Journal of Midwifery & Women's Health www.jmwh.org

Original Research

First Trimester Dietary Intake, Biochemical Measures, and Subsequent Gestational Hypertension Among Nulliparous Women

Desiree L. Tande, PhD, RD, LRD, Jody L. Ralph, PhD, RN, LuAnn K. Johnson, MS, Angela J. Scheett, MPH, RD, Bonita S. Hoverson, RD, Cindy M. Anderson, PhD, RN, WHNP-BC

Introduction: The purpose of this study was to evaluate the relationships between first-trimester dietary factors and biochemical measures and subsequent risk of gestational hypertension.

Methods: This pilot study used a prospective design utilizing a convenience sample of nulliparous women enrolled at their first prenatal visit. A total of 57 women completed the study. Participants were divided into 2 groups for data analysis: normotensive pregnancy and gestational hypertension.

Results: Nearly one-quarter of study participants (22.8%) developed gestational hypertension, of whom 84.6% had significant proteinuria meeting the criteria for preeclampsia. There were no significant differences in micronutrient or macronutrient dietary intakes between groups. Serum iron and zinc levels were lower for the gestational hypertension group compared with the normotensive pregnancy group ($P \leq .01$). Low serum zinc levels were related to a risk of developing gestational hypertension (adjusted odds ratio, 0.930; 95% confidence interval, 0.872-0.992).

Discussion: Ensuring adequate intake of zinc and monitoring serum zinc levels in nulliparous pregnant women may help to prevent or contribute to early detection of gestational hypertension.

J Midwifery Womens Health 2013;00:1–8

Keywords: preeclampsia, pregnancy, nutrition, questionnaires

INTRODUCTION

Hypertensive disease in pregnancy affects 12% to 22% of pregnancies and is associated with an increased risk for maternal and neonatal morbidity.[1–5] Gestational hypertension and preeclampsia are 2 of the most common types of new-onset blood pressure elevation in pregnancy. Gestational hypertension and preeclampsia are both characterized by blood pressure at or exceeding 140 mm Hg systolic or 90 mm Hg diastolic after 20 weeks' gestation in a previously normotensive woman, with the additional diagnostic criteria of significant proteinuria of at least 300 mg in a 24-hour period in those who have the diagnosis of preeclampsia.[6,7] Although the causes of gestational hypertension and preeclampsia are not clearly elucidated, maternal nutritional status is a moderating factor that may affect the risk.[8–10] The primary aim of this pilot study was to evaluate the relationship between maternal dietary intake and biochemical measures in early pregnancy with subsequent development of preeclampsia.

Preeclampsia, characterized by placental insufficiency during early pregnancy, becomes manifest in mid- to late pregnancy with hypertension that is secondary to vascular dysfunction and vasospasm. Maternal nutritional status during pregnancy has been investigated as a potential treatment target in the prevention of preeclampsia. Poor dietary quality in mid-pregnancy, including energy, micronutrient, and macronutrient intake, has been implicated in increased risk for preeclampsia.[11] Previous findings linking diet quality and birth outcomes demonstrated that low dietary intake of milk,[12,13] fiber,[13,14] and fruits and vegetables[13,15] were related to increased preeclampsia risk. High intake of sucrose-based beverages during the second trimester of pregnancy was also associated with increased risk for preeclampsia development.[16] Although sugar-sweetened beverages increase the risk for preeclampsia, consumption of foods and drinks with naturally occurring sugars such as those found in fruits reduced the risk of preeclampsia.[17] Overall, limited data evaluating the influence of dietary consumption combined with serum biomarkers on the development of preeclampsia are available, particularly during the critical developmental period of early pregnancy.

Micronutrients are trace elements that can be ingested and measured in blood, serving as biomarkers to assess nutritional status. Needed in small amounts to carry out physiologic functions essential for normal development, growth, and maintenance of the human body, micronutrients including folate, sodium, calcium, potassium, iron, copper, and zinc represent potential etiologic and treatment targets for preeclampsia prevention. Maternal micronutritional status in early pregnancy, a particularly susceptible period, may influence placental development. In the early weeks of pregnancy, maternal spiral artery remodeling and trophoblast invasion are central to placental development and establishment of the perfusion needed to support the advancing pregnancy.

Address correspondence to Cindy M. Anderson, PhD, RN, WHNP-BC, College of Nursing and Professional Disciplines, University of North Dakota, 430 Oxford Street, Stop 9025, Grand Forks, ND 58202-9025. E-mail: cindy.anderson@und.edu

1526-9523/09/$36.00 doi:10.1111/jmwh.12007

Quick Points

- First-trimester dietary intake was not associated with gestational hypertension in this prospective study; however, women with low serum zinc levels in early pregnancy were at increased risk for the development of gestational hypertension.
- Maternal nutritional status in early pregnancy represents a critical period for placental and fetal development, serving as a target for interventions to improve pregnancy outcomes.

Micronutrients including copper and zinc may reduce the likelihood of preeclampsia because of their antioxidant properties.[18] Oxidative stress is a natural byproduct of placental growth that demands the action of antioxidant-dependent enzymes such as copper/zinc superoxide dismutases to protect the placenta from oxidative damage.[19] Iron[20] and folate[21] are involved in nitrosylation and oxidation processes associated with the generation of oxygen free radicals in preeclampsia. Calcium-,[22,23] magnesium-,[24] sodium-, and potassium-related alterations in preeclampsia may be the result of complex interactions of electrolytes in this multisystem disorder. Potassium channels in placental syncytiotrophoblasts involved in maternal-fetal exchange[25] and in human umbilical vein endothelial cells regulating calcium influx[26] are altered in pregnancy complicated by gestational hypertension. Increases in sodium chloride intake in animal models are associated with a preeclampsia-like syndrome, with a potential etiology linked to altered placental remodeling and trophoblast invasion consistent with the human condition.[27] The need for micronutrient fortification of foods for pregnant women, including iron, zinc, copper, iodine, selenium, and folic acid, provides evidence of their importance in the maternal diet.[28] Overall, findings suggest altered intake of these micronutrients among childbearing women represent a potential target to reduce the risk for preeclampsia.

Macronutrients are needed in relatively large amounts to carry out physiologic functions essential for normal development, growth, and maintenance of the human body. Macronutrient dietary intake can also affect the risk for preeclampsia, taking into consideration carbohydrate, protein, fat, and overall energy intake. Increased energy intake is associated with increased body mass index and weight gain,[29,30] contributing to an increased risk of gestational hypertension.[31] A high-carbohydrate diet may contribute to oxidative stress in women with pregnancies complicated by preeclampsia.[32] A high-fat diet may contribute to preeclampsia through promotion of placental[33] lipid infiltration and storage, as suggested in animal models. Fiber intake, along with a diet high in fruits, vegetables, low-fat dairy, cereal, and dark bread, has an inverse relationship with preeclampsia, suggesting that diet composition and quality rather than select macro- and micronutrients contribute to risk attenuation.[13]

As preeclampsia is influenced by maternal nutritional status, early pregnancy represents a critical window for the provision of essential nutrients favoring optimal placental development to reduce the risk of preeclampsia. Although gestational hypertension and preeclampsia are recognized as important maternal pregnancy outcomes, there are no clear guidelines regarding dietary intake of micronutrients, macronutrients, energy consumption, or weight gain.[34] This pilot study was designed to identify the relationship between maternal dietary intake and biochemical measures in early pregnancy in relation to the subsequent development of preeclampsia.

METHODS

This prospective study included a convenience sample of pregnant women recruited at a local obstetrics clinic in the upper Midwest at the time of the first prenatal visit. Eligibility criteria included being nulliparous, aged at least 18 years, and less than 14 completed weeks of pregnancy. On determination of eligibility, women were invited to participate in the study at the time of their initial prenatal care visit. All participants accepted the invitation to join the study. After obtaining consent, participants provided data about dietary and supplement intake patterns over the previous 3-month period. At the time of laboratory analyses associated with routine prenatal care, an additional 8-mL sample of blood was collected for serum analyses of calcium, copper, iron, magnesium, and zinc. Dietary intake and multiple biochemical measures (ie, serum calcium, copper, iron, magnesium, and zinc) in the first trimester were evaluated and compared to determine potential differences associated with the development of gestational hypertension after 20 weeks' gestation. After birth, pregnancy outcome data were determined by review of medical records. Approval from the institutional review boards of the University of North Dakota and the health care system were received.

Dietary Intake

Dietary and supplement intake over the first 3 months of pregnancy was determined by administration of a single internally developed Food Frequency Questionnaire (FFQ) patterned after the Harvard Service FFQ format.[35] No separate reliability or validity testing has been done on the FFQ used for this study, although similar versions have been used in studies to quantify nutrient intake in pregnant women.[36] The FFQ includes 78 food items without serving sizes indicated (natural portion implied; eg, 1 cup of milk, 1 slice of bread). All food items on the FFQ were matched to food codes from the USDA National Nutrient Database for Standard Reference, Release 20[37] or the USDA Food and Nutrient Database for Dietary Studies 2.0, both of which have been incorporated into the onsite nutrient database.[38] For each food item, subjects designated their average consumption by marking 1 of 9 frequency categories ranging from "zero per month" to "six or more times per day." The frequency chosen for each food item was converted to a daily intake. For example, a response of "1-3 per month" was converted to 0.07 servings per day (2 servings per month). Supplemental vitamin intake was calculated based on participant report of multivitamin and

supplement use. Patterns of dietary intake including frequency, manner, and source of meals were also determined. Specifically, participants were asked to report how many days per week they usually ate a morning, midday, and/or evening meal and snacks.

Biochemical Measures

Maternal serum samples collected in a nonfasting state during the first trimester were analyzed for nutritional biomarkers including calcium, copper, iron, magnesium, and zinc. Samples were analyzed by inductively coupled argon plasma emission spectrometry using a Thermo Fisher Scientific 6500 Dual ICP instrument (Thermo Fisher Scientific, Waltham, MA) equipped with automated sample injection. Quality control measures included continuing calibration blank and continuing calibration verification, completed before and after the samples were analyzed. Initial calibration verification was completed every 10 samples. UTAK-certified (Utak Laboratories, Valencia, CA) serum standard was also used at a frequency of 30 samples for validation.

Medical Record Abstraction

All participants were categorized into 2 groups: normotensive pregnancy or gestational hypertension. Group designation was determined based on abstraction of data from the medical records detailing the prenatal and immediate postpartum course. Participants were included in the gestational hypertension group if they met criteria for preeclampsia or gestational hypertension. Preeclampsia was determined based on new-onset hypertension, defined as systolic blood pressure of at least 140 mm Hg or diastolic blood pressure of at least 90 mmHg on 2 separate occasions at least 6 hours apart, coupled with proteinuria (>300 mg/24 hours or +1 on a dipstick) in the second half of pregnancy.[5] Women were categorized as having gestational hypertension using the criteria for preeclampsia with the exclusion of evidence of proteinuria. The criteria for the normotensive pregnancy group were blood pressure lower than that for gestational hypertension diagnosis and no significant proteinuria during pregnancy. Blood pressures were measured at the time of the first prenatal visit with participants in a seated position with arm at heart level. Pregnancy outcomes, including routine laboratory analyses, mode of birth, and maternal/infant complications, were collected from the medical record.

Statistical Analysis

Descriptive statistics, including frequencies and means (standard error [SE]) were calculated to provide sample characteristics. Dietary factors and nutritional biomarkers were compared across study groups (normotensive pregnancy and gestational hypertension). Multivariable logistic regression analysis was conducted to determine odds ratios and included covariates of age and energy intake for dietary factors and age for biochemical measures. Analysis was performed using SAS software, version 9.2 (SAS Institute, Inc., Cary, NC). Cases were excluded with incomplete data depending on the individual statistical test; therefore, sample size varied by test.

RESULTS

A total of 65 pregnant women were recruited at their first prenatal visit and provided consent to participate in the study. Four participants left the study location to give birth elsewhere. Four participants had missing data related to failure to fully complete the food frequency questionnaire. Thus, 57 women had complete dietary data available for analysis at the end of the study period. Analysis of biochemical measures of nutrient status was limited to women who contributed samples satisfactory for analyses (n = 50).

Thirteen participants (22.8%) were diagnosed with gestational hypertension. Of the 13 participants with gestational hypertension, 11 met the definition for preeclampsia (84.6%). Table 1 provides baseline demographic information describing the women included in this study. There were no significant differences in age, race, gestational age at birth, or season of birth between groups. Infant birth weight was not correlated with maternal serum micronutrient levels.

Dietary assessment indicated that most participants (95.1%) reported taking a daily prenatal vitamin. The majority of study participants (52.5%) reported they did not eat breakfast on each of 7 days per week, with similar breakfast frequency for both groups. However, the majority of study participants did eat both a midday meal (82.0%) and an evening meal (88.5%) daily. Dietary intake (Table 2) varied between the groups. Dietary intake of nutrients examined was adequate with the exception of low fiber intake reported among both groups, each failing to meet the 28 g per day recommen-

Table 1. Demographic Characteristics of Participants[a]

Variable	Normotensive Pregnancy (=44)	Gestational Hypertension (n=13)
Maternal age, mean (SE), y	24.2 (0.62)	25.3 (0.72)
Ethnicity, n (%)		
White	36 (81.8)	10 (76.9)
Other	8 (18.2)	2 (15.4)
Missing	0 (0)	1 (7.7)
Gestational age at birth,[b] n (%), weeks		
33	1 (2.3)	0 (0)
34	0 (0)	2 (16.7)
35	2 (4.6)	0 (0)
36	3 (6.8)	1 (8.33)
37	6 (13.6)	3 (25.0)
38	6 (13.6)	2 (16.7)
39	15 (34.1)	2 (16.7)
40	14 (31.8)	3 (25.0)
41	1 (2.3)	0 (0)
Blood pressure, first trimester, mean maximum (SE), mm Hg		
Systolic	109.6 (1.49)	116.5 (2.41)
Diastolic	63.5 (1.06)	68.5 (1.37)

Abbreviation: SE, standard error.
[a]Sample size for blood pressure derived from cases with complete data (n = 57).
[b]Gestational age at birth includes all participants (n = 61).

Table 2. First-Trimester Mean Daily Dietary Intake for Normotensive and Gestational Hypertension Groups

Dietary Intake	Normotensive Pregnancy (n = 44), Mean (SE)	Gestational Hypertension (n = 13), Mean ± SE	*P* Value	Dietary Reference Intakes
Energy intake (kcal)	2332.50 (139.1)	2597.1 (248.3)	.364	ND
Carbohydrate (g)	301.5 (18.2)	323.0 (36.6)	.605	175 (RDA)
Protein (g)	93.9 (6.2)	105.7 (8.81)	.283	71 (RDA)
Total fat (g)	88.6 (5.89)	102.4 (13.2)	.350	ND
Saturated fat (g)	32.7 (2.42)	37.0 (4.86)	.443	ND
Folate (mcg), DFE	692.3 (60.9)	844.2 (84.4)	.156	600 (RDA)
Sodium (mg)	2925.8 (199.8)	3544.6 (373.0)	.160	1500 (AI)
Fiber (g)	20.7 (1.45)	23.1 (2.61)	.425	28 (AI)
Calcium (mg)	1364.1 (131.7)	1328.7 (135.9)	.853	800 (AI)
Potassium (mg)	3818.1 (254.4)	3863.3 (329.8)	.914	4700 (AI)
Iron (mg)	19.9 (1.7)	25.5 (3.02)	.121	27 (RDA)
Copper (mcg)	1.48 (0.09)	1.63 (0.18)	.473	1000 (RDA)
Zinc (mg)	15.4 (1.03)	16.9 (1.56)	.432	11 (RDA)
Alcohol intake (g)	0.18 (0.14)	1.21 (1.06)	.352	-

Abbreviations: AI, adequate intake; DFE, dietary folate equivalents; DRI, dietary reference intakes; ND, not determined; RDA, recommended dietary allowance; SE, standard error.

dation. In addition, neither group met the current US Dietary Guidelines to keep intake from saturated fat below 10% of total energy intake. Both groups consumed more than 12% of calories from saturated fats. Total fat intake as a percentage of energy was borderline high with the normotensive (34.2%) and gestational hypertension (35.5%) groups on the upper end of the acceptable macronutrient range of 20% to 35%.

Logistic regression was performed to determine whether independent components of dietary intake during the first trimester could predict the risk of developing gestational hypertension later in pregnancy. The model included 12 participants who developed gestational hypertension and 44 participants in the normotensive group, excluding one participant for whom complete data were unavailable. Sodium intake findings (OR, 1.001; 95% CI, 1.000-1.002; $P = .083$), when controlling for age and energy, indicate that a 100-g increase in sodium intake per day results in a 1% increase in the risk of developing gestational hypertension at a significance level of *P* less than 0.10.

Mean serum iron and zinc levels were significantly lower in the gestational hypertension group compared with the normotensive group ($P = .007$ and $P = .006$, respectively; Table 3). Zinc levels during the first trimester significantly predicted the risk of gestational hypertension diagnosis later in pregnancy after controlling for age (OR, 0.930; 95% CI, 0.872-0.992; $P = .028$), indicating a reduced risk of the condition with higher serum zinc levels. Alternatively, first-trimester serum iron levels were not found to be a significant predictor for risk of gestational hypertension after controlling for age and energy intake.

DISCUSSION

Maternal nutrition in pregnancy is central to the provision of optimal nutrient delivery to meet maternal, embryo/fetal, and placental needs.[39] In a recent report linking placental biomarkers with vitamin and mineral dietary intake among low-income pregnant women, Fowles et al reported that vitamin and mineral intakes were significant predictors of increased sFlt-1 (an antiangiogenic antagonist to vascular endothelial growth factor associated with placental insufficiency), providing further evidence of the link between

Table 3. Nutritional Biomarkers in Maternal Serum in Normotensive and Gestational Hypertension Groups

Nutritional Biomarker (Reference Range)[c]	Normotensive Pregnancy[a] (n = 39), mean (SE)	Gestational Hypertension[b] (n = 11), mean (SE)	*P* Value
Calcium (8.5-10.3 mg/dL)	9.38 (0.079)	9.16 (0.130)	.154
Copper (70-155 mcg/dL)	168.5 (5.18)	171.8 (13.2)	.821
Iron (60-170 mcg/dL)	107.8 (6.76)	84.6 (4.76)	.007
Magnesium (1.5-2.4 mEq/L)	1.83 (0.028)	1.87 (0.041)	.456
Zinc (60-130 mcg/dL)	78.9 (2.15)	67.1 (3.19)	.006

[a] Normotensive pregnancy group includes participants without hypertension and proteinuria.
[b] Gestational hypertension group includes participants with gestational hypertension and preeclampsia.
[c] Results represent units common to the reference range.

maternal nutrition and subsequent development of preeclampsia.[40]

This study compared micronutrient and macronutrient dietary intakes in women who were normotensive versus those who developed gestational hypertension or preeclampsia. Dietary zinc intake did not vary between women with gestational hypertension and those who had a normotensive pregnancy in our study; however, serum zinc was significantly different. It is likely that the reduction in serum zinc concentration in preeclampsia is an issue of metabolism rather than inadequate dietary intake, as there were no significant differences in dietary intake between groups. Our findings of decreased maternal serum zinc levels in early pregnancy and subsequent diagnosis of preeclampsia are consistent with many previous studies that have explored the relationship between nutritional biomarkers and preeclampsia and are in conflict with other research findings, potentially influenced by the severity of preeclampsia and gestational timing. A prospective study with a sample of 97 pregnant women with gestational hypertension, preeclampsia, or normotensive pregnancy identified no significant differences in maternal serum copper or zinc at time of diagnosis, although women with preeclampsia had significantly increased serum iron levels and evidence of oxidative stress.[20] In contrast, Bassiouni et al[41] found that maternal serum zinc levels were significantly decreased only in women with severe, not mild, preeclampsia among a group of 52 women in late pregnancy. Further, a prospective case (preeclampsia)–control (normal pregnancy) study that included 48 women in each group revealed an association between first-trimester serum zinc and severe preeclampsia.[42] Monia et al[43] conducted a prospective case-control study of maternal serum zinc and copper among 56 women, identifying significantly reduced zinc and copper levels in preeclampsia. Lazebnik et al also reported reduced maternal zinc levels in women with preeclampsia at the time of diagnosis. Although our findings of reduced first-trimester maternal serum zinc levels in preeclampsia are consistent with many studies, the timing of serum zinc measures in late and early pregnancy and the severity of preeclampsia may contribute to the discrepancy of findings with studies that do not identify a significant relationship with maternal serum zinc levels and preeclampsia. Our findings suggest that women with lower serum zinc levels may have an increased risk of developing gestational hypertension or preeclampsia when compared with women whose first-trimester serum zinc levels were higher. However, there is inadequate evidence to support zinc supplementation to improve maternal serum levels as a therapeutic target for preeclampsia prevention. The potential implications of single mineral supplementation or dietary manipulation without adequate consideration of the impact on other nutrients must be considered.[44,45]

Achieving optimal iron levels is a delicate balance, with high levels associated with toxicity. We found that participants in our study who subsequently developed gestational hypertension had lower serum iron levels during the first trimester than did those who did not develop gestational hypertension. These results contradict previous findings that higher iron levels are associated with an increased risk for preeclampsia.[27] In a recent study by Fenzl et al, serum iron levels measured at 20 weeks' gestation were higher in women with preeclampsia, but not gestational hypertension, compared with normotensive pregnancies.[20] Differences between our findings and those of others are potentially explained by different methodologies and gestational timing for collecting serum samples. Although others have shown that adequate iron intake is a concern in pregnancy,[46] dietary iron intake did not differ between groups in our study.

Current dietary recommendations for sodium during pregnancy are liberal for healthy women because previous research has reported detrimental effects of low-sodium diets.[33] Recent research has explored dietary patterns, reporting that expectant mothers were at higher risk of high blood pressure, specifically in mid- and late pregnancy, with higher adherence to a typical American diet[31] offering a liberal sodium intake. There were no significant differences in dietary sodium intake between women with and without gestational hypertension in our study. Notably, the effect of dietary sodium independently was not reported by others who have studied diet and gestational hypertension.[15,24,31]

Improved overall dietary quality has also been associated with a decreased risk of gestational hypertension.[9,12,18,29–31] We did not identify significant differences in energy or macronutrient intake in women who developed gestational hypertension compared with those who remained normotensive. Our findings were consistent with others who did not identify differences in energy intake as predictors of preeclampsia. Bouthoorn et al investigated energy intake among pregnant women enrolled in a large, prospective cohort study in early pregnancy and found that energy intake was not a predictor of preeclampsia.[47] Likewise, Morris et al, in a large prospective observational study of more than 4000 women, failed to identify any nutritional factors predictive of preeclampsia.[48]

The gestational timing of macronutrient intake in late pregnancy may confound accuracy of measures because of the concurrent presence of disease. A study by Davies reported significant reductions in dietary intake of protein, fat, and energy in women with preeclampsia at the time of diagnosis, results that may have been influenced by the consequences of preeclampsia rather than utility as a predictor.[49] In a large prospective population-based study (N = 3133), Clausen identified a significant association between preeclampsia and second-trimester increased energy intake of more than 3350 kcal/day, in contrast to our findings.[16] Sucrose and polyunsaturated fatty acids were identified as energy-rich nutrients significantly associated with energy intake and preeclampsia. In a multicenter case-control study of Latin American women, dietary intake was determined using food frequency questionnaires among women with preeclampsia and normotensive controls (n = 201/group). Although energy intake was increased in the preeclampsia group, increased dietary intake of carbohydrates was the only macronutrient predictive of preeclampsia.[50] Findings from this study may have been influenced by the late gestational timing of dietary intake measures. Synthesis of these findings also suggests that energy quality, rather than total energy, may be more influential in the prediction of preeclampsia.

This study has some limitations. To minimize participant burden for this group of community-dwelling women, the presence of proteinuria (to differentiate between

preeclampsia and gestational hypertension) was determined clinically by the observation of +1 on a dipstick.[6] In the ideal situation, diagnosis of proteinuria would be confirmed by the presence of more than 300 mg/dL protein in a 24-hour urine collection. However, our approach was consistent with other studies reporting urinary protein measured by dipstick as a gross determinant of significant proteinuria consistent with preeclampsia. The incidence of gestational hypertension in this convenience sample was higher than that in previously published research.[1–3] The high number of women with gestational hypertension was an unexpected finding in this study sample but did allow us to make comparisons between groups with a relatively small sample size. However, the incidence of gestational hypertension in this upper Midwest sample of nulliparous women is alarming. The absence of body mass index data for each participant prevented the determination of the association of prepregnancy weight on outcomes of interest. With regard to prenatal vitamin consumption, although it was anticipated that the content of the micronutrients of interest would fall within the standard ranges of prenatal vitamins expected, all participants did not consume the same brand of prenatal vitamins, and this may have contributed to the variability in nutrient intake and/or serum nutrient levels. Additional limitations include the small sample size of participants, who were relatively homogenous with regard to race and ethnicity. The small sample size may have contributed to the failure to establish significant differences between dietary intake group means. In addition, the results may not be generalizable to larger or ethnically diverse populations.

Although the relationship was not significant, the results suggest the need for further examination of the relationship between sodium and gestational hypertension and preeclampsia in a larger sample. At minimum, additional research is needed to determine if current recommendations for sodium intake are appropriate or if closer monitoring of dietary sodium intake is needed during pregnancy to attempt to prevent dangerous conditions such as preeclampsia and gestational hypertension in pregnant women. The inconsistent findings for the influence of maternal micronutrient, macronutrient, and energy intake as a predictor of preeclampsia may be the result of other factors such as metabolic processes and body mass index that have the potential to alter measures of maternal nutritional status. Although animal studies have demonstrated direct relationships with altered nutritional intake during gestation and pregnancy outcomes associated with characteristics of preeclampsia,[51,52] the application of such studies in pregnant women is unethical. As such, investigators are dependent on measures of dietary intake that reflect general measures of typical nutrient consumption.[53] The long-term implications of future health in light of maternal dietary increases in energy, protein, fat, and carbohydrate intake with advancing gestation are unknown.

CONCLUSION

Identification of nutritional influences in the pathogenesis of gestational hypertension has the potential to improve maternal and neonatal outcomes, providing cost-effective and accessible strategies for gestational hypertension screening and treatment.[18,19] Our results indicate an increased risk of the subsequent development of gestational hypertension or preeclampsia with lower first-trimester laboratory zinc values. Serum zinc values also merit further scrutiny, as they may be a valuable screening tool for practitioners in the future. Additional research is needed to establish a strong causal relationship between zinc levels and gestational hypertension and to describe the incidence of gestational hypertension across regions of the United States.

AUTHORS

Desiree L. Tande, PhD, RD, LRD, is an assistant professor in the College of Nursing and Professional Disciplines at the University of North Dakota in Grand Forks, North Dakota.

Jody L. Ralph, PhD, RN, is an assistant professor in the College of Nursing and Professional Disciplines at the University of North Dakota in Grand Forks, North Dakota.

LuAnn K. Johnson, MS, is a statistician with the University of North Dakota at the US Department of Agriculture, Agricultural Research Service, Grand Forks Human Nutrition Research Center.

Angela J. Scheett, MPH, RD, is a research dietitian with the University of North Dakota at the US Department of Agriculture, Agricultural Research Service, Grand Forks Human Nutrition Research Center.

Bonita S. Hoverson, RD, is the chief research dietitian with the University of North Dakota at the US Department of Agriculture, Agricultural Research Service, Grand Forks Human Nutrition Research Center.

Cindy M. Anderson, PhD, WHNP-BC, FAAN, is an associate professor in the College of Nursing and Professional Disciplines at the University of North Dakota in Grand Forks, North Dakota, and a Robert Wood Johnson Foundation Nurse Faculty Scholar Alumni.

CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

ACKNOWLEDGMENTS

This project was supported by the following grants: the Robert Wood Johnson Foundation Nurse Faculty Scholar Award (CMA, 64202), the Sigma Theta Tau International Small Grant Award (CMA, 3781) and the University of North Dakota Senate Scholarly Activity Committee New Faculty Scholar Award (CMA).

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