Original Article

Food-based recommendations for Minangkabau women of reproductive age with dyslipidemia

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Background and Objectives: Considering the impact of unfavorable dietary practices on inadequate nutrient intake, this cross-sectional study aimed to explore dietary practices, including problem nutrients, and develop local food-based recommendations (FBRs) to improve the intake of problem nutrients among women of reproductive age (WoRA) with dyslipidemia in Minangkabau, Indonesia. **Methods and Study Design:** The study was conducted in the Padang township inhabited mostly by the Minangkabau tribe. Accordingly, 74 WoRA with dyslipidemia completed the study. Two replicate 24-h recalls and a 5-day food record were used to assess food consumption patterns. Then, linear programming (LP) analysis using three modules of the WHO Optifood software was employed to identify problem nutrients and develop FBRs. **Results:** Median (5th and 95th percentiles) weekly consumption frequencies for grain; meat, fish, and eggs; and added fat were 18 (14–27), 11 (6–16), and 15 (7–30), while those for fruits and vegetables were 2 (0–11) and 7 (2–16), respectively. Based on the aforementioned food pattern, PUFA (both n-3 and n-6 fatty acids), dietary fiber, iron, and zinc were identified as typical problem nutrients. The final FBR emphasized on incorporating locally available nutrient-dense foods, as well as food groups and sub-groups, which would improve the intake of problem nutrients. **Conclusions:** Minangkabau WoRA have dietary practices that predispose them to dyslipidemia. Moreover, the LP approach is a sensitive tool for identifying nutrient-dense foods that could potentially improve problem nutrient intake, as well as those that need to be limited in the final FBR.

Key Words: food-based recommendations, problem nutrients, women of reproductive age, dyslipidemia, Minangkabau

INTRODUCTION

The people of Minangkabau have long been known to comprise the largest matriarchal society in the world. In Minangkabau culture, women play an important role in passing down knowledge and inheritances to members of their clan. Mothers are responsible for ensuring household food availability, kitchen activity and meal decision, and managing household expenditures to fulfill the nutrition needs of household members.[1]

The traditional Minangkabau diet had formerly been based on coconut, vegetable, and fish.[2,3] However, nowadays, there has been a shift toward using more oil instead of coconut. Based on the Indonesian Total Diet Survey data, the Minangkabau population consumed fat at an amount higher than that of the national average, mainly in the form of cooking oil and coconut milk. Additionally, vegetable and fruit consumption in the community was much lower than that recommended by the Indonesian dietary guidelines.[4] Current dietary practices were believed to be related to an unfavorable lipid profile and high prevalence of dyslipidemia within the community, especially among women. A previous study had found that based on category risk levels of total and LDL cholesterol, Minangkabau women over 40 years old had the highest mean plasma total cholesterol and prevalence of dyslipidemia among all other ethnicities.[5]

Dyslipidemia, characterized by plasma lipid abnormalities, is one of the major modifiable factors for cardio vascular diseases in both developed and developing countries.[6-9] The WHO has suggested that dyslipidemia is associated with more than half of all ischemic heart disease

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cases globally and more than four million deaths per year.[8]

Dyslipidemia has several adverse effects among women of reproductive age (WoRA) regarding not only maternal but also newborn and adult offspring health. It has been associated with polycystic ovary syndrome, the most common endocrine disorder and a leading cause of infertility among WoRA.[10] Dyslipidemia may have negative effects on both the fetus and mother during pregnancy, including severe preeclampsia, preterm birth risk,[11-13] increased risk for gestational diabetes mellitus, intrahepatic cholestasis of pregnancy, large gestational age newborns, macrosomia, increased risk for small gestational age newborns,[14] and susceptibility to early onset atherosclerosis when the newborn reaches adulthood.[15] The Framingham Heart Study found that maternal pre-pregnancy low-density lipoprotein cholesterol (LDL-C) levels explained 13% of the variation in adult offspring LDL-C levels beyond common genetic variants and classic risk factors for elevated LDL-C levels. Such findings support the possibility of a maternal epigenetic contribution to cardiovascular disease risk in the general population. Therefore, the identification, prevention, and reduction of dyslipidemia among women prior to their childbearing years may have additional potential health benefits for the subsequent generation.[16] Furthermore, considering their roles in family and society, targeting nutrition intervention toward WoRA in matriarchal societies would be beneficial for the entire household.

Diet has been the first line of treatment for an abnormal lipid profile. Improvement in dietary pattern and nutrient intake is a long-term solution for preventing the occurrence of dyslipidemia and its co-morbidities. High proportions of energy intake from fat, especially from SFAs, have undoubtable adverse effects on the lipid profile,[17] whereas high intake of PUFA (such as n-3 and n-6 fatty acids), dietary fiber, and sterols offers protective measures against dyslipidemia.[18-20]

Thus far, the Indonesian dietary guidelines published in 2003 and revised in 2014 have been used by nutrition policy makers and program stake holders to promote a healthy balanced diet.[21] Therapeutic nutrition guidelines have also been globally and nationally issued for dyslipidemia management.[22,23] However, dietary data at the national level has shown that most individuals do not adhere to such guidelines.[4,24] This might have been due to the non-compatibility between the guidelines and local conditions, including food availability, consumption patterns, purchasing power, and other local knowledge within the region. Key concepts in developing food-based recommendations (FBRs) include addressing dietary patterns, practicality, comprehensibility, culturally acceptability, and local availability of consumed foods.[25] FBRs and food guides should be based on current scientific evidence regarding nutritional requirements and diet-related diseases, as well as local dietary patterns and culinary practices. They provide information regarding food choice, meal preparation, and meal planning. Available data on their effectiveness suggest that they enhance awareness and understanding related to healthy eating.[25]

Recently, locally specific FBRs have been developed as translations of national dietary guidelines to suit the context of local dietary patterns using the linear programming (LP) approach. This approach has been used to address undernutrition problems, especially among children, and was found to be quite sensitive for detecting problem nutrients and ensuring nutrient adequacy in daily habitual diet.[26-33] During pregnancy and lactation, women were unlikely to consume adequate amounts of several micronutrients, such as iron, zinc, folate, vitamin B-12, and vitamin C.[34] However, information regarding problem nutrients related to dyslipidemia among women prior to conception has been lacking. Based on such circumstances, the LP approach is believed to be useful in bridging this gap and optimizing dietary patterns among WoRA living in vulnerable areas. Therefore, the present study is among the first to describe habitual dietary patterns, including problem nutrients, and develop a set of optimized FBRs aimed at improving dietary practices and intake of problem nutrients among WoRA with dyslipidemia. The information presented herein is especially useful in understanding dietary and nutritional dynamics related to dyslipidemia among WoRA, which would allow preventive actions to be taken.

METHODS

Study design and subjects

A cross-sectional study was conducted in Koto Tangah Sub-district of Padang township, the capital of West Sumatra Province, Indonesia and homeland of the Minangkabau population (Figure 1). Eligible subjects included native Minangkabau WoRA (20–44 years) who were disease-free at the time of study enrollment, were not pregnant, were not smoking, were not taking regular cholesterol-lowering drugs, had settled within the study sites for at least 6 months, and were willing to undergo blood measurement.

The ethnicity of the respondents was determined through the ethnicity of their parents and grandparents. At least both grandparents and parents of the respondents should be of the same ethnicity with no mixed marriages. Information concerning the ethnicity of the respondents and parents was obtained through self-report. The sample size was calculated based on the formula for estimating population means.35 Based on the mean intake of fat in the population (44 ± 18.6 g)[3] and a 10% attrition rate, this study required 68 subjects with dyslipidemia.

Prior to data collection, a health center nutritionist and field volunteers were requested to identify and list potential subjects that satisfied the inclusion criteria in the selected villages. An invitation letter was sent to all identified eligible subjects who were willing to visit the appointed field laboratory for blood measurements. A total of 170 subjects were screened to obtain a sufficient number of subjects. The final analysis included 74 subjects with dyslipidemia identified through blood lipid screening.

Data collection

Data collection was conducted between July and August 2018. Dyslipidemia was screened by measuring serum total cholesterol and LDL-C. As much as 5 mL of venous blood samples was drawn after overnight fasting by professional and skilled analysts. Blood sampling was

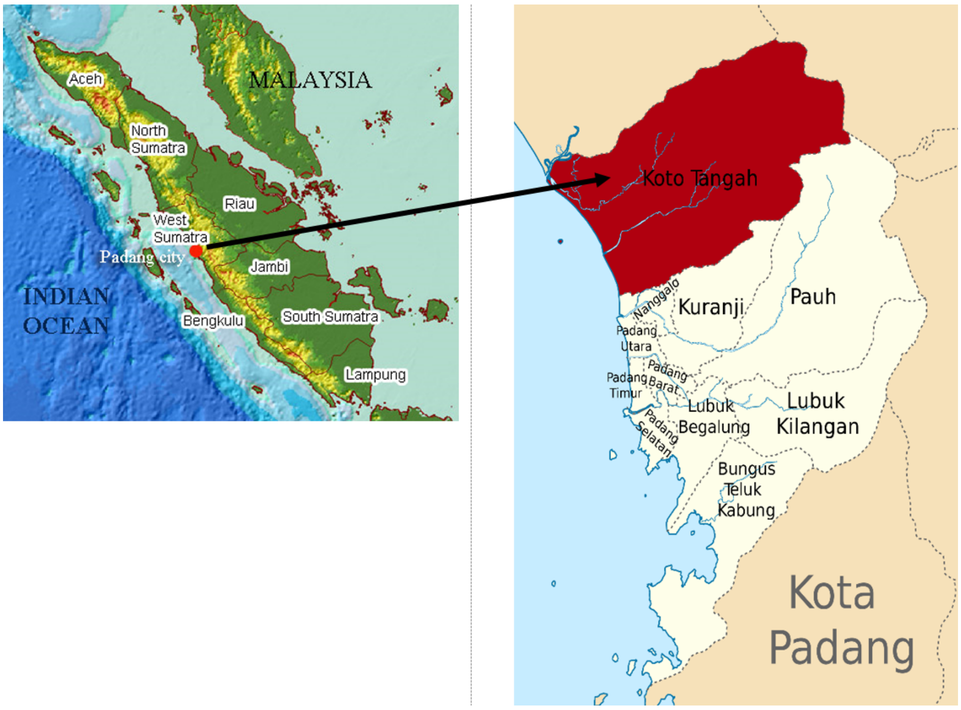

Figure 1. The study site.

conducted at the appointed field laboratory, after which collected blood samples were directly transported to the certified local Health Laboratory for centrifugation and measurement. Serum cholesterol was measured through the enzymatic colorimetric method with standardized procedures using the Selectra-E Analyzer. Classification guidelines were based on the National Cholesterol Education Program Adult Treatment Panel II22, in which total cholesterol levels ≥200 mg/dL and/or LDL-C levels ≥130 mg/dL were used to identify those with dyslipidemia.

Sociodemographic characteristics included data related to age, household size, household income, expenditure, education, and occupation. Nutritional status was assessed using BMI, waist circumference (WC), and blood pressure (BP). Body weight, height, WC, and BP were measured simultaneously during the screening process. Body weight was measured to the nearest 0.1 kg with subjects minimally clothed and standing on digital seca-scales. Height was measured to the nearest 0.1 cm using a non-stretch tape measure fixed to a wall with subjects standing without shoes and their shoulders in a normal position. BMI was calculated by dividing their weight in kg by the square of their height in meters (kg/m^2). WCs were measured using a seca measuring tape with an accuracy of 0.1 cm, while BP was measured by trained enumerators using standardized procedures with a battery-powered digital sphygmomanometer (Omron M7 Intelli IT). Arterial hypertension was determined when systolic BP was ≥140 mmHg and/or diastolic BP was ≥90 mmHg. All measurements were taken by trained field enumerators.

Dietary data was measured through two replicate 24-h dietary recalls on nonconsecutive days and a 5-day qualitative food record. Four trained enumerators who had nutrition education background and were fluent in the local language recorded all food and beverages consumed by the WoRA within the last 24 h starting upon waking up in the morning. Standard household measures were used to estimate portion sizes. When samples of the food consumed were still available, the enumerators weighed the food to estimate the actual portion size. Data for the 5-day food records were obtained using a self-administered questionnaire and was checked by the enumerator every 2 days.

Data processing and analysis

Socioeconomic characteristics, anthropometric measurements, and lipid profile data were entered into IBM SPSS software for windows version 20 (SPSS Inc., Chicago, Illinois, USA) for cleaning and all statistical analyses. Descriptive statistics were used to report sample distributions. The Kolmogorov-Smirnov test was used to determine normality of continuous variables. Continuous variables were presented as mean or median, standard deviation, or min–max values, whereas discrete variables were presented as frequencies and percentages.

Dietary data were initially entered into the NutriSurvey program, the output of which was exported to Excel. Then, a list of food items was obtained from the 24-h recall and 5-day qualitative food record. Food groups and sub-groups were classified based on the food grouping used in Optifood. The average portion size of each food was defined as the estimated median intake per day in grams. The final LP input parameters consisted of a list of food items consumed by at least 5% of the subjects; the average portion size of each food item; the minimum, median, and maximum (10th, 50th, 90th percentiles, respectively) weekly intake frequency of each food item; and food groups and sub-groups.

All three Optifood modules were used during LP analysis.[36] Module I examined the model parameters to ensure that Optifood generated realistic diets. Module II identified the two best diets for the target population given the dietary constraints—one diet follows the average population's food patterns (i.e., the 'food pattern best diet'), while the other deviates from them but remained within the observed food pattern ranges (i.e., the 'no food pattern best diet'). Both diets came as close as possible to meeting the recommended nutrient intake. Module II also provided information on problem nutrients, which were defined as nutrients that did not fully satisfy the Recommended Nutrient Intake (RNI) in the two best diets. Additionally, it identified nutrient-dense foods that could potentially be promoted. Module III analysis tested and compared alternative sets of FBRs. Diets having the lowest (i.e., nutrients minimized to identify the worst-case scenarios) and highest (i.e., nutrients maximized to identify the best-case scenarios) nutrient contents were first generated without the FBR to provide baseline levels for comparison. Nutrient levels in the worst-case scenario for each alternative FBR were generated and compared to obtain the most feasible FBR to fill nutrient gaps.

During LP analysis, original slots for the 14 nutrients available in the software were modified with the inclusion of PUFA, n-3 PUFA, n-6 PUFA, MUFA, and fiber. The nutrients that were replaced included thiamin, niacin, B-12, vitamin A (RE), and vitamin A (RAE), which had been previously found to be sufficient in the diets of WoRA. As a nutrient reference, a food composition table was developed for all food items consumed by at least 5% of the respondents. Most of the food items' nutrient content were adopted from the Indonesian Food Composition Table, except for fatty acid content, which was adopted from United States Department of Agriculture Food Composition Table. Macronutrient, vitamin, mineral, and fiber requirements were determined using the Indonesian RNI for women aged 19–50 years,[37] except for fatty acids (MUFA, PUFA, n-3, and n-6), which were determined using the Food and Agriculture Organization standard for fat and lipid requirements in adult populations.[18]

Ethical approval

Ethical approval (reg no: 0363/UN2.F1/ETIK/2018) was obtained from the Human Ethics Committee of the Faculty of Medicine, Universitas Indonesia prior to data collection. The study objectives and purpose were explained to local authorities, community leaders, and respondents. Before data collection, permission was sought from provincial, district, and respective local authorities. Respondents provided verbal consent, which was recorded as part of the questionnaire responses. A comprehensive understanding and agreement to participate was confirmed by all participants through signature prior to data collection. Data from all respondents were treated with confidentiality.

RESULTS

Selected sociodemographic characteristics, lipid profile, and nutritional status of subjects

A total of 170 WoRA who sastisfied the eligibility criteria participated in the dyslipidemia screening. Accordingly, 75 (44.1%) subjects identified as having total serum cholesterol and/or LDL above normal cutoff points were classified as having dyslipidemia. Among them, 74 subjects completed the interview on sociodemographic characteristics and dietary patterns. The median (min–max) age was 37.5 (22–44) years, while majority of the participants were 30–44 years old (83.8%). Almost two-thirds of the respondents had tertiary education with 12 years of schooling. Most of the participants were either housewives or unemployed, while nearly one-third worked as small traiders, private employees, and enterpreuners. The median household size was 5 members (range 3–10). Appoximately 13.5% of the paticipants had a family history of non-communicable diseases, such as stroke, heart diseases, diabetes mellitus, and hypertention.

Median (min–max) total serum cholesterol and LDL were 215 (166–306) and 146 (130–221) mg/dL, respectively. Appoximately 10.8% of the subjects had high total serum cholesterol levels (above 240 md/dL), while 58.1% had levels between 200 and 240 mg/dL (borderline high category). Based on their serum LDL, 71.6%, 25.7%, and 1.4% of the respondents were classified into borderline high (130–159 mg/dL), high (160–189 mg/dL), and very high (≥190 mg/dL) categories, respectively.

The median (min–max) BMI was 25.1 (16.5–36.1) kg/m^2. Based on the BMI cutoff point, 2 (2.7%), 24 (32.4%), and 29 (39.2%) subjects were categorized as underweight (<18.5 kg/m^2), overweight (23–27.50 kg/m^2), and obese (>27.50 kg/m^2), respectively. The median (min–max) WC was 83.4 (58.4–108.8) cm with 50 (68.9%) participants having a WC in the increased risk (≥80 cm) category. Based on BP measurements, the median systolic and diastolic BP were 117 and 77 mmHg, respectively, with 7 (9.5%) subjects being classified as hypertentive (BP ≥140/90 mmHg).

Dietary pattern

Table 1 presents the consumption frequency of food groups or sub-groups. Overall, although more than 100 different food items in the list were reported in the dietary record, only 98 foods that were consumed by at least 5% of the subject or considered nutrient dense were used. The main meals of the subjects consisted of staple food, protein-rich foods, and vegetables. Staple food included refined grains and grain products with rice being the most frequently consumed by all of the subjects. Starchy plant foods, such as potatos and cassavas, were also consumed by 55% and 12% of the subjects, respectively.

The following two food groups were identified as the main sources of protein in the subjects' diet: (1) meat, fish, and egg and (2) legumes and nuts. Regarding the first food group, fresh water fish, chicken eggs, non-bony sea fish, chicken meat, and small bony fish (e.g., anchovy) were the most common food items consumed by 88%, 76%, 74%, 61%, and 32% of the subjects, respectively, while beef was only consumed by 28% of the subjects. The portion size per serving for the food items varied between 10 and 75 g. Regarding the second food group, soybean products, such as tofu and tempeh (fermented soybean), were consumed by 74% and 39% of the subjects, while peanuts and mugbeans were consumed by 42% and 9% of the subjects, respectively.

Palm oil and coconut milk were the two frequently consumed food items in the added fat food group. The median (min–max) frequencies of palm oil and coconut milk consumption were 10 (6–18) and 2 (0–12) times per week, respectively. All of the subjects used palm oil for deep fried foods, such as side dishes from the rich foods and a variety of starchy snack foods, while 92% of the subjects used coconut milk for curry recipes of protein dishes, vegetables, and sweetened composite snack foods. Portion sizes per serving of cooking oil and coconut milk were approximately 7 and 30 g, respectively.

Approximately 20 vegetables were consumed by the subjects within the last week, albeit in small portions. The most common vegetables consumed by 30%–45% of the subjects included tomatoes, Chinese convolvulus (kangkung), french beans (buncis), cassava leaves, carrots, spinach, cucumbers, and young jack fruit (nangka muda). Portion sizes for vegetables ranged between 20 and 100 g wet weight.

Several types of spices and herbs were identified in the condiment food group consumed by most of the subjects. Accordingly, red pepper, shallots, garlic, ginger, tumeric, galangal, and salt were consumed by 30%–100% of the subjects. These condiments were used in combination as seasoning mainly when cooking animal products, legumes, and vegetables, especially when coconut milk was used.

Besides the main meals, the subjects also consumed several snack foods between meals. Snacks consisted of fruits, bakery products, composite foods, and beverages. Although several types of fruits were locally available, only few of them were consumed by most of the subjects. Bananas, oranges and papayas were the most common fruits consumed by 39%, 27%, and 22% of the subjects within the last week. Other fruits, such as avocados, apples, guavas, melons, snake fruits, and watery roseapples, were consumed by less than 10% of the subjects. The median portion size of fruits consumed varied between 20 and 170 g depending on the type of fruit. Other snack foods, such as composite snacks, bakery products, and biscuits, were consumed by less than 20% of subjects. The beverages most frequently consumed by 57% and 27% of the subjects were tea and coffee with sugar, respectively, while only 11% of the subject consumed fresh milk and other dairy products.

Nutrient intake

Table 2 presents the energy, macronutrient, fatty acid, and fiber intakes among the study participants. Actual energy, protein, fat, and carbohydrate intakes were below the respective RNI for WoRA. Proteins, fats, and carbohydrates contributed to approximately 11.7%, 20.3%, and 68% of the total energy intake, respectively. PUFA intake and the PUFA:SFA (P/S) ratio were lower than the recommended levels, while fiber intake was only approximately one-third of the recommended levels.

Problem nutrients and food-based recommendation

Table 3 shows the results from Modules II and III of LP analysis. Accordingly, Optifood Module II (two best diets) identified six problem nutrients, namely total PUFA, n-3 PUFA, n-6 PUFA, iron, zinc, and fiber. Potential nutrient-dense food groups and sub-groups that could be promoted to help achieve dietary adequacy were MFE (non-bony fish, poultry, and eggs), legumes (soybean products), fruits, vegetables, and added fats. Tuna fish, potatoes, cassava leaves, chicken meat, tofu, tempeh, and guavas were identified as potential nutrient-dense foods and incorporated either separately or in combination with the food groups and sub-groups to establish FBR alternatives.

Optifood Module III (worst- and best-case scenarios) revealed that the highest achievable RNI for the aforementioned problem nutrients with a maximized diet (best-case scenario) ranged from 49.7% (total PUFA) to 104.14% (zinc). Zinc was considered as a partial problem nutrient given that 100% of the RNI could not be achieved with the best diet (Module II) but could be achieved in the best-case scenario (Module III). On the other hand, total PUFA, n-3 PUFA, n-6 PUFA, iron, zinc,

Table 1. Consumption frequency of the food groups and sub-groups by the respondents

Food Group/Sub-group	No. of food items	Low servings/ week†	Median servings/ week‡	High servings/ week§
Added fats	3	7	15	30
Vegetable oil (palm oil)	1	6	10	18
Other added fat (coconut, coconut milk)	2	0	2	12
Added sugars	2	0	2	10
Bakery (sweetened bakery, unfortified biscuit)	6	0	1	4
Beverages (tea, coffee, non-diary beverages)	2	0	2	9
Composites (mixed food groups)	5	0	2	8
Dairy product (fluid or powdered milk)	3	0	0	3
Fruits	14	0	2	11
Grains & grain products	8	14	18	27
Legumes	6	2	6	11
Meat,fish & eggs	16	6	11	16
Eggs	3	0	0	3
Fish without bones (fresh water, tuna)	7	1	5	15
Poultry (chicken meat)	2	0	1	4
Red meat (beef)	1	0	0	2
Small, whole fish, with bones (anchovy, etc.)	3	0	0	2
Miscellaneous (condiment, herbs, spices)	8	25	52	89
Savory snacks (salted, spiced, fried chips)	3	0	0	2
Starchy roots & other starchy plant foods	3	0	1	6
Vegetables	19	2	7	16

†5th percentile, ‡50th percentile, §95th percentile of weekly frequency was used.

Table 2. Energy and selected nutrient intake† of the study participants

Parameters	Median (min–max)	RNI‡
Energy (kcal)	1858 (1115–3055)	2150
Proteins (g)	55.7 (19–117)	57
Fats (g)	40 (10.7–98.6)	48
Carbohydrates (g)	316 (149–606)	323
Energy from protein (%)	11.7 (6–25.5)	10–15
Energy from fat (%)	20.3 (5.5–40.5)	20–35
Energy from carbohydrates (%)	68 (39–83)	50–60
Total SFA (g)	21.3 (4.94–67.9)	23.9
Total MUFA 9 (g)	8.8 (3.1–25.4)	22
Total PUFA (g)	5.4 (1.31–19.86	14–26
n-3 PUFA (g)	0.86 (0.12–-15.56)	1.1
n-6 PUFA (g)	2.07 (0.59–8,05)	12
Energy from SFA (%)	10.4 (2.6–22.6)	10
Energy from MUFA (%)	4.2 (1.6–11.3)	4–14
Energy from PUFA (%)	2.51 (0.9–8.3)	6–11
PUFA/SFA (P/S) ratio	0.24 (0.08–2.09)	0.6–1.1
Fiber (g)	9.05 (3.5–21.1)	30

RNI: recommended nutrient intake.
†Intake was the average of 2-day nonconsecutive 24-h dietary recalls.
‡RNI for energy and most nutrients refers to the Indonesian RNI for WoRA,[37] while RNI for fat and fatty acids refers to or was calculated from Food and Agriculture Organization recommendations for fat and fatty acid intake.[18]

and fiber were categorized as absolute problem nutrients given that 100% of the RNI could not be achieved in both the best and the maximized diet (best scenario). Other nutrients in the list, except protein, were inadequate with a minimized diet (cannot achieve 65% of the RNI in the minimized or worst-case scenario).

Table 4 shows the 18 alternative FBRs determined based on identified nutrient-dense foods and food groups or sub-groups. Then, they were compared based on their worst-case scenario nutrient levels in Module III. These alternative FBRs did not meet 65% of the RNI for all nutrients, except for protein, fat, Ca, and vitamin C. Among these alternatives, the 18th FBR was the most promising considering that it achieved the highest RNI percentage for all problem nutrients in the list. Table 5 shows the final FBR formulated to improve the intake of problem nutrients identified among Minangkabau WoRA with dyslipidemia and the recommended minimum portion sizes for each food.

DISCUSSION

This study has been the first to explore dietary patterns to identify problem nutrients and develop dietary recommendations based on the traditional diet of WoRA with dyslipidemia in Minangkabau, West Sumatra, Indonesia. The present study showed that the prevalence of dyslipidemia among Minangkabau WoRA was considerably high (44.1%), much higher than that presented in the findings of previous studies (i.e., 24%–35.9%).[5,38] This finding seems to be related to the shift in the dietary patterns. With the former traditional diet consisting of rice, fish, coconut, and vegetables, coronary heart disease had rarely occurred within the community,[39] while the consumption of coconut milk was thought to be a protective measure against coronary heart disease.[3] However, the use of coconut milk during food processing has lately been replaced by the frequent use of palm oil, with palm oil being consumed almost five times more frequently than coconut milk. Although both coconut milk and palm oil are sources of saturated fatty acids, 50% of which are saturated,[40] both are used for different food processing methods. Coconut milk has been more widely used for making curry, while palm oil has been more frequently used for frying. Accordingly, the use of coconut milk in food processing had been found to promote greater consumption of vegetables, herbs, and spices rich in antioxidants and fiber,[3] which are considered protective measure against dyslipidemia. On the other hand, the use of palm oil may result in the increased fried food consumption given that most of the side dishes from animal and plant based-foods are processed through deep fat frying. One previous review revealed a strong relationship between fried food consumption and a higher risk of developing chronic diseases among adults.[41]

LP analysis revealed that in addition to iron and zinc, total PUFA, n-3, n-6, and fiber were typical problem nutrients for WoRA. PUFA are needed for maintaining maternal health prior to conception, as well as during pregnancy and breastfeeding.[42] Essential n-6 and n-3 fatty acids, such as linoleic acid and alpha-linolenic acid, are essential nutrients and precursors of a family of fatty acids having a 20- or 22-carbon chain, such as arachidonic acid, eicosapentaenoic acid, and docosahexaenoic acid. These fatty acids are vital structural components of membrane phospholipids in central nervous system cells (neurons and glial cells).[43] The effects of essential fatty acids on health and disease, such as the normal growth and development of newborns and infants, protection against cardiovascular diseases, certain cancers, and autoimmune diseases, and healing of autoimmune skin diseases, has long been documented.[44] The final local FBR, which included nutrient-dense foods, can improve intake of the identified problem nutrients, although some dietary inadequacies may still remain.

Dietary data presented herein showed that Minangkabau WoRA with dyslipidemia had nutrient intakes that were generally similar to those in Asians. The highest proportion of energy intake came from carbohy-

Table 3. Energy and nutrient intake from the two "nutritionally best diets" based on LP analysis Module II and the type of problem nutrient and nutrient adequacy based on LP analysis Module III (worst-best case scenario) among WoRA with dyslipidemia

Energy and nutrient	LP analysis Module II				LP analysis Module III				Type of nutrient‡‡
	Intake/day		%RNI†		Intakes/day		%RNI		
	FP‡	NFP§	FP‡	NFP§	Minimized¶	Maximized††	Minimized¶	Maximized††	
Energy (kcal)	2150	2150	100	100	943.60	2765.6	43.90	128.60	DI
Proteins (g)	74.50	85.80	130.70	150.60	42.30	96.80	74.20	169.80	DA
Fats (g)	39.0	49.40	81.70	103.10	14.10	60.8	29.50	127.20	DI
Vitamin C (mg)	123.70	227.20	164.90	302.90	0.20	259.70	0.30	346.2	DI
Riboflavin (mg)	1.40	1.70	108.5	131.70	0.10	2.00	9.40	156.80	DI
Vitamin B-6 (mg)	1.30	2.00	100	152.40	0.20	2.50	16.10	194.3	DI
Folate (mg)	400	400	100	100	12.00	931.6	3.00	232.9	DI
Total PUFA (g)	7.00	9.40	32.50	46.90	1.10	9.90	5.40	49.7	APN
n-6 PUFA (g)	5.40	6.20	44.70	51.30	0.90	6.80	7.60	56.30	APN
n-3 PUFA (g)	1.00	2.50	28.20	71.30	0.20	2.90	5.00	83.10	APN
MUFA (g)	13.30	15.50	85.60	100	2.30	18.60	14.80	120.10	DI
Calcium (mg)	959.40	1160	95.90	116	567.3	1382	56.70	138.20	DI
Iron (mg)	11.60	17.60	44.60	67.50	5.70	21.00	22.0	80.90	APN
Zinc (mg)	7.60	9.00	76.40	90.10	3.00	10.40	30.40	104.40	PPN
Fiber (g)	13.20	15.90	44.0	69.00	2.40	22.80	8.00	75.80	APN

LP: linear programming; RNI: recommended nutrient intake; FP: food pattern; NFP: non-food pattern; DI: dietary inadequacy; DA: dietary adequacy; APN: absolute problem nutrient; PPN: partial problem nutrient.
†RNIs refer to Indonesian RNI[37] and FAO recommendations for fat and fatty acids among the adult population.[18]
‡Food pattern: Best diet closely resembling the target population's average food patterns.
§No food pattern: Best diet that deviates from the average food patterns but remains within upper and lower food group constraints.
¶Each diet sequentially minimizes each micronutrient (Optifood Module III; "worst-case scenario").
††Each diet sequentially maximizes each micronutrient (Optifood Module III; "best-case scenario").
‡‡PPN: The nutrient cannot achieve 100% of its RNI with the best diet (Module II) but can achieve 100% of its RNI with the best-case scenario (Module III); APN: The nutrient cannot achieve 100% of its RNI with the best diet (Module II) and less than 70% of its RNI with the best-case scenario (Module III); DA: Nutrient intake achieves ≥65% of the RNI with the worst-case scenario; DI: Nutrient intake achieves <65% of the RNI with the worst-case scenario; Both PPN and APN are automatically considered dietary inadequacy (DI).

drates (68%), which exceeded the acceptable range of 50%–60%.[37] Carbohydrate sources mostly included refined grains, with rice being the main carbohydrate source with a consumption frequency of 2–3 times a day (Table 4). Accordingly, a previous study suggested that the increased intake of highly processed carbohydrates had a complex and unfavorable effect on lipid profile, which may have implications for metabolic syndrome, diabetes, and coronary heart disease.[45]

The consumption frequency of added fat among the subjects was considerably high. Although the absolute intake of fat remained within the recommended intake, the proportion of total energy intake from saturated fat was more than 10%. Moreover, PUFA intake was determined to be far below the recommended intake.[18] Accordingly, one previous study had found that dietary fat intake was positively associated with total cholesterol and LDL patterns, although Asian populations have lower fat intakes (<25% of energy) that Western populations.[46] With sufficient fat intake, low proportions of PUFA and MUFA imply high SFA contents in the diet. The adverse effects of high SFA intake on lipid profile seems to depend greatly on the P/S ratio. The P/S ratio of 0.24 obtained herein suggested that the diet was likely to be atherogenic. Previous studies have suggested that a P/S ratio of less than 0.6 would indicate that a diet might increase plasma cholesterol levels and be considered highly atherogenic, while a higher P/S ratio of around 0.8 would suggest that a diet was considered less atherogenic.[47,48]

The present study found that the animal protein food group, such as meat, fish, and eggs, have been the main sources of dietary protein in the Minangkabau community, a finding also confirmed by a previous study.[2] Although the consumption of animal products provides protein, fat, fatty acids, and minerals required by the WoRA, animal food sources are usually deep fried, cured (with or without coconut milk), or grilled. Consequently, the consumption of animal protein would increase the use of added fat in the daily diet.

Dietary fiber intake had also been considerably low among the participants who consumed only approximately 30% of the recommended intake. Moreover, the low intake of fiber among the subjects was consistent with low consumption of fruits and vegetables, which were the main sources of dietary fiber in their habitual dietary pattern. Accordingly, a previous study had documented the favorable effects of dietary fiber on the lipid profile wherein an increase in the average dietary fiber intake from less than 18 g/day to over 30 g/day resulted in an 11.1% increase in the average HDL cholesterol level among women, suggesting its potential beneficial effect in decreasing cardiovascular disease risk.[49]

Our study also found that WoRA with dyslipidemia had food patterns that were not significantly different from those without dyslipidemia. Although categorized as normal, the lipid profiles of WoRA without dyslipidemia were mostly near the cutoff level for dyslipidemia (data not shown here). This finding implies that the population's food patterns predisposes them to dyslipidemia, necessitating interventions that improve the existing food patterns.

Apart from identifying problem nutrients among WoRA with dyslipidemia, LP also identifies potential nutrient-dense foods that are rich in PUFA, fiber, and other problem nutrients. LP analysis using Optifood Module II revealed several PUFA-rich foods (i.e., foods that comprised at least 5% of problem nutrient intakes), including several types of fish (non-bony sea fish, fresh water fish, and small bony fish), eggs, and poultry. These foods are also rich in iron and zinc, which were also identified as typical problem nutrients. Moreover, meat, poultry, and soybean products, such as tofu and tempeh (fermented soybean), are also important sources of problem nutrients, such as PUFA (both n-3 and n-6), iron, and zinc. Additionally, several types of fruits and vegetables had been available to satisfy fiber and vitamin requirements. The final FBR was established considering the participants' food patterns and emphasized on the use of locally available nutrient-dense foods. However, given the limited food options in the participants' diet, ensuring dietary adequacy of all problem nutrients based on the worst-case scenario was difficult. The use of oils, whether in meals or snacks, has been explicitly indicated in the FBR as one of the main sources for PUFA in the diet. The final FBR could increase the intake of PUFA, n-6, n-3, iron, zinc, and fiber to around 23.4%, 23.4%, 41.3%, 16.4%, 33.1% and 28.1% of the RNI in the worst scenario, respectively, suggesting the need to improve further the food options among WoRA in terms of PUFA, iron, and fiber food sources.

The strengths of the current study include the use of LP analysis for the identification of total PUFA, n-3, n-6, and fiber as typical problem nutrients among WoRA besides iron and zinc. Additionally, LP identified not only nutrient-dense foods worth promoting but also fat sources whose consumption needed to be limited in the final FBR. One limitation of the present study was the fatty acid composition of some foods was still adopted from other food composition tables that may not precisely estimate fatty acid content. Moreover, fatty acid requirements were adopted from the Food and Agriculture Organization, which may have slightly higher requirements than those of the study population.

Conclusions

Considering the high prevalence of dyslipidemia in the study area, as well as the apparent change in the traditional diet, WoRA may suffer from the insufficient intake of essential fatty acids, vitamins, and minerals that have a significant impact on both maternal and offspring health. In this context, the early identification of the problem nutrients may thus assist in the formulation of specific food-based interventions. Given the habitual food patterns of our respondents, as well as the use of the LP approach, PUFA (both n-3 and n-6) and dietary fiber had been identified as absolute problem nutrients in addition to other common problem nutrients related to pregnancy outcomes, such as iron and zinc. The LP approach has been determined to be a sensitive tool for identifying nutrient-dense foods, as well as those that need to be limited, to establish a final FBR that could potentially improve the intake of problem nutrients. Nonetheless, further study is needed to evaluate the efficacy of the FBR in improving dietary practices as part of nutrition education and life-

Table 4. Percentage of the recommended nutrient intake (RNI) for the optimized diet, the best- and worst-case scenario results, and the worst-case scenario results in the alternative FBRs

Analysis		Achievement of nutrients (%RNI)													
		Protein	Fat	Ca	Vit C	PUFA	Riboflavin	n-6	Vit B-6	Folate	n-3	MUFA	Fiber	Iron	Zinc
Optimized diets - with FP		130.7	81.7	95.9	164.9	35.2	108.5	44.7	100.0	100.0	28.2	85.6	44.0	44.6	76.4
Optimized diets - without FP		150.6	103.4	116.0	302.9	46.9	131.7	51.3	152.4	100.0	71.3	100.0	69.0	67.5	90.1
Best-case scenario without FBR		169.8	127.2	138.2	346.2	49.7	156.8	56.3	194.3	232.9	83.1	120.1	75.8	80.9	104.4
Worst-case scenario without FBR		74.2	29.5	56.7	0.3	5.4	9.4	7.6	16.1	3.0	5.0	14.8	8.0	22.0	30.4
Tested FBR alternatives (worst-case scenario only)															
1	Soybean10	88.3	36.7	65.7	1.0	16.5	21.5	18.3	19.9	7.3	33.5	23.0	11.7	30.2	34.8
2	Fish9	82.8	30.2	56.7	0.3	8.5	10.7	7.8	23.4	3.2	19.7	20.3	8.0	24.3	36.7
3	Poultry3	74.2	37.5	56.7	0.3	8.3	10.7	11.9	18.3	3.0	8.2	20.8	8.0	22.0	31.4
4	Egg3	74.6	33.7	57.2	0.3	8.3	16.2	10.2	16.7	5.7	5.0	19.4	8.0	24.1	31.8
5	Vegetable (veg)14	74.5	29.5	56.7	11.9	5.4	11.9	7.6	19.2	5.4	5.0	14.8	10.0	23.3	31.5
6	Fruit 9	74.5	29.5	58.3	98.1	5.8	12.4	8.1	22.8	12.4	7.0	15.2	18.7	25.6	31.9
7	Veg14, cassava Leave (CL)5	80.6	30.5	67.1	100.8	6.0	15.4	8.6	32.3	5.4	5.6	14.8	20.7	25.3	48.7
8	Fruit7, Guava1	74.3	29.5	57.1	54.6	5.8	11.6	8.1	21.1	8.7	6.2	15.0	15.6	23.1	31.4
9	Tuna5	77.5	30.0	59.2	0.3	7.6	9.4	7.6	43.3	3.0	19.6	17.1	8.0	23.7	35.6
10	Potato5	76.1	29.7	60.3	20.3	5.4	12.9	7.7	26.0	5.6	5.1	14.8	12.9	23.3	32.6
11	MFP 14, Tuna5, Egg3, Chicken2	87.1	40.6	60.0	0.3	14.6	18.7	13.6	48.3	5.7	24.7	29.3	8.0	26.7	39.3
12	Tofu4, tempe3	84.0	34.4	62.7	0.8	13.2	18.2	15.4	18.8	6.0	24.1	20.7	10.8	27.6	33.3
13	Veg14, CL5 - Fruit7, Guava1	80.6	30.5	67.5	155.2	6.5	17.7	9.1	37.6	11.1	6.9	15.0	28.3	26.4	49.7
14	MFP14, Tuna5, Egg3, Chicken2 - Tofu4, tempe3	96.9	45.9	66.1	0.8	22.5	27.6	21.5	51.8	8.9	43.8	35.2	10.8	32.4	42.1
15	Veg14, CL5 - Fruit7, Guava1 - MFP14, Tuna5, Egg3, Chicken2 - Tofu4, tempe3	103.2	47.0	77.0	155.8	23.7	36.0	23.0	74.8	17.4	45.7	35.4	31.1	36.9	61.4
16	Potato5 - Veg14, CL5 - Fruit7, Guava1 - MFP14, Tuna5, Egg3, Chicken2 - Tofu4, tempe3	105.0	47.1	82.2	175.8	23.8	39.7	23.1	85.5	20.4	45.9	35.4	36.1	38.4	63.5
17	Oil14	74.2	48.3	56.7	0.3	10.2	9.4	15.5	16.1	3.0	5.4	40.7	8.0	22.0	30.4
18	Potato5 - Veg14, CL5 - Fruit7, Guava1 - MFP14, Tuna5, Egg3, Chicken2 - Tofu4, tempe3 - Oil14	105.0	66.4	82.2	175.8	28.8	39.7	31.0	85.5	20.4	46.3	61.3	36.1	38.4	63.5

LP: linear programming; RNI: recommended nutrient intake; FP: food pattern; NFP: non-food pattern; DI: dietary inadequacy; DA: dietary adequacy; APN: absolute problem nutrient; PPN: partial problem; FBR: food based recommendation; MFP; meat, fish and poultry; CL: cassava leaf

Table 5. Food-based recommendations formulated for Minangkabau WoRA with dyslipidemia

No	Recommendations	Recommended portion size
1	Consume 2–3 main meals and 2 snacks in a day	1 serving of rice milled = 150 g (dry weight)
2	Consume at least 2 servings/day of meat, fish, or poultry, including:	
	a. At least 5 servings/week of tuna	1 serving of tuna = 60 (wet weight)
	b. At least 3 servings/week of egg	1 serving of egg = 45 (wet weight)
	c. At least 2 servings/week of chicken	1 serving of chicken= 40 (cooked weight)
3	Consume at least 7 servings/week of soybean products (tofu or tempe)	1 serving of tofu= 50 g (wet weight) 1 serving of tempeh = 50 g (wet weight)
4	Consume at least 2 servings/day of vegetable, including 5 servings/week of cassava leaves	1 serving of vegetable = 100 g (wet weight)
5	Consume at least 1 serving/day of fruit, including at least 1 serving/week of guava	1 serving of fruit = 100 g (wet weight)
6	Consume at least 5 servings/week of potato (e.g., small potato in chicken rendang, potato pure with eggs, etc.)	1 serving of potato = 50 g (wet weight)
7	Limit fried foods or foods cooked with coconut milk to a maximum of 2 servings/day	1 serving of fried foods or food cooked with coconut milk could absorb 5–7 g oil or about 30 g of coconut milk (in one portion of curry)

style interventions to overcome dyslipidemia among WoRA for optimal pregnancy outcomes.

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AUTHOR DISCLOSURES

The authors declare that there are no conflicts of interest.

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