·2
High school/technical diploma	133	54·7
University	78	32·1
Employment		
Housewife/homemaker	199	81·9
Employee	44	18·1
Maternity leave		
49 d (~ 1·5 months)	14	35
70 d (~ 2·5 months)	17	42·5
> 3 months	9	22·5
Don't know/not applicable	203	–
Income		
< 10 000 AED	85	46·2
≥ 10 000 AED	99	53·8
Don't know	59	–
Nationality		
Emirati	99	40·7
Arab	144	59·3
Number of children		
0	59	24·3
1 or 2	81	33·3
> 2	103	42·4
Gestational diabetes		
No	196	80·7
Yes	47	19·3
Breast-feeding status (2 months postpartum)		
No	3	2·1
Yes	140	97·9
Breast-feeding status (6 months postpartum)		
No	21	16·0
Yes	110	84·0

AED, United Arab Emirates Dirham.

Figure 3 shows the adherence to the MD (defined as having the corresponding total score above the upper tertile cut-off for aMED and LMD) by categories of GWG, GWGR and PPWR at 2 and 6 months among study participants. A similar trend is shown for both MD scores, whereby for each outcome the proportion of women who are adherent to the MD is highest for those belonging to adequate GWG/GWGR and low $PPWR_2$ and $PPWR_6$. (Fig. 3).

The association between adherence to the MD (as examined by aMED and LMD scores) and GWG, GWGR among study participants was examined using simple and multiple multinomial regression analysis and results are summarised in Tables 4 and 5. The multiple regression models, in addition to age and energy intake variables, significantly associated with MD scores at the univariate level were included.

After adjustment for potential confounders, high adherence to the MD, as examined by both scores, was associated with lower odds of excessive GWG. High adherence to the MD,

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Table 2. Gestational weight gain (GWG), gestational weight gain rate (GWGR), and postpartum weight retention (PPWR) at 2 and 6 months among study participants
(Numbers and percentages; mean values and standard deviations)

	n	%
GWG (*n* 240)		
Mean ± SE: 12·0 kg ± 0·5		
Insufficient	58	24·2
Adequate	44	18·3
Excessive	138	57·5
GWGR (*n* 240)		
Mean ± SE: 0·5 kg/week ± 0·02		
Insufficient	84	35·0
Adequate	61	25·4
Excessive	95	39·6
$PPWR_2$ (*n* 150)		
Mean ± SE: 5·4 kg ± 0·7		
Tertile distribution		
1st tertile (up to 2·8 kg)	51	34·0
2nd tertile (2·81–7·0 kg)	50	33·3
3rd tertile (≥ 7·1 kg)	49	32·7
Any weight (> 0 kg):		
No	35	23·3
Yes	115	76·7
5 kg or more		
No	74	49·3
Yes	76	50·7
$PPWR_6$ (*n* 131)		
Mean ± SE: 3·8 kg ± 0·7		
Tertile distribution		
1st tertile (up to 0·8 kg)	45	34·4
2nd tertile (0·81–7·4)	46	35·1
3rd tertile (> 7·4 kg)	40	30·5
Any weight (> 0 kg):	35	26·7
No		
Yes	96	73·3
5 kg or more		
No	72	55·0
Yes	59	45·0

according to the LMD, was associated with 66 % lower odds of excessive GWGR (Table 4).

Table 5 summarises the associations of adherence to the MD during pregnancy (as examined by aMED and LMD scores) with high $PPWR_2$ and $PPWR_6$ among study participants. The results of the adjusted models showed that while only a high aMED score was significantly associated with PPWR at 2 months, both scores showed significant associations with PPWR at 6 months. (Table 5).

Discussion

This study examined adherence to the MD during the third trimester of pregnancy and its association with GWG and weight retention at 2 and 6 months postpartum among women participating in the MISC cohort in the UAE. The results of this study showed that higher adherence to the MD during pregnancy was associated with lower odds of both insufficient and excessive GWG. Similarly, a negative association was observed between high adherence to the MD during pregnancy with weight retention at 2 and 6 months postpartum. In the study population, while an adequate intake of vegetables and olive oil/(MUFA/SFA) was the main contributors to adherence to the MD, those of legumes and whole grains were among the lowest contributors. Among participants, high prevalence rates of excessive GWG and GWGR during pregnancy were observed. Furthermore, at 2 months postpartum, 3 out of 4 women retained weight (> 0 kg) and 1 in 2 women retained substantial weight (> 5 kg). Similar estimates for weight retention trends were observed at 6 months postpartum. The findings of this study also showed a strong association between GWG and PPWR at 2 and 6 months.

The findings of this study showed that over 80 % of women had inadequate GWG, and over 50 % of participants retained 5 kg or more at 2 and 6 months postpartum. Such alarming rates are higher than those reported by the Mother and Infant Nutrition Assessment (MINA) cohort conducted in Lebanon and Qatar (64 % had inadequate GWG and 36 % retained more than 5 kg at 6 months postpartum)[51]. Compared with other countries around the world, the mean PPWR at 6 months in the study was also higher than those reported from Taiwan (2·1 kg)[52], Malaysia (3·12 kg)[10] and the USA of American (3·3 kg)[53]. The excessive GWG and PPWR observed in this study are concerning, especially in light of the mounting evidence for their association with a higher risk of lifetime obesity, especially central obesity among women of childbearing age[54]. Therefore, it is critical to research the context and culture-specific determinants and the factors associated with excessive GWG and PPWR in order to develop evidence-based interventions and public health nutrition programmes.

In this context, the results of this study revealed a negative association between higher adherence to the MD during pregnancy with insufficient as well as excessive gestational weight gain. Despite the considerable variability in the definition and

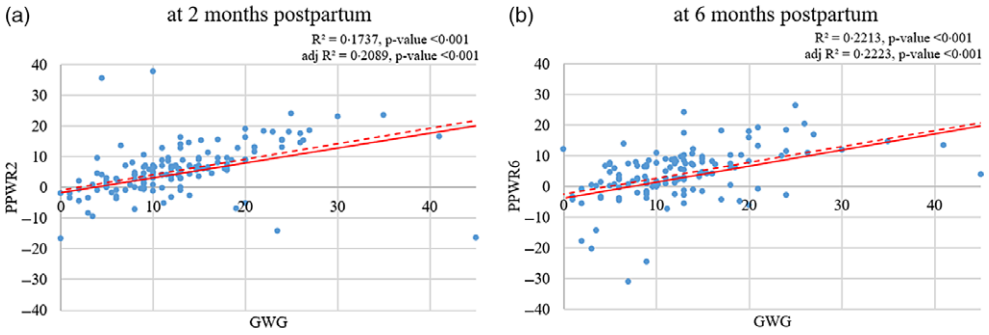

Fig. 1. Association between gestational weight gain (GWG) and postpartum weight retention (PPWR) at 2 and 6 months postpartum among study participants. ----, Crude; ——, age adjusted

Table 3. Adherence to the Mediterranean diet (MD) in the study population, as per the alternate Mediterranean diet (aMED) and Lebanese Mediterranean diet (LMD) scores
(Mean values and standard errors, *n* 243)

	Intake				aMED		LMD	
					% contribution to the aMED		% contribution to the LMD score	
Food components	Mean (g)	SE (g)	Mean (grams/1000 kcal)	SE (grams/1000 kcal)	Mean	SE	Mean	SE
Whole grains/Bulgur	30·3	3·93	10·45	1·19	8·4	0·89	10·75	0·32
Olive Oil	27·04	2·25	8·92	0·65	–		12·43	0·3
MUFA	49·03	1·8	15·82	0·27				
SFA	38·34	1·38	12·36	0·2				
Ratio MUFA/SFA	–		–		14·96	1·15	–	
Fruits (including dried)	78·22	8·98	24·93	2·39	10·63	1·07	–	
Fruits	70·06	8·65	22·23	2·31	–		10·3	0·29
Dried fruits	8·16	1·52	2·69	0·5	–		8·77	0·26
Vegetables (excluding starchy)	142·29	8·93	48·28	2·67	13·59	1·09	12·13	0·3
Starchy vegetables	15·59	2·52	5·22	0·84	–		9·28	0·26
Legumes	29·04	2·7	9·68	0·86	7·12	0·82	11·51	0·29
Nuts	16·46	2·16	5·06	0·61	9·18	1·05	–	
Fish and sea food	37·03	3·65	12·26	1·01	12·9	1·21	–	
Eggs	25·88	1·78	9·61	0·74	–		11·79	0·32
Milk and dairy products	273·99	16·82	98·22	5·99	–		12·84	0·31
Red and processed meats*	33·02	2·97	11·4	0·88	22·88	1·76	–	
Range of possible score					0–8		9–27	
Range of reported score					0–8		9–25	
Tertile cut-offs					2, 4		13, 17	
Mean ± SE of reported score					3·26	0·10	14·31	0·22

* A higher score was assigned to a lower intake: the corresponding % contribution refers to the contribution of a lower intake of red and processed meat.

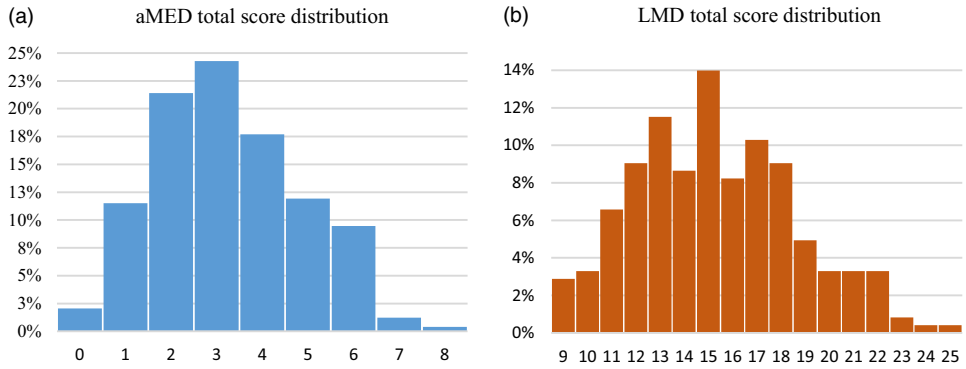

Fig. 2. Distribution of the alternate Mediterranean diet (aMED) and Lebanese Mediterranean diet (LMD) scores in the study population. (*n* 243).

assessment of MD across the literature, the protective effect of adherence to the MD against suboptimal GWG was reported in many previous studies. For instance, a study among pregnant women in Spain showed that one-point increase in adherence to the MD was associated with higher odds of appropriate weight gain among participants (OR: 1·39, CI: 1·06, 1·82)[34]. Another more recent study from Spain also indicated a negative association between adherence to the MD and GWG in a sample of 503 women[35]. Furthermore, the results of PRINCESA cohort showed that higher adherence to the MD was protective against an insufficient (OR: 0·63; CI:0·42, 0·95) and excessive GWG (OR: 0·62; CI, 0·41, 0·94) among 660 pregnant women in Mexico[55]. Adherence to MD like patterns has shown similar results, whereby in a sample of 538 pregnant women in Urban South Africa, adherence to a dietary pattern rich in whole grains, legumes and vegetables was associated with a 30 % decrease in the odds of excessive weight gain[56]. Such an observed association between the MD and GWG was not only described in observational studies but was also reported in intervention studies, whereby a multicentre trial in the UK showed that simple MD dietary advice was effective in reducing GWG among 593 pregnant women[33]. Furthermore, a meta-analysis including four clinical trials (2277 patients) and aiming to evaluate the effect of adherence to the MD during pregnancy on weight gain during pregnancy concluded that the MD was associated with a reduced GWG[27]. This effect of adherence to the MD on optimal GWG could be attributed to the anti-obesity effect of this pattern and its constituents. Using either of the two scores considered in this study, the MD included whole grains, olive oil and MUFA, fruits, vegetables and legumes. These constituents

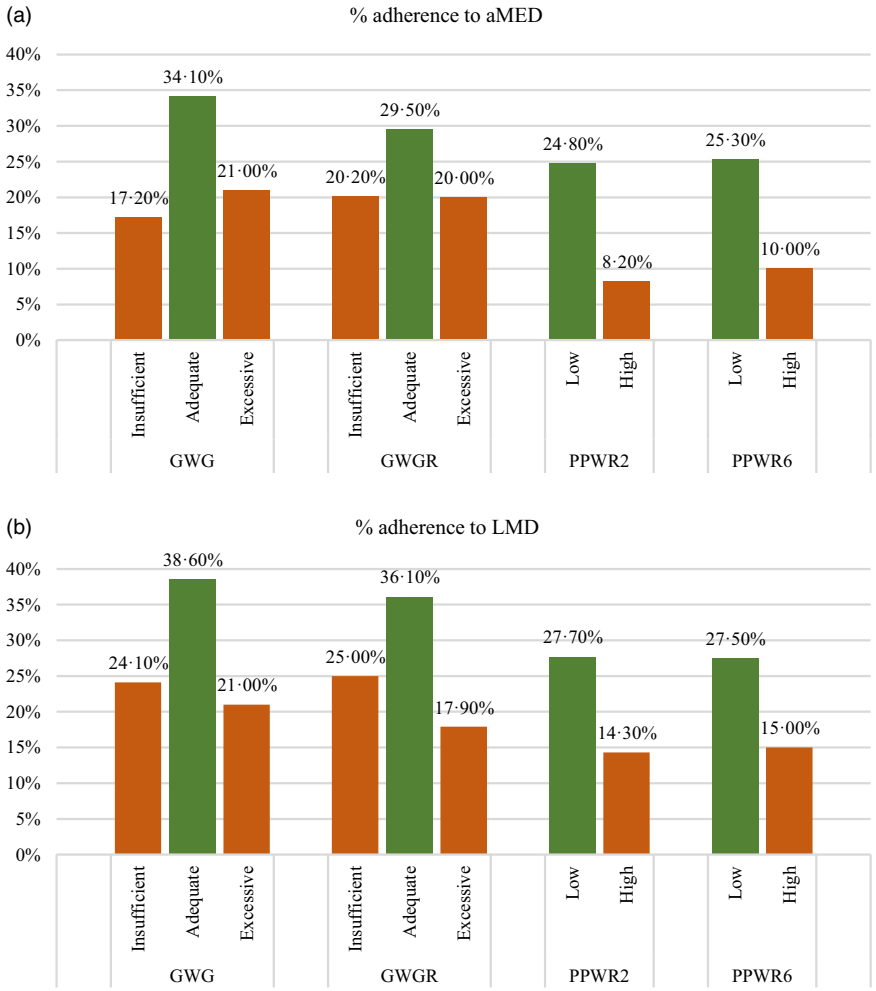

Fig. 3. Adherence to the Mediterranean diet (MD) (according to alternate Mediterranean diet (aMED) and Lebanese Mediterranean diet (LMD) scores) by categories of gestational weight gain (GWG), gestational weight gain rate (GWGR) and postpartum weight retention (PPWR) at 2 and 6 months among study participants.

provide a considerable quantity of dietary fiber. The latter has been associated with increased satiety via several physiological mechanisms, including longer mastication time, increased gastric detention, slower gastric emptying and a greater release of cholecystokinin[57]. As for the fat content, the MD does not seem to fit the definition of low-fat diets as it contains 30–35 % of energy as fat; however, it is argued that the quality of the fat in the MD that seems to exert a protective effect against excessive weight gain. More specifically, the MD has a low content of saturated and trans fats and is high in monounsaturated fats (approximately 67 % of fat energy) as found in oleic acid in olive oil[57]. Furthermore, fruits and vegetables, integral components of the MD, are rich sources of polyphenols such as hydroxycinnamic derivatives, quercetin, resveratrol, oleuropein and hydroxytyrosol. These polyphenols are known for their antioxidant and anti-inflammatory activities, which are consequently implicated in preventing excessive weight gain and obesity[58]. It remains important to note that the beneficial effect of the MD on GWG may be greater than the sum of the benefits derived from each of the components. For instance, in a systematic review of randomised trials where the effect of polyphenols supplementation on weight gain and obesity was considered in isolation of a whole dietary pattern, the results did not support polyphenol supplementation as a complementary strategy for enhancing weight loss[59]. Therefore, it seems plausible to suggest that the beneficial effects of the MD could be attributed to the potential synergistic actions of its multiple ingredients[60–62].

The findings of this study indicated that in addition to its association with GWG, a high adherence to the MD during pregnancy was associated with significantly lower odds of high PPWR at 2 and 6 months postpartum. This finding suggested that the protective effect of adherence to the MD during pregnancy against excessive weight gain extended well beyond delivery to reach 2 and 6 months postpartum. Few studies have examined the impact of dietary intake during pregnancy on PPWR. A prospective cohort in Singapore, The Growing Up in Singapore Towards healthy Outcomes (GUSTO) study, showed that a lower diet quality during pregnancy, as examined by the Healthy Eating Index was, in fact, associated with higher odds of substantial PPWR (5 kg or higher)[63]. A possible explanation of the association of adherence to the MD with lower odds of high PPWR could be explained by the fact that women who were adherent to the MD during their pregnancy would most likely also be adherent to this diet after delivery and hence would

Table 4. Association between adherence to the Mediterranean diet (MD) (as examined by alternate Mediterranean diet (aMED) and Lebanese Mediterranean diet (LMD) scores) with Gestational weight gain (GWG) and gestational weight gain rate (GWGR) among study participants
(Odds ratio and 95 % confidence intervals)

	Crude model								Adjusted model*							
	GWG†				GWGR†				GWG†				GWGR†			
	Insufficient		Excessive		Insufficient		Excessive		Insufficient		Excessive		Insufficient		Excessive	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
aMED score‡																
Low adherence	1·00		1·00		1·00		1·00		1·00		1·00		1·00		1·00	
High adherence	0·40	0·16, 1·01	0·51	0·24, 1·08	0·61	0·28, 1·3	0·60	0·28, 1·26	0·31	0·11, 0·83	0·41	0·18, 0·93	0·46	0·2, 1·04	0·52	0·23, 1·15
LMD score‡																
Low adherence	1·00		1·00		1·00		1·00		1·00		1·00		1·00		1·00	
High adherence	0·51	0·22, 1·19	0·42	0·2, 0·88	0·59	0·29, 1·21	0·39	0·18, 0·81	0·48	0·18, 1·34	0·40	0·16, 0·98	0·47	0·2, 1·1	0·34	0·14, 0·81

Data are presented as Odds ratio (95 % CI).
* Adjusted for age, energy and number of children.
† Reference categories are adequate GWG and adequate GWGR.
‡ Low and high adherence to MD scores are defined as having the total score below or above the corresponding upper tertile cut-off, respectively.

benefit from its protective effect against PPWR then. In fact, available evidence indicates that dietary patterns tend to be stable across time[64]. Another explanation of the protective effect of adherence to the MD during pregnancy against high PPWR could relate to the strong association between GWG and PPWR. More specifically, the adherence to the MD protect seems to protect against excessive GWG, the latter being closely associated with PPWR. In fact, in this study, a strong positive association was found between GWG and PPWR at both 2 and 6 months. This association has been repeatedly reported in the literature. In fact, GWG has been postulated as the single most important factor in predicting PPWR[52,65–67]. A closer examination of the various contributors to the MD in the study population indicated that, while an adequate intake of vegetables and olive oil/ (MUFA/SFA) were the main contributors, legumes and whole grains were among the lowest contributors. Aside from this study, little is known about the intake of legumes in the UAE. As for whole grains, according to Afshin *et al.*, in the UAE, the average intake of whole grains falls below 40 g/d which is far lower than the recommended 125 g/d[68].

In light of the findings of this study and others underscoring the important role of MD in ensuring adequate GWG and PPWR rates, it seems sensible to recommend integrating the elements of this dietary pattern into national health programmes aiming to promote optimal weight gain among pregnant women. Such programmes may target clinical practice as well as public health interventions. More specifically, based on the findings of this study, health care professionals could be trained to include the MD recommendation within their routine antenatal care. For example, obstetricians, who have frequent encounters with pregnant women, are ideally situated to promote and support a higher adherence to the MD in this population group. At the public health level, although there exist no national dietary guidelines for pregnant women in the UAE, the available evidence of this research could justify integrating the MD within such guidelines once developed in the future. Among the factors that could facilitate the promotion of the MD among pregnant women in the UAE is the fact that the UAE hosts a multitude of nationalities, not the least of which are those coming from Mediterranean countries[69], making up around 10 % of the total population in the UAE. As such, residents of the UAE may be familiar with many culinary habits native to these Mediterranean countries and which are part of the MD.

Strengths and limitations

This is the first study to investigate the effect of adherence of the MD during pregnancy on both GWG as well as PPWR at two different time points after delivery. The cohort design of the study allows causation inference and minimises the effect of recall bias, whereby the exposure (adherence to the MD) was measured before the outcome (PPWR). The measurements of the maternal weight during pregnancy and after delivery were conducted by trained research assistants, rather than being reported or recalled by the mother. Such an approach enhances the accuracy of the data and improves the validity of the results. That said, the findings of this study ought to be considered in light of a few

Table 5. Association between adherence to the Mediterranean diet (MD) (as examined by alternate Mediterranean diet (aMED) and Mediterranean diet (LMD) scores) with high postpartum weight retention (PPWR)* at 2 and 6 months among study participants (Odds ratio and 95 % confidence intervals)

	Crude model				Adjusted model†			
	$PPWR_2$		$PPWR_6$		$PPWR_2$		$PPWR_6$	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
aMED score‡								
Low adherence	1·00		1·00		1·00		1·00	
High adherence	0·27	0·09, 0·83	0·33	0·11, 1·02	0·23	0·06, 0·88	0·26	0·08, 0·86
LMD score‡								
Low adherence	1·00		1·00		1·00		1·00	
High adherence	0·43	0·17, 1·08	0·47	0·17, 1·24	0·51	0·19, 1·4	0·32	0·1, 0·98

Data are presented as odds ratio (95 % CI). $PPWR_2$, 2 months postpartum weight rate; $PPWR_6$, 6 months postpartum weight retention.
* High PPWR is defined as belonging to the third tertile of postpartum weight retention.
† Adjusted for age, energy and number of children.
‡ Low and high adherence to MD scores are defined as having the total score below or above the corresponding upper tertile cut-off, respectively.

limitations. First, in this study, the number of participants dropped significantly between visit 1 (*n* 243), visit 2 (*n* 150) and visit 3 (*n* 131). High dropout rates are a common concern in cohort studies. In this study, every effort was exerted to retain subjects, whereby the timing of the visits was scheduled based on the participants' preference. In case of no-show, the research assistant would conduct a minimum of multiple attempts before considering the participant as a drop-off. Second, in this study, adherence to the MD was not examined using a questionnaire specifically designed and validated for this purpose, rather it was estimated using an FFQ that assessed overall dietary intake. The use of short questionnaires as opposed to using long FFQ has been advocated for clinical and epidemiological research purposes as they are less burdensome and time consuming and consequently leading to a higher response rate[70]. In the context of this cohort study, the breadth of dietary exposures of interest favoured the use of FFQ. It is important to note that the FFQ method of dietary assessment relies considerably on the memory as well as on the motivation of the participants, and as such could be subject to recall error. However, the FFQ remains the most suitable dietary data assessment tool in epidemiological studies as it provides information on an individual's habitual diet and dietary patterns over long periods of time and also allows ranking of individuals according to intake[71], which in the case of this study was applied to rank individuals according to their MD scores. Third, though not required for the calculations of the MD scores considered in this study, there are characteristics of certain food groups that could affect their nutritional value and ultimately their effect on weight gain, which were not accounted for in this study. An example of such foods is olive oil, whereby refined olive oil is a poor source of vitamins, polyphenols and phytosterols, while extra virgin olive oil contains the highest level of polyphenols[72]. Taking such characteristics of olive oil into account in future studies of the health benefits of the MD is therefore warranted. Lastly, the interview-based approach in data collection could have led to a social desirability bias, as is the case of most questionnaire-based epidemiological research[73]. In this study, the research assistants were thoroughly trained to maintain a neutral attitude and avoid judgemental comments[43].

Conclusions

GWG and PPWR are critical factors that not only play a pivotal role in fostering optimal nutrition during the critical 1000 days' period of life but are also implicated as causal factors for obesity among women. In a country with soaring rates of overweight and obesity, such as the UAE, it is critical to unearth the modifiable risk factors for excessive GWG and PPWR. In this context, the findings of this study confirmed the high rates of excessive GWG and high PPWR among women in the UAE and showed that a higher adherence to the MD during pregnancy protected against excessive weight gain during pregnancy. Furthermore, such an effect seemed to extend beyond the pregnancy period, whereby adherence to the MD was found to be associated with lower odds of PPWR. These findings lay the foundation for the development of evidence-based and culture-specific interventions and programmes for the promotion of the MD. According to the findings of this study, low intake of legumes and whole grains could be plausible targets for the interventions and programmes aiming to increase the adherence to the MD among women in the UAE. Future follow-up studies are warranted to examine the effect of maternal adherence to the MD on infants' health and reveal the long-term health implication for both the mother and child.

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Supplementary material

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References

1. Huda SS, Brodie LE & Sattar N (2010) Obesity in pregnancy: prevalence and metabolic consequences. *Semin Fetal Neonatal Med* **15**, 70–76.
2. Patro B, Liber A, Zalewski B, *et al.* (2013) Maternal and paternal body mass index and offspring obesity: a systematic review. *Ann Nutr Metab* **63**, 32–41.
3. Gaillard R, Rifas-Shiman SL, Perng W, *et al.* (2016) Maternal inflammation during pregnancy and childhood adiposity. *Obesity* **24**, 1320–1327.
4. Marchi J, Berg M, Dencker A, *et al.* (2015) Risks associated with obesity in pregnancy, for the mother and baby: a systematic review of reviews. *Obes Rev* **16**, 621–638.
5. Ma RC, Tutino GE, Lillycrop KA, *et al.* (2015) Maternal diabetes, gestational diabetes and the role of epigenetics in their long term effects on offspring. *Prog Biophys Mol Biol* **118**, 55–68.
6. Goldstein RF, Abell SK, Ranasinha S, *et al.* (2017) Association of gestational weight gain with maternal and infant outcomes: a systematic review and meta-analysis. *JAMA* **317**, 2207–2225.
7. Goldstein RF, Abell SK, Ranasinha S, *et al.* (2018) Gestational weight gain across continents and ethnicity: systematic review and meta-analysis of maternal and infant outcomes in more than one million women. *BMC Med* **16**, 1–14.
8. Nehring I, Schmoll S, Beyerlein A, *et al.* (2011) Gestational weight gain and long-term postpartum weight retention: a meta-analysis. *Am J Clin Nutr* **94**, 1225–1231.
9. McKinley MC, Allen-Walker V, McGirr C, *et al.* (2018) Weight loss after pregnancy: challenges and opportunities. *Nutr Res Rev* **31**, 1–14.
10. Fadzil F, Shamsuddin K, Puteh SEW, *et al.* (2018) Predictors of postpartum weight retention among urban Malaysian mothers: a prospective cohort study. *Obes Res Clin Pract* **12**, 493–499.
11. Nicklas JM, Rosner BA, Zera CA, *et al.* (2019) Association between changes in postpartum weight and waist circumference and changes in cardiometabolic risk factors among women with recent gestational diabetes. *Prev Chronic Dis* **16**, E47.
12. Tahir MJ, Haapala JL, Foster LP, *et al.* (2019) Higher maternal diet quality during pregnancy and lactation is associated with lower infant weight-for-length, body fat percent, and fat mass in early postnatal life. *Nutrients* **11**, 632.
13. Catalano PM & Shankar K (2017) Obesity and pregnancy: mechanisms of short term and long term adverse consequences for mother and child. *BMJ* **356**, j1631.
14. Bogaerts A, De Baetselier E, Ameye L, *et al.* (2017) Postpartum weight trajectories in overweight and lean women. *Midwifery* **49**, 134–141.
15. Wahabi HA, Fayed AA, Tharkar S, *et al.* (2019) Postpartum weight retention and cardiometabolic risk among saudi women: a follow-up study of RAHMA Subcohort. *Biomed Res Int* **2019**, 2957429.
16. Hill B, Skouteris H, Boyle JA, *et al.* (2020) Health in preconception, pregnancy and postpartum global alliance: international network pregnancy priorities for the prevention of maternal obesity and related pregnancy and long-term complications. *J Clin Med* **9**, 822.
17. Dalrymple KV, Flynn AC, Relph SA, *et al.* (2018) Lifestyle interventions in overweight and obese pregnant or postpartum women for postpartum weight management: a systematic review of the literature. *Nutrients* **10**, 1704.
18. Vincze L, Rollo M, Hutchesson M, *et al.* (2019) Interventions including a nutrition component aimed at managing gestational weight gain or postpartum weight retention: a systematic review and meta-analysis. *JBI Database Syst Rev Implement Rep* **17**, 297–364.
19. Trichopoulou A, Martínez-González MA, Tong TY, *et al.* (2014) Definitions and potential health benefits of the Mediterranean diet: views from experts around the world. *BMC Med* **12**, 112.
20. L□c□tu□u CM, Grigorescu ED, Floria M, *et al.* (2019) The Mediterranean Diet: from an environment-driven food culture to an emerging medical prescription. *Int J Environ Res Public Health* **16**, 942.
21. Widmer RJ, Flammer AJ, Lerman LO, *et al.* (2015) The Mediterranean diet, its components, and cardiovascular disease. *Am J Med* **128**, 229–238.
22. Mancini JG, Filion KB, Atallah R, *et al.* (2016) Systematic review of the mediterranean diet for long-term weight loss. *Am J Med* **129**, 407–415.
23. Schwingshackl L, Missbach B, König J, *et al.* (2015) Adherence to a Mediterranean diet and risk of diabetes: a systematic review and meta-analysis. *Public Health Nutr* **18**, 1292–1299.
24. Schwingshackl L, Schwedhelm C, Galbete C, *et al.* (2017) Adherence to Mediterranean Diet and risk of cancer: an updated systematic review and meta-analysis. *Nutrients* **9**, 1063.
25. Ventriglio A, Sancassiani F, Contu MP, *et al.* (2020) Mediterranean Diet and its benefits on health and mental health: a literature review. *Clin Pract Epidemiol Ment Health* **16**, 156–164.
26. Melero V, García de la Torre N, Assaf-Balut C, *et al.* (2020) Effect of a Mediterranean Diet-based nutritional intervention on the risk of developing gestational diabetes mellitus and other maternal-fetal adverse events in hispanic women residents in Spain. *Nutrients* **12**, 3505.
27. Zhang Y, Xia M, Weng S, *et al.* (2021) Effect of Mediterranean diet for pregnant women: a meta-analysis of randomized controlled trials. *J Matern Fetal Neonatal Med* 1–11. doi: 10.1080/14767058.2020.1868429
28. Biagi C, Nunzio MD, Bordoni A, *et al.* (2019) Effect of adherence to Mediterranean Diet during pregnancy on children's health: a systematic review. *Nutrients* **11**, 997.
29. Amati F, Hassounah S & Swaka A (2019) The impact of Mediterranean Dietary patterns during pregnancy on maternal and offspring health. *Nutrients* **11**, 1098.
30. Parisi F, Milazzo R, Savasi VM, *et al.* (2021) Maternal low-grade chronic inflammation and intrauterine programming of health and disease. *Int J Mol Sci* **22**, 1732.
31. Bonaccio M, Costanzo S, Di Castelnuovo AF, *et al.* (2021) Mediterranean Diet trajectories and changes in cardiovascular risk factors and inflammation markers over a 12·7 years follow-up: prospective findings from the moli-sani study cohort. *Circulation* **143**, A025.
32. Billingsley HE & Carbone S (2018) The antioxidant potential of the Mediterranean diet in patients at high cardiovascular risk: an in-depth review of the PREDIMED. *Nutr Diabetes* **8**, 13.

33. H. Al Wattar B, Dodds J, Placzek A, *et al.* (2019) Mediterranean-style diet in pregnant women with metabolic risk factors (ESTEEM): a pragmatic multicentre randomised trial. *PLoS Med* **16**, e1002857.
34. Silva-del Valle MA, Sánchez-Villegas A & Serra-Majem L (2013) Association between the adherence to the Mediterranean diet and overweight and obesity in pregnant women in Gran Canaria. *Nutr Hosp* **28**, 654–659.
35. Cano-Ibáñez N, Martínez-Galiano JM, Luque-Fernández MA, *et al.* (2020) Maternal dietary patterns during pregnancy and their association with gestational weight gain and nutrient adequacy. *Int J Environ Res Public Health* **17**, 7908.
36. Mokdad AH, Jaber S, Aziz MI, *et al.* (2014) The state of health in the Arab world, 1990–2010: an analysis of the burden of diseases, injuries, and risk factors. *Lancet* **383**, 309–320.
37. Salti N (2020) Non-Communicable Diseases (NCD) in the Middle East and North Africa: What Macroeconomic Savings can be Expected from Achieving SDG Target 3·4? https://files.emrsdgslearn.net/uploads/Cost%20of%20NCDs.pdf (accessed June 2021).
38. Mokdad AH, Jaber S, Aziz MIA, *et al.* (2014) The state of health in the Arab world, 1990–2010: an analysis of the burden of diseases, injuries, and risk factors. *Lancet* **383**, 309–320.
39. Fayed AA, Wahabi H, Mamdouh H, *et al.* (2017) Demographic profile and pregnancy outcomes of adolescents and older mothers in Saudi Arabia: analysis from Riyadh Mother (RAHMA) and Baby cohort study. *BMJ Open* **7**, e016501.
40. AlSeaidan M, Al Wotayan R, Christophi CA, *et al.* (2016) Birth outcomes in a prospective pregnancy–birth cohort study of environmental risk factors in Kuwait: the TRACER study. *Paediatr Périnat Epidemiol* **30**, 408–417.
41. Mahmoud I & Sulaiman N (2019) Dyslipidaemia prevalence and associated risk factors in the United Arab Emirates: a population-based study. *BMJ open* **9**, e031969.
42. Sulaiman N, Elbadawi S, Hussein A, *et al.* (2017) Prevalence of overweight and obesity in United Arab Emirates Expatriates: the UAE National Diabetes and Lifestyle Study. *Diabetol Metab Syndr* **9**, 88.
43. Radwan H, Hashim M, Shaker Obaid R, *et al.* (2018) The Mother-Infant Study Cohort (MISC): methodology, challenges, and baseline characteristics. *PLoS One* **13**, e0198278.
44. Naja F, Nasreddine L, Yunis K, *et al.* (2016) Study protocol: mother and infant nutritional assessment (MINA) cohort study in Qatar and Lebanon. *BMC Pregnancy Childbirth* **16**, 98.
45. National Collaborating Centre for Ws, Children's H (2015) *National Institute for Health and Care Excellence: Clinical Guidelines. Diabetes in Pregnancy: Management of Diabetes and Its Complications from Preconception to the Postnatal Period*. London: National Institute for Health and Care Excellence (UK).
46. Institute of M & National Research Council Committee to Reexamine IOMPWG (2009) *The National Academies Collection: Reports funded by National Institutes of Health. Weight Gain During Pregnancy: Reexamining the Guidelines*. Washington, DC: National Academies Press (US).
47. Posner BM, Smigelski C, Duggal A, *et al.* (1992) Validation of two-dimensional models for estimation of portion size in nutrition research. *J Am Dietetic Assoc* **92**, 738–741.
48. Authority ADFC (2014) A Photographic Atlas of Food Portions for the Emirate of Abu Dhabi. https://docplayer.net/45546937-A-photographic-atlas-of-food-portions-for-the-emirate-of-abu-dhabi.html (accessed March 2021).
49. deKoning L & Anand SS (2004) Adherence to a Mediterranean diet and survival in a Greek population. *N Engl J Med* **348**, 2599–608.
50. Naja F, Hwalla N, Itani L, *et al.* (2015) A novel Mediterranean diet index from Lebanon: comparison with Europe. *Eur J Nutr* **54**, 1229–1243.
51. Nasreddine L, Ayoub J, Abbas N, *et al.* (2020) Postpartum weight retention and its determinants in lebanon and qatar: results of the Mother and Infant Nutrition Assessment (MINA) Cohort. *Int J Environ Res Public Health* **17**, 7851.
52. Shao HH, Hwang LC, Huang JP, *et al.* (2018) Postpartum weight retention risk factors in a Taiwanese cohort study. *Obes Facts* **11**, 37–45.
53. Walker LO (1996) Predictors of weight gain at 6 and 18 months after childbirth: a pilot study. *J Obstet Gynecol Neonatal Nurs* **25**, 39–48.
54. Smith DE, Lewis CE, Caveny JL, *et al.* (1994) Longitudinal changes in adiposity associated with pregnancy: the CARDIA study. *JAMA* **271**, 1747–1751.
55. Ancira-Moreno M, Vadillo-Ortega F, Rivera-Dommarco J, *et al.* (2019) Gestational weight gain trajectories over pregnancy and their association with maternal diet quality: results from the PRINCESA cohort. *Nutrition* **65**, 158–166.
56. Wrottesley SV, Pisa PT & Norris SA (2017) The influence of maternal dietary patterns on body mass index and gestational weight gain in Urban Black South African Women. *Nutrients* **9**, 732.
57. Buckland G, Bach A & Serra-Majem L (2008) Obesity and the Mediterranean diet: a systematic review of observational and intervention studies. *Obes Rev* **9**, 582–593.
58. Nani A, Murtaza B, Sayed Khan A, *et al.* (2021) Antioxidant and anti-inflammatory potential of polyphenols contained in mediterranean diet in obesity: molecular mechanisms. *Molecules* **26**, 985.
59. Llaha F & Zamora-Ros R (2020) The effects of polyphenol supplementation in addition to calorie restricted diets and/or physical activity on body composition parameters: a systematic review of randomized trials. *Front Nutr* **7**, 84.
60. Trichopoulou A, Bamia C & Trichopoulos D (2009) Anatomy of health effects of Mediterranean diet: greek EPIC prospective cohort study. *BMJ* **338**, b2337.
61. Jacobs DR & Tapsell LC (2013) Food synergy: the key to a healthy diet. *Proc Nutr Soc* **72**, 200–206.
62. Tapsell LC (2014) Foods and food components in the Mediterranean diet: supporting overall effects. *BMC Med* **12**, 100.
63. Loy SL, Cheung YB, Marjorelee C, *et al.* (2020) Maternal night-eating and lower diet quality during pregnancy are associated with substantial postpartum weight retention. *Proc Nutr Soc* **79**, E102.
64. Borland SE, Robinson SM, Crozier SR, *et al.* (2008) Stability of dietary patterns in young women over a 2-year period. *Eur J Clin Nutr* **62**, 119–126.
65. Abebe DS, Von Soest T, Von Holle A, *et al.* (2015) Developmental trajectories of postpartum weight 3 years after birth: Norwegian mother and child cohort study. *Matern Child Health J* **19**, 917–925.
66. Sha T, Cheng G, Li C, *et al.* (2019) Patterns of women's postpartum weight retention and its associations with maternal obesity-related factors and parity. *Int J Environ Res Public Health* **16**, 4510.
67. Koh H, Ee TX, Malhotra R, *et al.* (2013) Predictors and adverse outcomes of inadequate or excessive gestational weight gain in an Asian population. *J Obstet Gynaecol Res* **39**, 905–913.

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68. Afshin A, Micha R, Khatibzadeh S, *et al.* (2015) The impact of dietary habits and metabolic risk factors on cardiovascular and diabetes mortality in countries of the Middle East and North Africa in 2010: a comparative risk assessment analysis. *BMJ open* **5**, e006385.
69. Wikipedia Demographics of the United Arab Emirates. (2013) https://en.wikipedia.org/wiki/Demographics_of_the_United_Arab_Emirates#:~:text=Out%20of%20this%2C%20the%20number,6.1%25%2C%20other%2012.8%25 (accessed March 2021).
70. Gnagnarella P, Draga D, Misotti A, *et al.* (2018) Validation of a short questionnaire to record adherence to the Mediterranean diet: an Italian experience. *Nutr Metab Cardiovasc Dis* **28**, 1140–1147.
71. Willett W (1998) *Nutrition Epidemiology*. New York: Oxford University Press.
72. Gorzynik-Debicka M, Przychodzen P, Cappello F, *et al.* (2018) Potential health benefits of olive oil and plant polyphenols. *Int J Mol Sci* **19**, 686.
73. Okamoto K, Ohsuka K, Shiraishi T, *et al.* (2002) Comparability of epidemiological information between self-and interviewer-administered questionnaires. *J Clin Epidemiol* **55**, 505–511.

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