ORIGINAL ARTICLE

Nutrient intake and gestational weight gain adequacy in relation to fat taste sensitivity among pregnant women

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ABSTRACT

Background and aim: Research on nutrient intakes and adequacy among pregnant women is extensive. However, little is understood about the role of fat taste sensitivity in this context. This study aimed to investigate nutrient intake and gestational weight gain (GWG) adequacy between hyposensitive and hypersensitive pregnant women, categorised by healthy weight and overweight/obese, based on pre-pregnancy body mass index.
Methods: Fat taste sensitivity was measured using the ascending forced choice method (3-AFC), while dietary intake was assessed via a food frequency questionnaire (FFQ). GWG was evaluated based on Institute of Medicine (IOM) guidelines, and nutrient adequacy was determined according to Malaysian Recommended Nutrient Intakes (RNI).
Results: No significant differences ($p > 0.05$) were observed between hyposensitive and hypersensitive groups in the healthy weight category for all nutrients. In contrast, within the overweight/obese group, hyposensitive participants consumed significantly higher protein (81.50 vs 68.83 g/day, $p = 0.002$) and total fat (57.58 vs 48.33 g/day, $p = 0.012$) compared to hypersensitive individuals. Higher intakes of saturated, monounsaturated and polyunsaturated fatty acids, as well as vitamin B6, vitamin E, magnesium, and zinc (all $p < 0.01$), were also observed. Overall, energy and fat intake were suboptimal, and inadequate GWG was prevalent, particularly among overweight/obese pregnant women.
Conclusions: Fat taste sensitivity appeared to influence dietary intake in overweight/obese, but not healthy weight, pregnant women. Despite higher nutrient intake among hyposensitive- overweight/obese participants, overall inadequacies in energy, fat, and GWG were observed.

Key words: fat taste sensitivity, fat taste threshold, nutrient intake, gestational weight gain, pregnant women

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Introduction

Pregnancy is a critical period requiring appropriate nutrient intake for both maternal and infant survival. Adverse outcomes often result when gestational weight gain (GWG) deviates from recommended ranges, with associations to pre-eclampsia, gestational diabetes mellitus, premature birth, and abnormal infant growth (1). The dietary requirement of pregnant women are more specific to body maintenance, foetal development, and food safety. Proper nutrition is vital for the health of both the mother and developing foetus (2). Adequate intake of essential nutrients supports foetal organ development, skeletal growth, and optimal physiological function.

The obesity rate in Malaysia has risen steadily, with recent statistics indicating that over half of the population is classified as overweight or obese (3). Obesity is associated with an increasing prevalence of non-communicable diseases, such as type 2 diabetes, cardiovascular disease, and various cancers (4). For obese pregnant women, the responsibility of managing their pregnancy is heightened, making this condition even more critical. Previous studies in Malaysia have reported various nutrient intakes and their adequacy among pregnant women (5,6,7). However, few have considered the role of taste sensitivity, particularly with regard to fat taste.

Fat taste sensitivity is assessed by determining the fat taste threshold, defined as the minimum concentration of free fatty acids necessary to elicit a perceptible taste response (8). Based on this threshold, individuals may be categorised as either hyposensitive (less sensitive) or hypersensitive (more sensitive) to fat taste. In previous research, the relationship between fat preference and fat taste sensitivity was examined in healthy weight and obese pregnant women, revealing a positive correlation between fat preference and fat taste sensitivity (9). Therefore, the next logical step is to investigate whether hyposensitive and hypersensitive pregnant women differ in their nutrient intake.

Previous literature indicates that hyposensitive healthy women tend to consume more energy and lipids compared to their hypersensitive counterparts (10). A similar study involving male participants found that hypersensitive individuals scored higher in diet quality than hyposensitive individuals (11). Growing evidence suggests that individuals with low fat taste sensitivity are more likely to have a higher body mass index (BMI) (8,12,13). However, most studies were conducted on healthy non-pregnant individuals. Thus, this study, aims to assess the nutrient intake and GWG of hyposensitive and hypersensitive pregnant women. Additionally, the participants were grouped based on pre-pregnancy BMI (healthy weight and overweight/obese), to explore inter-individual variation within the same BMI category. We hypothesise that pregnant women with reduced fat taste sensitivity exhibit higher nutrient intake compared to their hypersensitive counterparts.

Materials and methods

Study population

A cross-sectional study was conducted in Kemaman, Terengganu, Malaysia, to evaluate the fat taste sensitivity and nutrient intake of pregnant women. A total of 160 Malay participants in their third trimester participated in this study. Data collection was conducted from 1st September 2022 until 30th August 2023.

Participants were selected using convenience sampling, recruited while attending maternal and child health clinics for antenatal care. Based on pre-pregnancy BMI, the participants were divided into two groups: healthy weight and overweight/obese group (80 participants per group). The sample size was determined based on a power analysis using G*Power software with an effect size of 0.4, an alpha level of 0.05, and a power of 0.8. Overweight individuals were grouped with obese individuals because their taste sensitivities are similar, and this combined group is referred to as the overweight/obese group (14). Exclusion criteria included a history of food allergies, dairy intolerance, adhered to a specific diet plan, gestational diabetes, or any chronic illness. Ethical approval was obtained from the Medical Research and Ethics Committee, Ministry of Health Malaysia (NMRR ID-22-00671-07G IIR) and the Human Research Ethics Committee, Universiti Sains Malaysia (USM/JEPeM/22020141). All participants provided informed consent prior to participation.

Methods

Pre-pregnancy BMI was calculated by dividing the pre-pregnancy weight in kilogrammes (kg) by the square of height in metres (m^2). Pre-pregnancy weight was self-reported, while height was measured using a stadiometer (SECA meter Model 208, Germany). Pre-pregnancy BMI was calculated by dividing the weight in kilograms by the height in meters squared, and it was categorised according to the World Health Organization's four classes: underweight (BMI < 18.5), normal weight (18.5 - 24.9), overweight (25 - 29.9), and obese (BMI ≥ 30).

GWG was estimated by subtracting pre-pregnancy weight from the maternal weight recorded at the last antenatal appointment (5). Maternal weight gain was classified into three categories: insufficient, sufficient, and excessive, based on the GWG. The categorization into inadequate, adequate, and excessive GWG was conducted separately for each BMI category. The cut-points for inadequate GWG according to the Institute of Medicine (IOM) guidelines are less than 12.5, 11.5, 7.0, and 5.0 kg for underweight, normal, overweight, and obese women, respectively. The cut-points for excessive GWG are more than 18, 16, 11.5, and 9.0 kg for underweight, normal, overweight, and obese women, respectively. Following this classification, overweight and obese participants were combined into a single "overweight/obese" group for subsequent statistical analyses. The proportions of inadequate, adequate, and excessive GWG were derived by aggregating the individually classified outcomes within this combined group.

Fat taste sensitivity was measured using the ascending forced choice method (3-AFC) (15). The details of the procedure have been reported previously elsewhere (9).

Dietary intake data were collected using a food frequency questionnaire (FFQ), which recorded the frequency and portion size of food and beverage consumption over a specific period. The FFQ was developed and validated for assessing dietary intake among Malaysian adults (16). The FFQs were administered through interviews conducted by the same interviewer to maintain consistency and minimise interviewer bias. The Nutritionist Pro™ software (version 7.8.0 Axxya Systems, version 2020, Redmond, USA) was used to estimate daily energy and nutrient intake. The nutrient values were compared to the Recommended Nutrient Intake (RNI) for Malaysian pregnant women (17) and categorised into these groups: 1) Inadequate, (below the estimated average requirement; 2) Adequate, (between the estimated average requirement and tolerable upper intake level), and 3) Excessive, (over the tolerable upper intake level). Estimation of under and over reporting of dietary data was assessed to minimise measurement bias related to dietary intake, using the Goldberg cutoff method (18) by comparing the ratio of reported energy intake to basal metabolic rate. Basal metabolic rate was calculated based on age and gender specific (19). Participants with ratio of less than 1.2 were classified as under reporters while ratio of more than 2.4 was classified as over reporters. To assess the impact of misreporting, a sensitivity analysis was conducted by excluding under-reporters, and the main findings remained unchanged.

Statistical analysis

The acquired data were analysed using the Statistical Package for Social Science (SPSS) software, version 29. There was no missing data. A *p*-value of < 0.05 was considered statistically significant and results were expressed as means ± standard deviation. The data's normality was assessed using skewness and kurtosis measurements (20). An independent two-sample t-test was employed to determine significant differences between two groups despite some variables showing deviations from normality, in accordance with the Central Limit Theorem (21). A Mann–Whitney U test was further conducted to ensure the validity of the findings, and the results were consistent with those obtained from the t-test. Therefore, the t-test results were presented for consistency and ease of interpretation.

Results

The fat taste sensitivity assessment categorised 17 and 63 participants into hyposensitive and hypersensitive groups, respectively, within the healthy weight category. In contrast the overweight/ obese group comprised 39 hyposensitive and 41 hypersensitive individuals. Detailed sample characteristics have been presented elsewhere (9). Table 1 presents the nutrient intakes of healthy weight and overweight/obese participants. No significant differences ($p > 0.05$) were observed between hyposensitive and hypersensitive individuals in terms of energy and carbohydrate in either group. Similarly, no significant differences ($p > 0.05$) were found between sensitivity groups in the healthy weight category for any of the nutrients.

Conversely, in the overweight/obese group, significant differences ($p < 0.05$) were identified in the intake of protein ($p = 0.02$), total fat ($p = 0.012$), saturated fatty acids (SFA) ($p = 0.005$), polyunsaturated fatty acids (PUFA) ($p = 0.042$), and monounsaturated fatty acids (MUFA) ($p = 0.016$) between hyposensitive and hypersensitive participants. Furthermore, significant differences ($p < 0.05$) were also observed for certain micronutrients, namely vitamin B6, vitamin E, magnesium, and zinc. Notably, hyposensitive individuals reported higher intakes for all nutrients showing significant differences. No significant differences were observed for the remaining micronutrients in either group. Underreporting was observed in 11% of healthy weight and 18% of overweight/obese participants while no over-reporting was detected (data not shown).

The adequacy of macronutrient intake revealed that both healthy weight and overweight/obese participants, irrespective of fat taste sensitivity, had insufficient energy intake to support pregnancy (Table 2). The highest rate of energy inadequacy (94.9%) was recorded among hypersensitive- overweight/obese participants.

Carbohydrate adequacy, by contrast, tended to fall within the adequate or excessive category. In the

Table 1. Comparison of dietary intake between hyposensitive and hypersensitive respondents for healthy weight and overweight/obese participants

	Healthy weight			**Overweight / Obese**		
Nutrient	**Hyposensitive (n =17)**	**Hypersensitive (n = 63)**	***p*-value**	**Hyposensitive (n = 39)**	**Hypersensitive (n = 41)**	***p*-value**
Energy intake (kcal/day)	1966.75 ± 389.12	1929.14 ±296.58	0.713	1925.73 ± 319.84	1857.42 ± 317.42	0.170
Carbohydrate (g/day)	276.49 ± 54.31	275.56 ± 54.88	0.950	270.34 ± 49.39	286.75 ± 45.20	0.126
Protein (g/day)	83.21 ± 16.40	81.70 ± 10.13	0.718	81.50 ± 18.90	68.83 ± 15.82	**0.002**
Fat (g/day)	58.64 ± 18.77	55.56 ± 11.02	0.520	57.58 ± 15.83	48.33 ± 16.44	**0.012**
SFA (g/day)	23.38 ± 8.02	22.13 ± 5.18	0.543	23.99 ± 6.24	19.52 ± 7.55	**0.005**
MUFA (g/day)	22.70 ± 7.50	21.91 ± 4.50	0.682	22.47 ± 6.53	18.85 ± 6.57	**0.016**
PUFA (g/day)	10.21 ± 3.43	9.99 ± 1.68	0.799	10.08 ± 3.76	8.61 ± 2.48	**0.042**
Vitamin A (mg/day)	1.18 ± 0.36	1.13 ± 0.20	0.583	1.07 ± 0.48	0.92 ± 0.33	0.146
Vitamin B6 (mg/day)	1.49 ± 0.57	1.41 ± 0.45	0.629	1.30 ± 0.77	0.76 ± 0.57	**<0.001**
Vitamin B12 (μg/day)	2.52 ± 0.92	2.24 ± 0.58	0.133	2.14 ± 0.72	1.89 ± 0.68	0.119
Vitamin C (mg/day)	147.44 ± 65.64	169.69 ± 120.04	0.472	153.49 ± 139.25	117.80 ± 42.11	0.124
Vitamin D (μg/day)	12.10 ± 1.93	11.94 ± 1.52	0.762	11.85 ± 1.89	11.36 ± 2,31	0.300
Vitamin E (mg/day)	2.76 ± 0.74	2.62 ± 0.14	0.466	2.69 ± 0.62	2.28 ± 0.36	**<0.001**
Calcium (mg/day)	649.31 ± 188.97	636.85 ± 159.52	0.804	685.32 ± 270.82	634.89 ± 188.09	0.339
Magnesium (mg/day)	317.72 ± 28.72	316.88 ± 23.67	0.911	293.87 ± 46.01	267.07 ± 31.85	**0.003**
Iron (mg/day)	21.27 ± 5.33	19.49 ± 2.88	0.072	19.45 ± 5.99	19.83 ± 7.01	0.793
Zinc (mg/day)	10.52 ± 1.86	10.12 ± 1.36	0.323	10.37 ± 1.64	9.59 ± 0.64	**0.007**

Values presented are means ± standard deviation

Bold values indicate significance difference at $p < 0.05$ (independent two sample t-test)

Table 2. Comparison of macronutrients and gestational weight gain adequacy between hyposensitive and hypersensitive respondents for healthy weight and overweight/obese participants

	Healthy weight						Overweight / Obese					
	Hyposensitive (n =17)			Hypersensitive (n = 63)			Hyposensitive (n = 39)			Hypersensitive (n = 41)		
	Inadequate (%)	Adequate (%)	Excessive (%)	Inadequate (%)	Adequate (%)	Excessive (%)	Inadequate (%)	Adequate (%)	Excessive (%)	Inadequate (%)	Adequate (%)	Excessive (%)
Energy intake	60.8	14.3	15.9	76.5	11.8	11.8	75.6	17.1	7.3	94.9	0.0	5.1
Carbohydrate	7.9	87.3	4.8	5.9	88.2	5.9	19.5	63.4	17.1	2.6	64.1	33.3
Protein	0.0	93.7	6.3	0.0	100.0	0.0	0.0	87.8	12.2	0.0	97.4	2.6
Fat	54.8	24.2	21.0	47.1	35.3	17.6	34.1	46.3	19.5	69.2	25.6	5.1
Gestational weight gain	61.9	34.9	3.2	47.1	47.1	5.9	87.8	12.0	0.0	89.7	10.3	0.0

healthy weight group, both hyposensitive and hypersensitive participants showed more than 80% adequacy. Although the overweight/obese group, displayed slightly lower adequacy percentages (around 60%), excessive carbohydrate intake was more prevalent (17.1% and 33.3% for hyposensitive and hypersensitive participants, respectively).

Protein intake adequacy was high across both BMI groups. The hypersensitive-healthy weight group achieved 100% adequacy. However, fat intake inadequacy was widespread. Among healthy participants, 54.8% of hyposensitive and 47.1% of hypersensitive participants did not achieve the minimum recommended intake for fat. A similar pattern was observed in the overweight/obese group, where hypersensitive participants had the highest rate of inadequate fat (69.2%).

According to Table 2, GWG adequacy was not achieved by 61.9% and 47.1% of hyposensitive and hypersensitive participants, respectively, in the healthy weight group. The situation was more concerning among overweight/obese participants, with 87.8% and 89.7% of hyposensitive and hypersensitive participants, respectively, exhibiting inadequate GWG.

Discussion

Previous studies have reported that a higher BMI individuals tend to exhibit reduced fat taste sensitivity (8,12). However, these studies were often conducted with mixed BMI populations. By analysing healthy weight and overweight/obese participants separately, the present study identified inter-individual variability in the fat taste sensitivity within both BMI categories. Both groups included hyposensitive and hypersensitive individuals, indicating that diversity exists even among individuals grouped in the same BMI category. This finding suggests that obesity does not necessarily equal to reduced sensitivity.

Dietary intake analysis revealed that significant differences between hyposensitive and hypersensitive individuals occurred only in the overweight/obese group. No such differences were identified in the healthy weight category. This suggests that fat taste sensitivity more substantially influences dietary intake in individuals with higher BMI. Therefore, fat taste sensitivity may be a dietary intake detriment in overweight/obese, but not among healthy weight individuals.

The elevated intake of macronutrients among hyposensitive individuals in the overweight/obese group supports previous research linking reduced oral detection of fatty acids in the oral cavity to increased energy and fat consumption (8,22). The absence of such a relationship in the healthy weight group suggests that BMI or related physiological processes may mediate this association. Obesity is associated with several physiological and behavioural changes, including disrupted appetite regulation and chronic low-grade inflammation (23). Inflammatory processes caused by obesity may impair taste bud function by disrupting their renewal and apoptosis cycles, thereby diminishing sensitivity (24). Habitual high-fat consumption can also reduce oral fat sensitivity over time, further altering food preferences and intake.

With respect to micronutrient intake, the higher vitamin E consumption among hyposensitive- overweight/obese individuals may reflect their increased total fat intake, as vitamin E is fat-soluble and abundant in fatty foods and plant oils. Thus, greater selection and consumption of fat-rich foods increase the intake and dietary bioavailability of vitamin E (25). Similarly, elevated intakes of magnesium, zinc, and vitamin B6 may result from greater consumption of energy-dense and nutrient-rich foods such as nuts, seeds, animal protein, and whole grains (26).

Although hyposensitive individuals in the overweight/obese group consumed significantly more nutrients, this does not necessarily indicate that their intake met recommended levels. Given that the participants were pregnant women, and previous studies have reported widespread nutrient inadequacy during pregnancy (27), it remains critical to assess adequacy. Sufficient nutrient consumption during pregnancy is essential to minimise risks such as unhealthy GWG, anaemia, pre-eclampsia, gestational diabetes mellitus and preterm births (28).

The present study revealed similar intake trends across BMI groups. Carbohydrate and protein adequacy levels were generally high, aligning with findings that Malaysians often exceed protein intake recommendations (29). In contrast, both energy and fat were inadequate. This corresponds with prior findings of insufficient energy intake among pregnant Malaysian women (7,30). However, while those studies reported excessive fat intake, the present findings indicate the opposite. The observed low intake of energy and fat appears to be reflected in the inadequate GWG recorded.

This study found a high prevalence of inadequate GWG, especially among overweight/obese women, despite prior reports indicating higher or excessive GWG among overweight and obese women (31). Some studies did report such inadequacy but predominantly in healthy weight individuals (5,6). It is quite unlikely to find obese pregnant women with lower inadequacy of GWG than the healthy weight pregnant women, as observed in this study. The unexpected trend may reflect participants' awareness of the risks associated with excessive GWG or a shift in dietary patterns. Weight-related concerns are influenced by complex interactions involving genetics, ethnicity, socioeconomic status, and environmental factors (32). Previous research has linked stress and anxiety during pregnancy with reduced GWG (33).

Despite the frequent focus on excessive GWG, inadequate GWG and its risk factors have received little attention (34). However, similar to excessive GWG, inadequate GWG has been associated with adverse outcomes for pregnant women. This claim is supported by a study that reported inadequate GWG among overweight and obese pregnant women results in increased risk of small-for-gestational-age (SGA) infants and reduced neonatal fat mass and lean body mass (35). An in-depth qualitative study reported that diabetic pregnant women in Malaysia expressed fear, low mood, and uncertainty, leading to over-restriction of their diet to control blood glucose levels (36). Although none of the participants in this study had medical complications such as diabetes, it remains possible that the overweight/obese group restricted dietary intake, due to concern over potential complications. High pre-pregnancy BMI is associated with increased risk of adverse pregnancy outcomes, including gestational diabetes mellitus and pre-eclampsia (37). While excessive GWG in obese women is a common concern, the present findings suggest that inadequate GWG also warrants clinical attention. Healthcare providers should continue to advocate for balanced, guideline-aligned weight gain during pregnancy.

This study has some limitations. Fat taste sensitivity was measured at a single time point, potentially limiting generalisability. Thus, findings may not generalise to non-Malay populations or different regions in Malaysia. While the findings suggest suboptimal energy and fat intake, these results should be interpreted with caution. The FFQ used in this study was not specifically validated for pregnant women and thus may not fully capture pregnancy-related dietary patterns such as increased snacking and food aversion. Selection bias may arise from the convenience sampling method, and therefore the results may not be fully generalisable to all pregnant women in Malaysia. Nevertheless, the focus on pregnant women, who are frequently underrepresented in fat taste sensitivity research, provides novel insight. The separation of healthy weight and overweight/obese groups enabled better identification of within-group variability in fat taste sensitivity.

Conclusion

The study underscores the intricate relationship between fat taste sensitivity, dietary intake, and GWG in pregnant women. Fat taste sensitivity appeared to influence nutrient intake primarily in the overweight/obese group, which exhibited significant differences between hyposensitive and hypersensitive individuals. Contrary to the prevailing concern over excessive GWG among overweight/obese women, a higher prevalence of inadequate GWG was observed, accompanied by low energy and fat intake. Future research should consider integrating taste sensitivity with behavioural and physiological factors while addressing maternal nutrition as well as developing nutrition interventions tailored to different BMI categories, with the aim to promote optimal nutrient intake and healthy GWG.

From a practical perspective, particularly in antenatal care, the utilisation of the 3-AFC fat taste sensitivity test may provide a novel method for identifying pregnant women at risk of suboptimal dietary intake, especially those with obesity. Hyposensitive individuals may benefit from strategies aimed at enhancing fat perception and regulating intake, while hypersensitive individuals might require assistance to ensure they consume adequate energy and fat. However, the integration of the 3-AFC test as a screening tool in standard antenatal care necessitates further validation. Additionally, considerations such as the training of healthcare professionals and the consistency of testing techniques are essential for ensuring effective implementation.

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