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Full length article

Paleolithic diet during pregnancy—A potential beneficial effect on metabolic indices and birth weight

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ABSTRACT

Background: Paleolithic diet has recently gained popularity due to its presumed health benefits. The favorable metabolic effects of this diet were assessed in non-pregnant population but its impact during pregnancy remains to be evaluated.
Study design: A retrospective cohort study comparing two groups. Group A comprised of women with singleton low-risk pregnancy adherent to paleolithic diet throughout gestation (n = 37). Group B comprised low risk pregnant women on a regular diet (n = 39). Women were excluded if they had low adherence to diet, started paleolithic diet during pregnancy, and had pre-gestational diabetes mellitus or other types of metabolic syndrome such as pre gestational hyperlipidemia, hypertension or BMI > 35. Blood indices such as Glucose challenge test scores, hemoglobin, ferritin, and TSH levels were compared. Other pregnancy factors such as maternal weight gain, rest days during gestation and pregnancy complications such as IUGR, GDM or preeclampsia were compared. Lastly, obstetrical outcomes such as mode of delivery and complications such as high-grade tears, as well as neonatal factors such as birth weight and pH were compared between the two groups.
Results: General maternal characteristics such as age, BMI and parity were comparable between the two groups. Women who maintained a paleolithic diet had a significant decrease in glucose challenge test scores (95.8 mg/dL vs. 123.1 mg/dL, $p < 0.01$) and increase in hemoglobin levels (12.1 g/dL vs. 11.05 g/dL $p < 0.01$) and Ferritin (32.1 vs 21.3 mg/mL, $p = 0.03$) compared to women maintaining regular diet. Maternal pregnancy weight gain was also slightly decreased in group A (9.3Kg vs. 10.8 kg, $p = 0.03$). Birthweights were lower in group A (3098 g Vs.3275 g, $p = 0.046$) with no difference in adverse neonatal outcomes. We found no differences in other pregnancy complications or labor outcomes such as mode of delivery, shoulder dystocia or high grade perineal tears.
Conclusion: Paleolithic diet maintained during pregnancy may have a beneficial effect on the glucose tolerance. It also may increase iron stores and hemoglobin levels. Neonates of women maintaining paleolithic diet are slightly lighter but appropriate for gestational age with no difference in neonatal outcomes.

Introduction

Paleolithic diet (also referred to as the “caveman diet” or “hunter–gatherer diet”) has recently gained popularity worldwide due to its presumed health benefits. Paleolithic nutrition consists of foods that are assumed to have been available to humans prior to the establishment of agriculture – the Paleolithic era. The principal components of this diet are based on animal and uncultivated-plants source foods such as lean meat, fish, vegetables, fruits, roots, eggs, and nuts. [1] The diet excludes grains, wheat, legumes, dairy products, refined sugar, and processed oils, all of which were unavailable before humans began cultivating plants and domesticating animals. Supporters of this diet believe that modern humans are genetically not adapted to the current industrialized "modern" diet, and that may lead to chronic diseases such as Type 2 DM, obesity, and cardiovascular disease [2].

This hypothesis was assessed by several studies in recent years. These studies found improved glucose tolerance and glycemic control compared to other types of diets in patients with type 2 diabetes mellitus [3–5]. Paleolithic nutrition resulted in improvements in all components of the metabolic syndrome when compared to diets bases on the current recommended guidelines [6].

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Pregnancy is associated with metabolic, bio-chemical, and hematological changes. In particular, pregnancy is associated with insulin resistance which is believed to serve as a physiological adaptation to ensure adequate carbohydrate supply for the rapidly growing fetus [7–9]. However, current dietary recommendations do not include a low carbohydrate diet [13].

Pregnant women are also prone to iron deficiency and anemia [10]. Iron supplements have been reported to increase hemoglobin levels, serum ferritin, mean cell volume, serum iron, and transferrin saturation.

Taking into account the above mentioned pregnancy related alterations in glucose and iron metabolism, along with the plausible beneficial effects of the Paleolithic diet, we aimed at assessing the effect of Paleolithic diet during pregnancy on maternal glycemic values, hemoglobin and ferritin levels and on other pregnancy-related metabolic changes.

Methods

We conducted a retrospective cohort study comparing pregnant women who maintained a Paleolithic diet before conception and throughout pregnancy to low-risk healthy pregnant women on a regular diet. The study was approved by the local medical ethics committee.

Patients were detected through publication on social media and publications in a large community maternity clinic. Subjects were assessed for eligibility by filling out detailed questionnaires regarding their diet and consumed ingredients during pregnancy. After detection patient pregnancy and birth records were assessed retrospectively.

Inclusion to the Paleolithic diet group mandated a diet based on lean meat, fish, fruit, leafy and cruciferous vegetables, root vegetables, eggs and nuts, while excluding dairy products, cereal grains, beans, refined fats, sugar, candy, soft drinks, beer and extra addition of salt. The intake of other foods was not restricted. Patients who did not maintain such a diet from prior to conception or self-reported as deviating from this strict diet over 20% of the time, were excluded. Patients with pre-gestational metabolic conditions such as diabetes mellitus, hyperlipidemia, chronic hypertension, and BMI > 35 were also excluded.

The control group was comprised of healthy pregnant women without a pre-existing metabolic condition. Control group was matched by age and BMI. All patients in the control group had at least one dietary consultation regarding the standard recommended diet during pregnancy, based on evenly distributed meals comprising protein, carbohydrates and fat. These dietary recommendations outlined a daily carbohydrate consumption accounting for 45–60% of daily allocated calories, similar to that recommended to non-pregnant women [13].

Sample size was influenced by the relative scarcity of pregnant women who are adherent to paleolithic diet during pregnancy. However, since we hypothesized a significant reduction in glucose challenge test levels as seen in non-pregnant patients, a relatively small sample size was sufficient to achieve statistical power.

Groups were compared for general characteristics such as age, pre-pregnancy BMI, parity and smoking status. We compared the following maternal values during pregnancy: maternal weight gain, maternal leave days from work, metabolic alterations such as glucose challenge test (GCT) score, hemoglobin and ferritin, TSH at 24 weeks gestation, obstetrical complications such as Intrauterine growth restriction, preeclampsia and fetal demise (IUFD). We also compared perinatal outcomes such as mode of delivery, high grade perineal tears, birth weight, 5 min Apgar score, and pH at birth.

Statistical analysis was performed using SPSS 25 for Windows. Descriptive statistics were used to characterise both the Palaeolithic diet and the regular diet groups in all demographics and clinical characteristics. Similarity between the two groups and confounders was assured using t-tests, chi-squares and Fisher's exact tests. Variables were selected according to clinically known significance, and according to the results of the preliminary comparison analysis. In order to ascertain the effects of the research's outcomes on the likelihood to be assigned to the Palaeolithic diet group, we performed two hierarchic binomial logistic models for maternal and neonatal outcomes. For both maternal and neonatal models, we included basic pregnancy related characteristics, clinically known significant factors, and according to the results of the preliminary comparison analysis.

Results

A total of 76 women were enrolled, with 37 in the Paleolithic diet group and 39 in the regular diet group. Table 1 summarizes the baseline characteristics of the study population. General maternal characteristics were similar between the two groups. The mean maternal age was similar between the two groups as well as maternal BMI and obstetrical history. Controlling for age, BMI parity and gravidity, a hierarchical binomial logistic regression was performed to ascertain the effects of GCT scores, hemoglobin and ferritin levels (Table 2). Women who were adherent to Paleolithic diet throughout pregnancy had a significant decrease in glucose challenge test scores, increase in hemoglobin and ferritin levels at 24 weeks gestation compared with women. Differences in glucose challenge test scores can also be seen on Fig. 1. Maternal pregnancy weight gain was slightly decreased in women maintaining Paleolithic diet. We also noted that women maintaining Paleolithic diet took less leave-days (days off work) compared with women on a regular diet. There was no difference in other maternal pregnancy outcomes (Table 3).

Controlling for age, BMI parity and gravidity, a different hierarchical binomial logistic regression was performed to ascertain the effects of neonatal birthweight, 5-minute Apgar Scores and gestational age at birth. Birthweights were slightly lower in women maintaining Paleolithic diet with no difference in adverse neonatal outcomes. We found no differences in other pregnancy complications or labor outcomes such as mode of delivery, shoulder dystocia or high-grade perineal tears (Table 4).

Discussion

Principal findings of the study

The principal findings of the study are as follows. First, we found that women who maintained a strict Paleolithic diet throughout gestation had significantly decreased glucose challenge test scores

Table 1
Demographic and clinical characteristics of patients in Paleolithic and Regular diet groups.

	Paleolithic Diet (N = 37)	Regular Diet (N = 39)	
	Mean ± SD (Range)	Mean ± SD (Range)	P-value
Age	30.6 ± 3.67 (23.9-38.0)	30.6 ± 4.33 (21.9-39.0)	.992
BMI	24.2 ± 2.52 (19.8-29.0)	24.6 ± 3.70 (17.9-34.4)	.601
Gravidity	1.54 ± 0.77 (1.0-4.0)	1.54 ± 0.68 (1.0-3.0)	.990
Parity	0.41 ± 0.64 (0-2.0)	0.41 ± 0.64 (0-2.0)	.974
Smoking Status	2/37 (5.4%)	1/39 (2.6%)	.610

Table 2
Blood indices of patients in Paleolithic and regular diet groups. GCT = Glucose challenge test (serum glucose 60 min after 50gr oral glucose intake).

	Paleolithic Diet (N = 37) Mean ± SD (Range)	Regular Diet (N = 39) Mean ± SD (Range)	P value
GCT score (mg/dL)	95.78 ± 12.07 (65.0-121.0)	123.1 ± 14.44 (100.0-153.0)	<.001
Maternal Hemoglobin (g/dL)	12.08 ± 0.60 (11.0-13.2)	11.05 ± 0.94 (9.7-13.2)	<.001
Maternal Ferritin (mg/mL)	32.08 ± 16.93 (11.0-13.2)	21.31 ± 10.54 (8.0-48.0)	.002

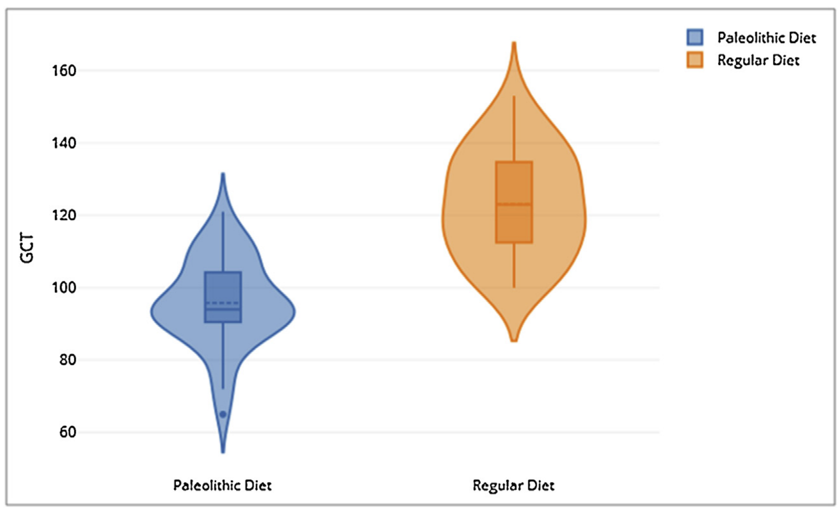

Fig. 1. GCT scores of patients in Paleolithic and regular diet groups.
GCT = Glucose challenge test (serum glucose 60 min after 50gr oral glucose intake)

Table 3
Pregnancy characteristics of patients in Paleolithic and Regular diet groups.

	Paleolithic Diet (N = 37) Mean ± SD	Regular Diet (N = 39) Mean ± SD	P-value
Weight gain during pregnancy (Kg)	9.3 ± 2.5	10.9 ± 3.8	.032
TSH levels	2.14 ± 1.4 (n = 34)	2.44 ± 1.2 (n = 39)	.268
Days off work during pregnancy	2.0 ± 2.04	5.0 ± 3.5	<.001
IUFD	0 (0%)	0 (0%)	1.0
IUGR	1 (2.7%)	3 (7.7%)	.241
Preeclampsia	0 (0%)	3 (7.7%)	.241

Table 4
Labor Outcomes of patients in Paleolithic and regular diet groups.

	Paleolithic Diet (N = 37) Mean ± SD	Regular Diet (N = 39) Mean ± SD	P Value
Gestational age at birth (days)	39 + 6 ± 1.14	39 + 3 ± 1.48	.103
Birth weight (Grams)	3099 ± 299.2	3275 ± 444.1	.046
5-min Apgar Score	9.6 ± 0.77	9.2 ± 1.01	.042
pH at birth	7.23 (n = 20)	7.18 (n = 28)	.033
Vacuum Extraction	4/37 (10.8%)	7/39 (17.9%)	.403
Cesarean Section	3/37 (8.1%)	4/39 (10.3%)	.532
3rd / 4th degree tears	0/37 (0.0%)	1/39 (2.6%)	1.0
Shoulder Dystocia	0/37 (0.0%)	0/39 (0.0%)	1.0

compared to women maintaining a regular diet, who have similar characteristics. Second, we found that women in the paleolithic group had an increase in hemoglobin and ferritin levels compared to women maintaining a regular diet. Third, maternal pregnancy weight gain was slightly decreased, and birthweights were lower in the Paleolithic diet group.

Effect on maternal glucose tolerance

The motivation to perform the study stemmed from studies in non-pregnant patients pointing out the beneficial effects of Paleolithic nutrition on type II diabetes, insulin resistance and metabolic syndrome [6]. More specifically Paleolithic nutrition was associated with lower insulin resistance compared to other types of nutrition [4–6]. A study conducted by Ghio et al [13] tested the association between insulin resistance and 1 -h plasma glucose concentration after glucose ingestion. This trial showed that the GCT is a fair predictor of insulin resistance.

The significant difference in GCT scores seen in our study between women on a Paleolithic diet in comparison to a regular diet suggests that the Paleolithic diet during pregnancy might have a positive effect on insulin resistance, even in low risk patients without gestational diabetes mellitus. This finding supports the findings of Jonsson et al. [21], which demonstrated better insulin sensitivity in swine models receiving Paleolithic nutrition.

One possible explanation for this finding of higher insulin sensitivity, is that the Paleolithic diet affects insulin action mainly at the level of muscle and adipose tissues. Another possible explanation can suggest an association between insulin resistance and decrease in adipose tissue and weight loss seen in patients on a Paleolithic diet.

Other lifestyle risk factors known to affect the development of gestational diabetes mellitus are age, pre gestational body weight, body mass index (BMI), physical activity family history and nutrition [14]. Our study showed similar pre-pregnancy risk factors in both groups including similar age and BMI. However, we did not compare physical activity levels between the two groups, a potential cofounder in the study.

Effect on hemoglobin and ferritin levels

The physiologic demand for iron is especially high in pregnancy. Roughly two thirds of absorbed iron is utilized for maternal needs, and one-third is for placental-fetal demands [11]. Iron requirement increases across gestation as a reflection of hematopoiesis and fetal growth. About 750 mg of additional iron is needed during pregnancy in iron-replete women. For women with low or depleted iron stores, 1000 mg or more of additional iron might be required to meet maternal and fetal iron demands during pregnancy. Paleolithic nutrition is considered an Iron-rich diet comprising iron-rich foods such as chicken, turkey, fish, meats, spinach, and kale [12]. In addition, the Paleolithic diet is assumes a low level of cow milk products. Consumption of cow milk has been associated with lower absorption of ingested iron supplements presumably through the inhibition of non-heme iron absorption by calcium and casein, both of which are present in high amounts in cow milk [15]. Hence, absorption of iron from both diet and iron supplement may be enhanced in pregnant women adhering to a Paleolithic diet.

Effect on birth-weight

Birth weight is determined by multiple factors, among them is maternal nutrition [16]. Pedersen et al. hypothesized that in maternal diabetes, high concentrations of glucose give rise to increased nutrient transfer to the fetus [17]. To prevent fetal hyperglycemia, fetal insulin secretion increases and subsequently fetal growth increases [17,18]. Studies have also shown that low glycemic index maternal diet is associated with benefits to the offspring including fetal and placental insulin and glucose regulation, fetal growth, birth weight and offspring adiposity [19].

Effect on maternal leave-days

We believe that this finding may, in part, be attributed to the different “mind-set” of women choosing a strict nutritional lifestyle regarding health and overall well- being. One other possible explanation can be seen in the connection between fatigue and insulin resistance and alteration in blood glucose levels, as this connection has been prior reported [22]. Altered blood glucose metabolism may result in acute and chronic hyperglycemic episodes, hypoglycemia, or blood glucose fluctuations and may result in fatigue causing abstinence from work.

Role of ketosis

Paleolithic nutrition is often criticized regarding its association with circulating ketones. Recent studies [20] investigated the direct implications of a gestational ketogenic diet on embryonic development in mice and found alterations in embryonic organ growth. Such effects may be associated with organ dysfunction and potentially behavioral changes in postnatal life. Given the retrospective method of our study, no measurement of ketone body values were made, however we did not find any difference in neonatal outcomes between two groups but our study was underpowered to detect such a disparity.

Strengths and limitations

After conducting a search in PUBMED and MEDLINE online databases, this study is the first study to our knowledge regarding Paleolithic nutrition during pregnancy. The strengths of our study are comparable cohorts and full access to computerized obstetric and non-obstetric parameters. Limitations of the study are mainly due to its retrospective nature as we had no strict control over patient’s nutrition and information was gathered by retrospective questionnaires which may be inaccurate. Another important limitation is the inability to control patient motivation or mind-set as women adhering to the paleolithic diet are probably stricter and more nutrition-conscious than women on regular diet. Furthermore, we did not compare socio-economic status and physical activity between the two groups as this may be a significant confounder.

Conclusion

Paleolithic nutrition has been gaining popularity worldwide, however no studies have assessed its effect during pregnancy. In this retrospective cohort study, we found that women who maintained a Paleolithic diet had a significant decrease in glucose challenge test scores compared to low risk pregnant women on a regular diet. We also found an increase in hemoglobin and ferritin levels compared to women maintaining regular diet, with no difference in adverse neonatal outcomes. These results may indicate the favorable nature of this diet during pregnancy, and may even become more substantial in women prone to gestational diabetes. Further prospective research may shed more light on the possible beneficial effect of such a diet.

Declaration of Competing Interest

The authors report no conflict of interest

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