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Consumption of ultra-processed foods in the third gestational trimester and increased weight gain: a Brazilian cohort study

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Abstract

Objective: To investigate whether the consumption of ultra-processed foods (UPF) during pregnancy is associated with gestational weight gain (GWG).

Design: Cohort study with collection of two 24-h dietary recalls during each gestational trimester obtained on non-consecutive days and differentiating weekday *v.* weekend/holiday. The foods were classified according to the NOVA system into fresh or minimally processed foods and their culinary preparations, processed and UPF and subsequently analysed as a percentage contribution to dietary energy. The outcome was average GWG in the second and in the third trimesters, expressed in g/week.

Setting: Botucatu, a medium-sized Brazilian city.

Participants: Pregnant women with regular obstetric risk (*n* 259) undergoing prenatal care in primary healthcare.

Results: In a multiple linear regression model, it was found that an increase of 1 percentage point in energy consumption from UPF in the third gestational trimester led to an average increase of 4·17 (95 % CI 0·55; 7·79) g in weekly GWG in this period. There was no association between second-trimester UPF consumption and GWG.

Conclusions: Consumption of UPF in the third gestational trimester is positively associated with average weekly GWG in this period.

Keywords
Pregnancy
Gestational weight gain
Pregnancy nutrition
Ultra-processed food
Food processing

Ultra-processed foods (UPF) are defined as formulations resulting from various industrial processes, produced from foods or other sources, but which contain very little or no food and are commercialised and ready for consumption or heating[1–3]. Sugary drinks, snack foods, sausages, chocolates and ice cream are some of the foods in this group.

Despite being a new topic in the scientific literature, the investigation of the health effects of UPF consumption has been the focus of growing attention due to negative impacts found in adults, elderly and teenagers[1,4–8]. Consumption of these foods has been linked to obesity. The prevalence of obesity in European countries increases by 0·25 % with each percentage point increase in the availability of UPF[9]. A systematic literature review found a relationship between increased body fat during childhood and adolescence and consumption of this food group[10]. UPF consumption was associated with an increased risk of being overweight and obese in a cohort of adult Spanish patients[11]. Similar results were also found in Brazil among adolescents and adults[12–14].

The investigation of the effects of UPF consumption in pregnant women is still in its initial phases[15–17]. We found only one study investigating its effects on obstetric outcomes, a small study of forty-five American pregnant women. In it, each one-point increase in the percentage of UPF-derived dietary energy increased the average gestational weight gain (GWG) by 1·33 kg[15]. Excessive GWG is considered an adverse obstetric outcome as it is associated with increased risks for diabetes and gestational hypertension, large for gestational age infants, macrosomia, caesarean section and higher postpartum weight retention rates[18–20]. Thus, discovering the determinants of excessive GWG is highly relevant to addressing obstetric complications and targeted prenatal guidance.

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The hypothesis that diets with higher percentages of energy from UPF may be associated with greater gestational weight gain is pertinent and deserves to be investigated in different contexts. UPF, in general, are highly palatable and high energy density foods[21], and it is plausible that excessive consumption increases maternal weight gain and thus negatively influences the health of the mother–baby binomial. This is especially true in obesogenic environments, which are now found throughout most of the world[22].

Given the high rates of excessive GWG during pregnancy[18,23–27], and the increasing consumption of UPF foods in low- and middle-income countries, the current study aims to investigate whether the consumption of UPF during pregnancy is associated with weekly GWG.

Methods

Study design and population

The current article's data come from a cohort study with pregnant women with regular obstetric risk, followed from the first gestational trimester to childbirth in the municipality of Botucatu, located in the state of São Paulo, Brazil. During the study period, the city had approximately 135 000 inhabitants and a Human Development Index of 0·800, higher than the Brazilian average of 0·744[28].

Recruitment for the cohort took place between November 2012 and June 2013. During this period, all pregnant women over 18 years and in the first trimester who enrolled prenatally in the seventeen primary healthcare units of the public health system of the municipality were invited to participate in the study.

Briefly, two cohorts of pregnant women were formed, one attended by professionals who took part in educational activities (classes and workshops, totaling 16 h) to prepare them for the promotion, in their prenatal consultations, of five food intake practices (consumption of three fruits daily; consumption of two portions of vegetables and beans at least 5 d a week; sporadic or zero consumption of soda and industrialised cookies) and stimulation of leisure walking at least 5 d a week. Pregnant women attended by professionals who did not take part in this training session formed the control cohort[29,30].

The eligibility criteria for the current study followed the same criteria as the original study, excluding pregnant women who had diseases or complications identified during the study, such as diabetes, hypertension, heart disease, being pregnant with twins or any adverse condition that implied a need for rest, reduced physical activity or changes in their diet.

After capturing 353 pregnant women at the beginning of pregnancy, data from 281 and 267 pregnant women were obtained in the second and third trimesters, respectively. The percentage of refusals was only 2·0 %, with the remaining losses due to abortions (7·4 %), patients moving to another city (3·7 %) or changing location of prenatal care (private 4·8 % and/or high risk 5·1 %) and premature births (0·9 %). Only 0·6 % of the patients were not found in their houses to be interviewed. The analyses presented in the current article included pregnant women from both cohorts for which valid data on food intake, gestational weight gain and birth weight of the child were obtained (n 259).

Data collection

Data collection took place from November 2012 to February 2014. Interviews were conducted with pregnant women at three stages: first trimester (<14 gestational weeks), second trimester (24–27 gestational weeks) and third trimester (31–34 gestational weeks). The interviews took place in person and by telephone, and the face-to-face interviews involved data collection on health, obstetric and lifestyle issues, as well as the collection of a 24-h food recall (R24h).

Gestational weight gain

After all babies were born, the weight and gestational age data for each prenatal visit were obtained in the pregnant women's health records. Based on these data, the average GWG per week in the second and third gestational trimesters was calculated using the method established by the Institute of Medicine[31] (i.e., difference between the last and the first weight measured in each trimester of pregnancy (second and third), divided by the number of gestational week in this interval). The average weekly GWG in each trimester was expressed in g/week.

Just to describe the sample, we also classify the weekly GWG as insufficient, adequate and excessive according to the same reference[31], but considering GWG during second and third trimesters together, what is more usual in the literature[26,31,32]. This evaluation required the calculation of each patient's pre-gestational BMI and their classification into underweight, normal weight, overweight and obese[33]. To this end, weight before pregnancy and height were also obtained from the medical records.

In order to avoid errors in this classification due to under- or overestimation of pre-gestational weight, the pre-gestational weight recorded in the medical records (usually self-reported) was compared with the first weight measured in the first gestational trimester, the latter being considered when the difference was >2 pounds[34,35].

The option to take average weekly GWG in the second and in the third trimesters of gestation as the outcome was due to the fact that this period, which goes from the 14th to the 42nd gestational week, is recognised as the phase of greatest maternal and newborn weight gain and which most influences their health[31]. The alternative – assessing total gestational weight gain – was not considered because it is not usual in Brazilian maternity hospitals to weigh pregnant patients upon arrival for hospitalisation for childbirth. Thus, we did not have information about the patients' final weights.

Food consumption

Aiming at guaranteeing the quality of the food consumption data in relation to the usual food consumption during pregnancy, there was strict control in the collection of the R24h. In each trimester, two R24h were collected. The first food recall was obtained in a face-to-face interview, and the second by telephone. They referred to non-consecutive days and different periods of the week: weekday *v.* weekend/holiday. In addition, to reduce dietary measurement errors, they were applied according to the *Multiple Pass Methods*[36].

The inclusion of food intake data was performed in the *Nutrition Data System for Research* software, 2010 version, with previous standardisation and quantification of foods and preparations in g or ml according to Brazilian home measurement tables[37,38]. Consistency analyses were performed concurrently with data entry, with special attention to *outliers* for portions, weights, energy and nutrients.

To evaluate the extension and purpose of processing, the *NOVA* classification was used as follows: (i) unprocessed or minimally processed foods (ii) processed culinary ingredients, (ii) processed foods and (iv) UPF and beverages[2]. Homecooked meals were grouped with fresh foods (we did not break down the recipes into their ingredients). Foods were therefore classified into three groups: (i) fresh or minimally processed foods and their culinary preparations, (ii) processed foods and (iii) UPF[3,6].

To classify the foods, we initially grouped them according to previous Brazilian studies which also adopted *NOVA*[39,40]. The complete description of food groups and their categorisation according to NOVA can be found in a previous publication[30]. Briefly, in group (i), we include fresh or minimally processed foods and their culinary preparations, such as rice; beans and other legumes; fresh fruits and juices; vegetables, roots and tubers; cereals such as oats, corn and flour; meat – beef, pork, poultry, fish and seafood; homemade cakes, pastries and savoury pies with minimally processed ingredients. Group (ii) included processed foods: French bread, processed cheeses, canned vegetables, processed jams such as jams and marmalades, and processed meat and fish. Group (iii) was made up of UPF: savoury and sweet biscuits, with or without filling; snacks; ultra-processed candies such as candies and chocolates; ultra-processed breads; ultra-processed meats such as sausage; ready-to-eat meals; sodas and juices; sweeteners and powder mixtures for drinks and other beverages.

Since we obtained two R24h per participant per gestational trimester, we considered the average energy and the energy percentage coming from each of the food groups in the analyses as continuous variables. Those pregnant women who had only one R24h had the value of this single R24h considered as the reference of the trimester (only 2·1 % of the total R24h were not obtained due to unsuccessful telephone contact). Exposure variables of interest were the percentage of UPF-derived dietary energy in the second and third gestational trimesters.

Statistical analysis

We performed descriptive analyses of the average energy percentage from the different NOVA and their respective constituent foods in each gestational trimester. The percentage of UPF in the second and in the third trimesters according to the socio-economic, obstetric and anthropometric characteristics of the cohort participants was calculated using a variance test. Descriptive GWG analyses were also carried out, and the normality of this variable was tested with the *Kolmogorov–Smirnov* test.

As GWG is a multidetermined event, covariates cited in the literature as possibly associated with weight gain during pregnancy[31] were evaluated. They are living with a partner; works outside the home; socio-economic status (divided into class B, class C and class D/E, according to the classification criteria provided by the Brazilian Association of Research Institutes, which is divided into classes A, B, C, D and E, from highest to lowest, considering both household assets – i.e., cars, televisions, washing machines, etc. – and education level of the head of household[41]); years of schooling; age; skin colour (white and non-white) parity (primiparous, one birth, two or more births) and pre-gestational BMI[33].

Thus, the effect of the energy percentage from UPF consumed in the second and in the third gestational trimesters on the average GWG per week in the second and in the third trimesters, respectively, was investigated by linear regression models, first with univariates and then adjusted for selected potential confounding effects. Variables with $P < 0{\cdot}25$[42] in univariate analyses were included in the multivariate model. The covariables that met this criterion were included together in the multivariate model and maintained regardless of the statistical significance they presented. The cohort variable (A or B) was included in model adjustment to control the effect of the intervention of the matrix study[29].

Total energy consumption in the second and third trimesters was not included as a covariate, since our hypothesis was that this variable was in the causal pathway (thus being a mediator) between the consumption of UPF and the pregnant woman's weight gain[12]. However, we evaluated the association between total energy intake and both UPF consumption and weight gain to explore the potential mediating effect of total energy intake in the association between UPF consumption and weight gain. All analyses

Table 1 Average energy contribution (%) of food subgroups, grouped according to the NOVA classification, in gestational trimesters and throughout pregnancy (*n* 259), Botucatu, Brazil 2012–2014

	First trimester		Second trimester		Third trimester		All pregnancy	
Groups	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Unprocessed and minimally processed foods and preparations	67·5	0·9	67·5	0·9	66·4	0·9	67·1	0·6
Rice	10·8	7·1	12·3	7·8	11·9	7·2	11·7	7·4
Grains	9·2	10·6	6·9	8·8	6·1	8·5	7·4	9·3
Red meat	6·8	7·7	7·2	8·5	6·6	7·7	6·9	8·0
Milk and plain yogurts	6·4	5·9	7·5	5·5	7·4	5·5	7·1	5·6
Beans and other vegetables	5·7	5·9	5·8	5·7	7·4	7·7	6·3	6·5
Poultry and pork	4·8	6·5	5·4	6·2	4·7	6·2	4·9	6·3
Fresh fruits and fruit juices	4·7	5·5	4·3	5·1	4·4	5·0	4·5	5·2
Homemade/unprocessed sweets	3·3	6·7	3·7	6·8	4·7	7·7	3·9	7·1
Minimally processed savoury snacks	3·3	6·7	3·7	6·8	4·7	7·7	3·9	7·1
Roots and tubers	3·1	5·8	2·8	5·1	2·6	5·0	2·8	5·3
Vegetables	2·2	5·0	1·2	2·3	1·3	3·1	1·6	3·5
Eggs	0·6	1·6	0·8	2·2	0·9	2·1	0·8	2·0
Seafood	0·3	1·6	0·3	1·5	0·4	2·0	0·3	1·7
Other minimally processed foods	5·3	4·5	5·4	4·6	5·4	4·8	5·4	4·6
Processed foods	7·2	0·4	8·7	0·4	8·6	0·4	8·1	0·3
French bread	5·7	5·5	6·8	5·9	6·9	6·1	6·5	5·8
Homemade sweets	0·6	2·2	1·0	2·9	0·8	2·4	0·8	2·5
Processed cheeses	0·6	1·8	0·5	1·3	0·4	1·1	0·5	1·4
Vegetable and preserved vegetable	0·2	1·2	0·2	1·3	0·2	1·4	0·2	1·3
Processed meats	0·2	1·2	0·3	1·1	0·2	1·1	0·2	1·2
Ultra-processed foods	25·3	0·9	23·8	0·9	25·0	0·9	24·8	0·6
Cookies and ultra-processed sweets	5·5	7·2	7·7	9·6	7·1	9·0	6·7	8·6
Sugar-sweetened beverages	5·1	5·2	3·9	4·4	4·9	4·9	4·6	4·8
Reconstituted meats	3·1	5·3	2·8	4·4	3·7	4·9	3·2	4·9
Crackers and packaged chips	3·2	5·2	3·1	5·2	2·4	4·9	2·9	5·1
Frozen dinners	3·3	6·8	2·0	4·6	2·1	5·3	2·5	5·6
Other ultra-processed foods	1·9	2·6	2·0	2·5	1·9	2·3	1·9	2·4
Other beverages	1·8	5·2	1·0	3·0	1·4	3·5	1·4	3·9
Ultra-processed breads	1·4	3·1	1·3	2·6	1·5	3·6	1·4	3·1

were performed using STATA version 14.2, considering $P < 0{\cdot}05$ as the level of statistical significance.

Results

The average energy consumption of pregnant women during pregnancy (all trimesters together) was 7962·152·9 (SD 1948·0704) kJ, out of which 67·1 % was classified in the minimally processed and culinary preparations group, 8·1 % in the processed foods groups and 24·8 % in the UPF groups. UPF consumption in each gestational trimester was stable: in the first, on average 25·3 % of consumed energy came from UPF, with rates of 23·8 and 25·0 % in the second and third gestational trimesters, respectively (Table 1). The minimum UPF consumption rate was 0 % of the total energy intake per day in all three trimesters, peaking at 73·1, 72·3 and 72·8 % in the first, second and third trimesters, respectively (data not shown in table).

Table 1 also presents the energy contribution of specific foods, according to the NOVA classification categories. On average, rice had the largest energy contribution in the 'Unprocessed and minimally processed foods and culinary preparations' group in all trimesters and considering the whole pregnancy. In the 'Processed foods' group, 'French' bread[1] was responsible for the largest energy supply. Ultra-processed cookies and sweets contributed the most to energy consumption in the 'Ultra-processed foods' group.

Table 2 describes the average percentage of UPF-derived energy in the second and third gestational trimesters according to maternal characteristics. In the second as well as in the third trimesters, the UPF energy contribution was higher among the youngest pregnant women, those with more years of education and among primiparous women. Working outside the home, living without a partner and having excessive weekly gestational weight gain were characteristics of pregnant women with higher UPF consumption in the third trimester, but who did not show differences in this consumption in the second. Women who started pregnancy with obesity had lower consumption of UPF in the second trimester, which did not remain in the third trimester.

[1]T.N.: 'French bread' (*pão francês*) is the most common Brazilian bread, known with different names in different regions of the country (pão de sal, pãozinho, cacetinho, etc.). It is typically bought fresh-baked from bakeries.

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Table 2 Average percentage of ultra-processed food (UPF)-derived energy according to socio-economic, obstetric and anthropometric characteristics of the cohort participants, Botucatu, SP, 2012–2014 (*n* 259)

	Frequency		UPF consumption second trimester			UPF consumption third trimester		
Characteristics	*n*	%	Average	95 % CI	*P**	Average	95 % CI	*P**
Age (years)					0·021			<0·001
18–19	34	13·1	28·4	24·1, 32·7		30·1	24·7, 35·5	
20–30	161	62·2	24·2	22·1, 26·4		26·0	23·8, 28·2	
≥30	64	24·7	20·3	16·7, 23·9		19·6	16·6, 22·5	
Schooling (years)					0·011			<0·001
11	132	51·0	25·8	23·5, 28·1		27·9	25·5, 30·3	
8–11	72	27·8	23·8	20·2, 27·4		24·2	20·6, 27·8	
<8	55	21·2	19·1	15·6, 22·6		18·9	16·0, 21·7	
Socio-economic classification*					0·388			0·071
Class B	23	9·1	26·6	20·9, 32·3		25·7	20·4, 31·1	
Class C	173	68·4	23·5	21·4, 25·6		26·3	24·2, 28·4	
Classes D + E	57	22·5	22·9	19·2, 26·7		21·2	17·5, 24·9	
Works outside the home					0·630			0·048
Yes	124	47·9	24·3	21·8, 26·7		26·7	24·2, 29·3	
No	135	52·1	23·4	21·0, 25·8		23·3	21·0, 25·6	
Lives with a partner					0·437			0·010
Yes	192	74·1	23·4	21·4, 25·4		23·6	21·7, 25·5	
No	67	25·9	24·9	21·5, 28·5		28·8	25·1, 32·4	
Parity					0·006			0·005
0	108	40·5	25·8	23·1, 28·5		27·0	24·1, 29·8	
1	73	27·3	25·6	22·1, 29·1		26·4	23·3, 29·5	
≥2	86	32·2	20·1	17·4, 22·8		20·9	18·3, 23·6	
Skin colour					0·307			0·207
White	164	63·3	24·5	22·3, 26·7		25·8	23·6, 28·0	
Not white	95	36·7	22·6	20·0, 25·3		23·5	20·8, 26·2	
Pre-gestational nutritional status†‡					0·026			0·248
Underweight	12	4·6	25·1	16·9, 33·4		27·4	9·4, 35·5	
Eutrophic	132	51·0	25·0	22·4, 27·5		26·0	23·6, 28·3	
Overweight	68	26·3	25·2	21·9, 28·6		24·8	21·4, 28·2	
Obese	47	18·1	18·2	14·7, 21·7		21·5	17·3, 25·0	
Adequacy of gestational weight gain§					0·689			0·048
Insufficient	55	21·2	22·4	18·7, 26·1		21·0	17·6, 24·4	
Adequate	66	25·5	24·5	20·7, 28·3		25·0	21·5, 28·4	
Excessive	138	53·3	24·1	21·8, 26·3		26·5	24·1, 28·9	

*One-way ANOVA.
†Differences refer to missing data.
‡WHO, 1995[33].
§Institute of Medicine, 2009[31].

The average weekly weight gain in the period from the beginning of the second to the end of the third trimester of gestation was 441·2 (SD 197·7) g/week; 21·2 % had insufficient GWG, whereas 25·5 % had adequate and 53·3 % excessive GWG. Pregnant women gained on average 483·37 (SD 23·6) g/week and 445·3 (SD 24·0) g/week in the second and in the third trimesters, respectively (data not shown). Table 3 presents the crude and adjusted analyses of the effect of the percentage of energy derived from UPF during the second and third gestational trimesters on average weekly GWG in each trimester. The energy percentage derived from UPF in the second trimester was not associated with GWG in the second trimester in crude ($P = 0·861$) or in adjusted analysis ($P = 0·409$). On the other hand, from the crude analysis, the energy percentage derived from UPF in the third trimester of pregnancy was positively associated with the average weekly GWG in this period ($\beta = 6·21$; 95 % CI 2·94, 9·49). In the adjusted analyses, this association remained significant: the increase of 1 percentage point from UPF in the third gestational trimester corresponded to an increase of 4·17 g in the average weekly GWG in the third trimester ($\beta = 4·17$; 95 % CI 0·55, 7·79).

There was no association between total energy consumption in the second trimester and GWG during this period ($\beta = 0·07$; 95 % CI −0·01, 0·15; $P = 0·091$), but there was an association in the third trimester ($\beta = 0·12$; 95 % CI 0·05, 0·19; $P < 0·001$). The energy percentage from UPF in the second and third trimesters was associated with total energy consumption in the same periods (second trimester: $\beta = 0·01$; 95 % CI 0·004, 0·01; $P < 0·001$; third trimester: $\beta = 0·01$; 95 % CI 0·004, 0·01; $P < 0·001$) (data not shown in table).

Discussion

The hypothesis of an association between UPF consumption and GWG was confirmed in the third gestational trimester. During this period, with each percentage point

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Table 3 Effect of ultra-processed food (UPF)-derived energy percentage during the second and third gestational trimesters on weekly gestational weight gain according to trimester, Botucatu, Brazil, 2012–2014 (*n* 259)

	GWG during second trimester						GWG during third trimester					
	Crude model			Adjusted model*			Crude model			Adjusted model*		
Variables	β	95 % CI	*P*	β	95 % CI	*P*	β	95 % CI	*P*	β	95 % CI	*P*
UPF consumption – second trimester (% energy)	−0·29	−3·61, 3·02	0·861	−1·50	−5·08, 2·08	0·409						
UPF consumption – third trimester (% energy)							6·21	2·94, 9·48	<0·001	4·17	0·55, 7·79	0·024
Gestational age at the last weighing	5·75	−11·79, 23·29	0·519				−10·70	−9·95, 31·35	0·308			
Age (years)	−1·44	−9·46, 6·57	0·723				−10·37	−18·48, −2·26	0·012	−3·36	−13·19, 6·47	0·501
Schooling (completed years)	13·75	−2·44, 29·95	0·096	7·04	−11·37, 25·46	0·452	17·72	1·06, 34·39	0·037	−1·58	−20·88, 17·72	0·872
Socio-economic classification	−19·80	−60·01, 20·41	0·333				−50·21	−88·75, −11·66	0·011	−41·70	−81·79, −1·62	0·042
Works outside the home	−37·18	−130·29, 55·92	0·432				−37·35	−134·11, 55·42	0·414			
Lives with a partner	6·60	−97·97, 111·17	0·901				86·91	−19·21, 193·03	0·108	32·96	−75·98, 141·91	0·552
Parity	−28·74	−63·38, 5·91	0·104	−16·95	−55·23, 21·34	0·384	−67·33	−102·25, −32·42	<0·001	−42·57	−87·31, 2·18	0·062
Skin colour	−72·96	−170·12, 24·19	0·140	−78·08	−176·82, 20·67	0·121	5·30	−93·68, 104·27	0·916			
Pre-gestational BMI	−13·40	−21·99, −4·80	0·002	−12·50	−21·73, −3·26	0·008	−4·85	−13·86, 4·15	0·289			

GWG, gestational weight gain.
*Cohort-adjusted multiple linear regression.

increase in UPF-derived energy in the third gestational trimester, the weekly GWG in the third gestational trimester increased 4·17 g. In other words, if we multiply this weight increase by the 12 weeks that make up the third gestational trimester, the average effect would be 50 g for each additional point of energy derived from UPF during this period. Thus, comparing the 25th percentile (14·1 %) and the 75th percentile (35·0 %) of third-trimester UPF energy percentage would mean a difference of 1045 g in total GWG during third trimester.

Our hypothesis was that higher UPF consumption would lead to greater weight gain potentially mediated through higher total energy consumption. Our study showed that increased UPF consumption was associated with higher GWG during the third gestational trimester, with total energy intake being a potential mediator as it proved to be associated with both UPF consumption and GWG during that period. Furthermore, when both the percentage of energy provided by UPF and total energy intake were included in the multiple model, both variables lost their association with third trimester gestational weight gain.

An interesting finding in our study is that third-trimester UPF consumption had a positive impact on GWG, but second-trimester consumption did not, despite UPF consumption being positively associated with total energy intake in both trimesters. One hypothesis for this is that insulin sensitivity is lower in the third trimester, which correlates with lower adiponectin levels[43], and the decline in serum adiponectin is associated with increased maternal fat mass[31]. Since UPF are high in fat and especially sugars[5,6], its effect on GWG would be more noticeable in a period of lower insulin sensitivity, when it is easier to gain weight. However, further studies are needed to investigate whether UPF consumption by pregnant women is relevant only in the third trimester of pregnancy and to clarify the mechanisms by which this consumption contributes to greater gestational weight gain.

At the time of this publication, the only previous localised study investigated the relationship between UPF consumption and total GWG: each additional percentage point in UPF-derived energy led to a mean increase of 1·33 kg in total GWG[15]. The comparison of this finding with our results is limited because our GWG was evaluated weekly in the second and in the third trimesters and was different by gestational trimester. Some other differences between the studies also deserve to be highlighted: it was a small study (*n* 45) which used a FFQ, applied in the third trimester, to determine the previous month's food intake; the patients consumed more than double the amount of UPF than those in our cohort[15].

Comparing UPF consumption in our patients with results from previous national and international studies can help us establish whether the evaluated cohorts have a consumption close to that reported for other populations or if they constitute a more specific group, aspects that

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affect the external validity of our results. There is a cross-sectional study with 745 pregnant women from Ribeirão Preto, Brazil, which investigated the relationship between their nutritional status and UPF consumption, according to their own gestational period guidelines (Atalah). The energy percentage from UPF in the diet of these pregnant women was 32 %[17] – higher, therefore, than in our study population (24·8 %).

A study with a cohort of Brazilian pregnant patients from Rio de Janeiro found an even higher percentage of UPF-derived energy intake: 41·3 % in a cohort of 189 patients[16]. However, the current study has important methodological differences in relation to our study, such as the use of FFQ, and some differences in food classification, such as the inclusion of 'French' bread (a commonly consumed food among Brazilians) in the UPF group. The current study included this specific bread in the processed foods group, as recommended by the used classification[2].

This higher percentage of UPF energy contribution reported in the Rio de Janeiro study[16] is similar to those observed in studies conducted with the general population in developed countries[6,44,45]. A Canadian study with a representative sample of its inhabitants over 2 years of age found a rate of UPF-derived energy of 47·7 %[6]. The Canadian study has methodological similarities to our research: both used R24h and followed the same food classification we performed[39,40]. On the other hand, our results regarding the percentage of UPF-derived energy were close to those estimated for a representative sample of the Brazilian population in general (adolescents and adults), which pointed to a rate of 20·4 %[5], a fact that supports the validity of our results. Another Brazilian cohort study, with data from 8977 adult individuals from different Brazilian states, presented results of UPF-derived energy contribution even more similar to our own (22·7 %)[13]. Thus, our patients are clearly at a lower level of UPF consumption than the Canadian population and are close to or slightly above the reported average for the Brazilian population.

One of the positive aspects of our study is that it is the first prospective study to investigate UPF consumption and its association with GWG, while also having low segment loss. Also, noteworthy are our uses of an internationally known software (Nutrition Data System for Research) and of R24h as a tool for obtaining consumption data, as well as the rigorous analysis, controlling several factors recognised in the literature as being associated with GWG[31]. On the other hand, the extrapolation of our results to pregnant women in general should be viewed with caution, since we investigated only the low-risk obstetric population in a prenatal public service. Thus, further studies with samples that include pregnant women from all socio-economic strata are desirable. Other outcomes also deserve to be studied, such as gestational diabetes and postpartum maternal weight retention. Beside this, we have to consider the possibility of social desirability bias that may lead to underestimation of the dietary contribution of UPF. This underestimate can reduce the magnitude of the effect of UPF consumption and weekly GWG, once participants with higher weekly GWG may be those who underreport UPF consumption. We also have limited collection of information indicative of food processing level (i.e., place of meals, product brands), which could lead to over or underestimation of UPF consumption

Conclusion

In Brazilian pregnant women with low obstetric risk, UPF consumption in the third gestational trimester (but not the second) was positively associated with weekly GWG in the third gestational trimesters, confirming its potential to negatively affect maternal and child health, as gestational weight gain beyond the recommended levels is a highly prevalent adverse event, including in the studied population.

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