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ORIGINAL ARTICLE

Dietary patterns of urban adults in Benin: relationship with overall diet quality and socio-demographic characteristics

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Objectives: To identify dietary patterns of urban Beninese adults and explore their links with overall diet quality and socio-demographics.
Subjects and methods: A sample of 200 men and women aged 25–60 years was randomly selected in 10 neighbourhoods. Food intake was assessed through three non-consecutive 24 h food recalls. Dietary patterns were examined using cluster analysis. Diet quality was assessed based on diversity, a micronutrient adequacy score (MAS) and a healthfulness score (HS). Socio-demographics were documented using a questionnaire.
Results: Two distinct dietary patterns emerged: a 'traditional' type (66% of the subjects) and a 'transitional' type (34%). Subjects with a 'transitional diet' were predominantly from the upper socioeconomic status or born in the city. Compared with the traditional type, the 'transitional diet' had a significantly higher percentage of energy from fat (17.6 vs 15.5%), saturated fat (5.9 vs 5.2%) and sugar (6.3 vs 5.0%). It was also significantly higher in cholesterol and lower in fibre. The 'transitional diet' was more diversified, but it also showed a lower HS than the 'traditional diet'. Mean intake of fruit was low in both clusters ($<16\,g\,day^{-1}$). A higher intake of vegetables was associated with both a higher MAS ($P<0.001$) and a higher HS ($P<0.001$).
Conclusions: The dietary transition is evidenced in this study, although both dietary patterns were still low in fat and sugar. Programmes focusing on the prevention of diet-related chronic diseases in this population should encourage the maintenance of the healthful elements of the diets, while emphasizing consumption of fruits and vegetables.
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Keywords: dietary patterns; cluster analysis; diet quality; urbanization; Benin; Africa

Introduction

The rising prevalence of obesity worldwide is an issue of great concern and the increase is often faster in developing countries than in the developed world (WHO, 2007). Current evidence suggests that nutrition transition, with progressive shifts in diet and lifestyle factors, plays a key role in the increasing prevalence of obesity and related chronic diseases (Popkin, 2002).

Although data on obesity and nutrition-related chronic diseases in West Africa are scanty, there are indications that they are becoming a serious public health concern. A recent review of available data shows that between 10–30% of men and 15–45% of women in West Africa are either overweight or obese (Thiam *et al*., 2006). Obesity is also emerging public health problem in Benin, along with undernutrition and micronutrient deficiencies (EDSB, 2001). We found a prevalence of 18% for overall obesity, 32% for abdominal obesity, 23% for hypertension and 13% for low high-density lipoprotein-cholesterol in adults of Cotonou (unpublished data). However, little is known about the contribution of diet to the risk of cardiovascular disease. There is a need to better

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understand the links of dietary habits with cardiovascular disease risk in this population.

In recent years, there has been increasing interest in using dietary pattern analysis to assess the relationship of diet with chronic diseases. Such an approach is meaningful, since it addresses the problem of collinearity of food and nutrient intake (Hu, 2002). Several indices of diet quality were developed based on nutrients, foods or both (Kant, 1996). More recently, Kim *et al.* (2003) developed the Diet Quality Index-International (DQI-I) to compare diet quality in developed and developing countries.

This study was undertaken to examine dietary patterns in urban Beninese adults and explore their links with overall diet quality and socio-demographics. We hypothesized that diet quality would be negatively associated with socioeconomic status (SES) and longer exposure to urban environment.

Subjects and methods

Subjects
The study was conducted in Cotonou, the largest city of Benin with an estimated population of one million inhabitants (INSAE, 2003). A total of 200 subjects aged 25–60 years were selected in 10 neighbourhoods picked at random. Twenty households were randomly selected in each neighbourhood, and then one subject was picked among the eligible members of every household. We alternated men and women to have equal number of subjects for each sex. Subjects with a prior history of metabolic diseases were excluded because of possible modification of their diet and lifestyle. Although obese subjects may also modify their diet or lifestyle, we nonetheless included these subjects, because it may be difficult to judge whether somebody is obese or not unless the person is weighed and measured, which was not deemed appropriate during the recruitment process. In addition, as obesity is socially desirable in many low-income countries (Stunkard, 2000), it is unlikely that obese subjects would have modified their lifestyle for health reasons. Pregnant and lactating women were also excluded. The study was approved by the Ethics committee of the Faculty of Medicine, Université de Montréal, and by the Ministry of Health in Benin. Written informed consent was obtained from each participant.

Dietary assessment
Dietary intake was assessed through three non-consecutive 24-h food recalls, conducted by two trained interviewers. The validated multiple-pass method was used to reduce memory bias (Conway *et al.*, 2004). The face-to-face recalls were conducted over an average period of 1 month. Local cups, bowls, spoons, plates and glasses commonly used in the study area served as visual aids to increase the accuracy of portion size estimations (Willet, 1998). Nutrient intakes were computed with the Worldfood Dietary Assessment System, version 2 (Calloway *et al.*, 1994). Complementary data were retrieved from food composition tables of neighbouring countries. Benin does not have a national food composition table and foreign food composition tables currently in use in the country have several limitations (Sodjinou, 2006). For mixed dishes, nutrient computation was based on recipe ingredients as described by respondents.

The Software for Intake Distribution Estimation (C-SIDE, Iowa State University) was used to estimate usual nutrient intake, while adjusting for differences between interviewers, recall day of week and number of days between the recalls. The method involves several steps: preliminary data adjustments, semiparametric transformation to normality, estimation of within and between individual variances for intakes, and back transformation into the original scale. The procedure is described in detail elsewhere (Nusser *et al.*, 1996).

Dietary patterns
A total of 13 main food groups were identified based on the foods and food habits of the study area. These food groups were further expanded into 21 food groups. Dietary patterns were identified using hierarchical cluster analysis, because this method is deemed appropriate for samples of small size (Everitt *et al.*, 2001). Mean intake of food groups (in grams per day) was converted into *z*-scores to avoid food groups with larger variance having more influence on the generation of clusters than food groups with a smaller range of values (Liese *et al.*, 2004). Ward's clustering approach helps classify subjects into non-overlapping groups based on the similarity of diet by minimizing Euclidian distances within clusters and maximizing these distances across clusters (Kant *et al.*, 2004). Iterations of the procedure allow the identification of the optimal number of clusters, which was determined by comparing the ratio of between-cluster variance to within-cluster variance divided by the number of clusters. The names for the dietary clusters were based on their food profile.

Diet quality
Diet quality was assessed based on diversity, micronutrient adequacy and healthfulness.

Dietary diversity score. Dietary diversity score (DDS) was based on the consumption of only 18 food groups; soft drinks, sweets and fast foods were excluded as superfluous items. DDS was calculated as the total number of different food groups consumed over the 3 food-recall days, irrespective of the frequency and the amounts consumed.

Micronutrient adequacy score. The adequacy of intake of 14 micronutrients (vitamins A, B_6, B_{12}, C and E, thiamin, riboflavin, niacin, pantothenic acid, folates, magnesium, calcium, iron and zinc) was checked against the recommended dietary intakes for age and sex (FAO/WHO, 2001). The % adequacy was obtained by dividing the intake of a nutrient by the recommended intake. Values for low bioavailability were used for iron and zinc because local diets are high in phytates. Vitamin E intake, given in tocopherol equivalents in the Worldfood database, was multiplied by 0.80 to approximate intake of α-tocopherol (Institute of Medicine, 2000). A score of 1 was given for 100% adequacy and above, and 0 if below 100%, with a maximum score of 14 for the micronutrient adequacy score (MAS).

Healthfulness score. For the healthfulness score (HS), we used eight WHO/FAO (World Health Organization/Food and Agriculture Organization) dietary recommendations for the prevention of the chronic diseases (WHO/FAO, 2003). These refer to total fat, saturated fatty acids, polyunsaturated fatty acids, cholesterol, sugar, protein, fibre, fruits and vegetables. Recommendations for ($n-3$) and ($n-6$) fatty acids were not included, because these nutrients are not in the Worldfood database. A score of 1 was given to each item if the recommendation was met and 0 if it was not, for a maximum total score of 8.

Socio-demographic variables

Urbanization status. Birthplace (urban or rural) and length of urban residence were used as proxy measures of urbanization. Length of urban residence was adjusted by age to have proportion of urban life.

Socioeconomic status. A SES score based on education, occupation and household amenities was computed. The score ranged from 0 to 6. The SES score was divided in three groups on the basis of tertiles (low, medium and high). Cronbach's alpha for the SES score was 0.71.

Education. Three education levels were considered: no schooling, primary school and secondary school or above, with respective scores of 0, 1 and 2.

Occupation. Three categories were defined for occupation based on the scale used in Benin (INSAE, 2003). The first category (unskilled) was coded 0, the second category (semi-skilled) was coded 1 and the third category (skilled professionals) was coded 2.

Household amenities. Household asset ownership was used as a proxy measure for income, because it better reflects economic status in developing country settings (Houweling *et al.*, 2003). Ten variables deemed appropriate in the Benin context were used: type of latrine, floor, roof and sidewalls; type of fuel used for cooking; paid domestic help; having electricity, a television set, a house phone and a fridge. On the basis of tertiles, low household amenity level was coded 0, while medium and high levels were, respectively, coded 1 and 2.

Statistical analysis

Data were analysed using SPSS, version 13.0 (SPSS Inc., Chicago, IL, USA). Comparisons between dietary clusters were performed using *t*-test or Mann–Whitney test for means, and χ^2-test for proportions. Backward linear regression was conducted to estimate the contribution of specific food groups to overall diet quality, while controlling for total energy intake. The level of statistical significance was set at $P<0.05$ for all tests except regression models ($P<0.1$).

Results

Figure 1 shows the proportion of subjects having consumed the food groups over the three food-recall days. Grains were universally consumed. Maize paste (*owo*) is the most common grain preparation and it is always accompanied by a spicy tomato or vegetable sauce to which groundnut or red palm oil and fish are often added. Bread or pasta, sweets, nuts and seeds, roots and tubers, vegetables, and legumes were also frequently consumed. The other food groups were consumed by less than 50% of respondents.

Two major dietary clusters were identified (Table 1). Cluster 1 subjects (34% of the participants) had a significantly higher intake of bread and pasta, roots and tubers, nuts and seeds, white meat, read meat, eggs, milk, milk products, fats and sweets, while cluster 2 subjects (66%) had a significantly higher intake of grains and fruits. Based on this, we used the term 'transitional diet' pattern to describe cluster 1 and 'traditional diet' pattern to describe cluster 2.

Table 2 shows socio-demographic characteristics of subjects according to dietary cluster. Subjects with a 'traditional diet' had a lower SES score compared to those with the 'transitional' diet ($P<0.001$). Likewise, participants with the 'transitional' diet were more educated than those with the 'traditional' diet ($P<0.001$). Early life environment also influenced the dietary patterns significantly, with a higher proportion of subjects born in the city in the 'transitional' cluster and a higher proportion of subjects born in rural area in the 'traditional' cluster ($P<0.001$).

In Table 3, micronutrient adequacy is described according to dietary cluster. The proportion of subjects reaching 100% of the recommended dietary intake was significantly higher for the 'transitional diet' compared with the 'traditional diet' for vitamin E, vitamin B12 and pantothenic acid. Intakes of vitamin E, vitamin B_{12}, calcium and zinc were overall very low, irrespective of dietary clusters.

Intakes of those nutrients (and foods) included in the HS are shown in Table 4 according to dietary cluster. Mean energy intake tended to be higher in the 'transitional diet' compared with the 'traditional diet' ($P=0.073$). Compared with the 'traditional diet', the 'transitional diet' was associated with a slightly but significantly higher percentage of energy from fat (17.6 vs 15.5%), saturated fat (5.9 vs 5.2%) and sugar (6.3 vs 5.0%). The 'transitional diet' also provided significantly more cholesterol (136.6 vs 76.1 mg day^{-1}) and less fibre (29.8 vs 34.9 g day^{-1}).

The 'transitional diet' was more diversified, but it also showed a lower HS than the 'traditional diet'. MAS tended to be higher in the 'transitional diet' compared with the

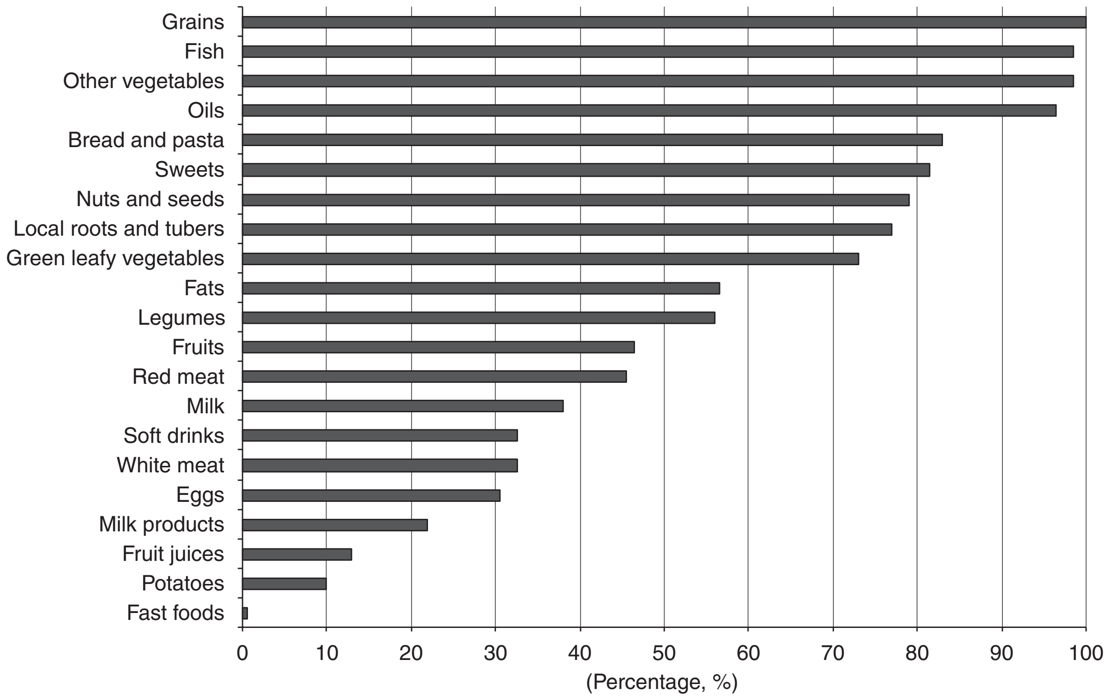

Figure 1 Percentage of subjects consuming each food group.

Table 1 Mean daily intake of food groups by dietary cluster (g day^{-1})

Food groups	*Cluster 1—'transitional diet' (n = 68)*	*Cluster 2—'traditional diet' (n = 132)*	P-*value*[a]
Grains	505.7 (242.0)	787.1 (338.6)	<0.001
White bread and pasta	101.8 (91.2)	66.3 (62.9)	0.005
Local roots and tubers	131.2 (119.5)	55.7 (63.1)	<0.001
Potatoes	7.0 (19.9)	0.4 (2.3)	0.008
Legumes	52.4 (73.4)	69.8 (107.1)	0.178
Nuts and seeds	10.1 (13.7)	3.3 (5.4)	<0.001
White meat	15.7 (27.8)	4.9 (9.7)	0.003
Red meat	29.4 (42.6)	8.2 (14.0)	<0.001
Fish	63.9 (69.2)	66.6 (31.4)	0.767
Eggs	14.1 (18.5)	3.1 (7.4)	<0.001
Milk	9.1 (13.4)	4.3 (8.5)	0.008
Milk products	15.9 (29.7)	1.9 (6.9)	<0.001
Fruits	8.2 (12.3)	15.7 (34.5)	0.026
Fruit juices	4.1 (18.0)	2.6 (7.1)	0.504
Green leafy vegetables	114.4 (125.9)	110.4 (130.1)	0.837
Other vegetables	226.3 (160.6)	189.6 (130.5)	0.106
Oils	13.4 (12.5)	12.1 (7.7)	0.433
Fats	9.6 (14.6)	5.6 (7.8)	0.037
Sweets	34.5 (46.8)	16.6 (21.8)	0.004
Soft drinks	35.3 (54.6)	23.3 (55.0)	0.144
Fast food	0.1 (1.5)	0	0.474

Values are expressed as mean (s.d.).
Underlined numbers mark cluster with significantly higher intake.
[a]*t*-Test for differences between mean.

traditional type (Table 5). DDS was positively correlated with MAS ($r = 0.26$, $P < 0.001$) but it also tended to be negatively associated with HS ($r = -0.10$, $P = 0.233$).

Table 6 shows key food groups that predict overall diet quality in the population under study. MAS was positively and significantly associated with the intake of cereals, roots and tubers, legumes and nuts. A higher intake of vegetables was significantly associated with both a higher MAS and a higher HS. In contrast, a higher intake of animal products, sweets and fast food was associated with a lower HS.

Discussion

In this cross-sectional study, we identified dietary patterns based on food group intakes in a representative sample of urban Beninese adults. Using cluster analysis, two distinct dietary patterns emerged: a 'transitional' and a 'traditional' type. Dietary patterns were identified in previous studies using the same approach (Martikainen *et al.*, 2003; Liese *et al.*, 2004; Villegas *et al.*, 2004; Song *et al.*, 2005; Crozier *et al.*, 2006), but none in West Africa. Traditional and non-traditional dietary patterns were described in diverse settings (Villegas *et al.*, 2004; Song *et al.*, 2005).

The 'transitional diet' pattern reflects to some extent the dietary changes that occur during the nutrition transition process, with increasing intakes of fat, animal products and sweets (Popkin, 2002). However, many features of the 'traditional diet' are maintained in the 'transitional diet'. In the study context, the 'transitional diet' is not a shift from traditional to western foods. Rather, the transitional diet is a more diversified diet with some imported foods being added to the traditional diet. Similar findings were reported in

Table 2 Socio-demographic characteristics by dietary cluster

	Transitional diet (n = *68*)	*Traditional diet* (n = *132*)	P-*value*[a]
Men (%)	58.8	45.5	0.100
Age (years)[b]	37.4 (9.4)	39.7 (9.9)	0.124
SES score (maximum = 6)	4.0±1.7	2.6±1.8	<0.001
Proportion of urban lifetime (%)[b]	68.4 (30.0)	69.2 (30.5)	0.858
Place of birth (%)			
Rural area	17.6	44.7	<0.001
Urban area	82.4	55.3	
Education (%)			
None	8.8	21.2	<0.001
Primary school level	17.6	35.6	
Secondary or higher	73.5	43.2	

Abbreviation: SES, socioeconomic status.
[a]*t*-Test or χ^2-test for differences between the two clusters.
[b]Values are expressed as mean (s.d.).

Amerindians undergoing dietary acculturation, that is, new commercial foods were being added, rather than replacing traditional foods (Szathmary *et al.*, 1987; Ritenbaugh *et al.*, 1996).

We found that the ‘traditional’ cluster subjects had a significantly lower SES score compared with those of the ‘transitional’ cluster. This was expected, as higher SES subjects usually have better economic access to a diversified diet, which is reflected in the ‘transitional diet’ pattern, whereas the urban poor face food insecurity.

Birthplace, urban or rural, also had a significant influence on dietary patterns, whereas duration of urban life did not. In a study among Puerto Rican women living in Connecticut, Himmelgreen *et al.* (2005) observed that women born in Puerto Rico drank fruit juices more frequently than those born in the US, again showing that food habits acquired in early childhood have a long-lasting influence. With rapid urbanization in sub-Saharan Africa, more and more people

Table 3 Micronutrient adequacy by dietary cluster

	Micronutrient adequacy ratio[a]		*% meeting RDI*		P-*value*[b]
	Transitional diet (n = *68*)	*Traditional diet* (n = *132*)	*Transitional diet* (n = *68*)	*Traditional diet* (n = *132*)	
Vitamin A (μg RE)	91.9 (16.3)	89.7 (17.8)	70.6	65.2	0.270
Vitamin E (mg α-TE)	65.6 (26.5)	47.9 (21.4)	19.1	3	<0.001
Vitamin C (mg)	99.3 (4.7)	99.9 (1.4)	97.1	99.2	0.267
Thiamin (mg)	97.4 (6.6)	97.7 (6.4)	82.4	81.1	0.493
Riboflavin (mg)	94.5 (10.8)	90.5 (14.4)	66.2	59.1	0.206
Niacin (mg)	94.1 (11.3)	93.7 (11.0)	67.6	61.4	0.237
Vitamin B_6 (mg)	99.4 (3.4)	99.6 (2.4)	97.1	96.2	0.555
Vitamin B_{12} (μg)	61.0 (25.7)	41.3 (17.6)	16.2	1.5	<0.001
Pantothenic acid (mg)	95.4 (9.6)	91.4 (12.1)	70.6	51.5	0.007
Folate (μg)	86.3 (16.5)	85.0 (18.5)	47.1	39.4	0.187
Magnesium (mg)	100 (0)	99.9 (0.5)	100	99.2	0.660
Calcium (mg)	63.3 (23.0)	72.5 (24.5)	14.7	22	0.149
Iron (mg)	79.5 (22.4)	79.3 (24.9)	36.8	43.2	0.236
Zinc (mg)	76.8 (16.8)	75.9 (15.7)	16.2	12.9	0.332

Abbreviation: RDI, recommended dietary intake.
[a]Values are expressed as mean percentages (s.d.).
[b]χ^2-test.

Table 4 Intakes of nutrients and foods included in the healthfulness score by dietary cluster

	Intake		
	Transitional diet (n = *68*)	*Traditional diet* (n = *132*)	P-*value*[a]
Total EI, kJ day^{-1} (kcal day^{-1})	557.0 (111.9) (2331.7 (468.3))	526.8 (112.2) (2205 (469.8))	0.073
Fat (% energy)	17.6 (4.4)	15.5 (2.9)	0.001
SFA (% energy)	5.9 (1.7)	5.2 (1.5)	0.002
PUFA (% energy)	3.8 (1.0)	3.8 (0.7)	0.839
Sugar (% energy)	6.3 (3.4)	5.0 (2.9)	0.003
Protein (% energy)	12.9 (1.8)	12.7 (1.2)	0.477
Cholesterol (mg day^{-1})[b]	136.6 (69.1)	76.1 (37.4)	<0.001
Fibre (g day^{-1})	29.7 (8.9)	34.9 (11.0)	0.001
Fruits and vegetables (g day^{-1})	348.9 (198.6)	315.7 (195.8)	0.260

Abbreviations: EI, energy intake; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids.
Values are expressed as mean (s.d.).
[a]*t*-Test or Mann–Whitney test for differences between the two clusters.
[b]Abnormal distribution.

Table 5 Diet quality indices by dietary cluster

	Total (n = 200)	*Transitional diet (n = 68)*	*Traditional diet (n = 132)*	P-*value*[a]
DDS (maximum = 18)	11.3 (2.0)	12.4 (1.9)	10.7 (1.9)	<0.001
MAS (maximum = 14)	7.6 (2.8)	8.0 (2.7)	7.4 (2.9)	0.169
HS (maximum = 8)	5.7 (0.8)	5.4 (0.9)	5.8 (0.7)	0.002

Abbreviations: DDS, dietary diversity score; HS, healthfulness score; MAS, micronutrient adequacy score.
Values are expressed as mean (s.d.).
[a]*t*-test for differences between dietary clusters.

Table 6 Multiple linear regression (backward) of food groups' intake on overall diet quality

Food group intake (g 1000 kcal^{-1})	*Dependent variables (diet quality scores)β coefficients**		
	DDS	*MAS*	*HS*
Cereal	−0.29[†]	0.20[‡]	
Roots and tubers		0.17[‡]	
Legumes and nuts		0.27[†]	
Meat	0.18[‡]		−0.15[¶]
Fish	−0.15[¶]		−0.12[§]
Eggs	0.11[§]		−0.19[‡]
Milk and milk products			−0.18[‡]
Fruit and fruit juices	0.14[¶]		
Vegetables		0.56[†]	0.31[†]
Fats and oils	0.21[‡]		−0.11[§]
Sweets			−0.25[†]
Soft drinks			
Fast food			−0.11[§]

Abbreviations: DDS, dietary diversity score; HS, healthfulness score; MAS, micronutrient adequacy score.
*Only significant values are reported. [†]$P<0.001$; [‡]$P<0.01$; [¶]$P<0.05$; [§]$P<0.1$.

will be born in cities, which means that they may acquire, as children, food habits that are more conducive to chronic diseases.

The 'transitional diet' phenotype, while being more diversified compared with the 'traditional diet', was also associated with a significantly higher intake of energy from fat, saturated fat and sugar. Yet the percentage of energy from fat, saturated fat and sugar in the 'transitional diet' is quite low compared to what is often reported in affluent societies. This is why we did not use the term 'western' to describe this pattern.

Our results confirm the positive association between dietary diversity and micronutrient adequacy as previously reported in low-income countries (Torheim *et al.*, 2004; Savy *et al.*, 2005). However, our results do not support the use of dietary diversity as indicator of overall diet quality (Torheim *et al.*, 2004). In the context of our study, a more diversified diet was associated with a lower HS. This is somewhat similar to what was observed among Mexican men in whom higher food diversity predicted a less healthy diet from the standpoint of the prevention of chronic diseases (Ponce *et al.*, 2006). Dietary diversity is based on a simple count of food groups over a given reference period (Ruel, 2003), which does not take into account quantitative aspects related to the healthfulness of diet. Additionally, DDS does not tell which food groups contribute the most to the score, and hence, to diet quality. A clearer definition of dietary diversity to include both qualitative and quantitative information would be more informative. Detailing diversity within food groups, protein sources for instance, as in the Diet Quality Index-International (Kim *et al.*, 2003), is one way of making dietary diversity more sensitive.

The importance of fruits and vegetables for the prevention of the chronic diseases is well established (WHO/FAO, 2003). In the present study, we found that a higher intake of vegetables was associated with both a higher MAS and a higher HS. Fruit consumption was overall very low, which may explain why it was not significantly associated with diet quality. Promoting fruit and vegetable consumption would therefore appear as a promising strategy for the prevention of nutrition-related chronic disease in this population.

We assessed overall diet quality based on diversity, micronutrient adequacy according to FAO/WHO recommended dietary intakes, and adherence to eight WHO recommendations for the prevention of chronic diseases. Although we recognize that the Diet Quality Index-International developed recently by Kim *et al.*, 2003 may be a sensitive tool to assess overall diet quality, we did not use it because it is entirely based on US guidelines. The international applicability of our diet quality assessment tools stems from the fact that they refer to international requirements and guidelines and they do not require food-serving determination.

Cluster analysis as applied in the present study to identify distinct dietary phenotypes has been criticized on several grounds (Jacques and Tucker, 2001). First, it involves many subjective decisions such as grouping foods or the labelling of the clusters, according to its detractors. Secondly, the dietary patterns so identified lack stability over time. Finally, variations in cluster names and in the number of clusters preclude comparisons across studies. However, we contend that the dietary patterns identified in the present study reflect to a large extent the dietary transition that is undergoing among urban adults in Benin and perhaps other West African countries. Dietary assessment was carried out based on three 24-h food recalls, which confers strength to the findings. We also used the validated multiple pass method to estimate food intake, which helps to reduce memory bias and thus increases the accuracy of estimated food intake. An additional strength was to use C-SIDE software as a means of reducing intraindividual variations of intake, thereby giving more prominence to inter-individual differences in food intake.

In conclusion, the dietary transition is evidenced in this study, although both dietary patterns were still low in fat and sugar. Programmes focusing on the prevention of diet-related chronic diseases in this population should encourage the maintenance of the healthful elements of the diets, while emphasizing consumption of fruits and vegetables.

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References

Calloway DH, Murphy SP, Bunch S, Woerner J (1994). WorldFood 2 dietary assessment system. FAO web site. Available at http://www.fao.org/infoods(Accessed September 2006).

Conway JM, Ingwersen LA, Moshfegh AJ (2004). Accuracy of dietary recall using five-step-multiple-pass method in men: an observational validation study. *J Am Diet Assoc* **104**, 595–603.

Crozier SR, Robinson SM, Borland SE, Inskip HM, The SWS Study Group (2006). Dietary patterns in the Southampton women's. *Eur J Clin Nutr* **60**, 1391–1399.

EDSB (2001). *Enquête démographique et de santé du Bénin. Rapport final*. Institut National de la Statistique et de l'Analyse Économique: Cotonou.

Everitt B, Landau S, Leese M (2001). *Cluster Analysis*, 4th edn. Edward Arnold Publishers Ltd: London.

FAO/WHO (2001). *Human vitamin and mineral requirements*. FAO: Roma. Report of a joint FAO/WHO expert consultation.

Himmelgreen D, Bretnall A, Perez-Escamilla R, Peng Y, Bermudez A (2005). Birthplace, length of time in the US, and language are associated with diet among inner-city Puerto Rican women. *Ecol Food Nutr* **44**, 105–122.

Houweling TAJ, Kunst AE, Mackenbach JP (2003). Measuring health inequality among children in developing countries: does the choice of the indicator of economic status matter? *Int J Equity Health* **2**, 8.

Hu FB (2002). Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol* **13**, 3–9.

Institut National de la Statistique et de l'Analyse Économique (INSAE) (2003). *Troisième Recensement Général de la Population et de l'Habitat*. Direction des Études Démographiques: Cotonou.

Institute of Medicine Food and Nutrition Board (2000). *Dietary Reference Intakes for Vitamin A, Vitamin E, Selenium and Carotenoids*. National Academy Press: Washington, DC.

Jacques PF, Tucker K (2001). Are dietary patterns useful for understanding the role of diet in chronic disease? *Am J Clin Nutr* **73**, 1–2.

Kant AK (1996). Indexes of overall diet quality: a review. *J Am Diet Assoc* **96**, 785–791.

Kant AK, Graubard BI, Schatzkin A (2004). Dietary patterns predict mortality in a national cohort: the national health interview surveys, 1987 and 1992. *J Nutr* **134**, 1793–1799.

Kim S, Haines PS, Siega-Riz AM, Popkin BM (2003). The diet quality index-international provides an effective tool for cross-national comparison of diet quality as illustrated by China and the United States. *J Nutr* **133**, 3476–3484.

Liese AD, Schulz M, Moore CG, Mayer-Davis EJ (2004). Dietary patterns, insulin sensitivity and adiposity in the multi-ethnic insulin resistance atherosclerosis study population. *Br J Nutr* **92**, 973–984.

Martikainen P, Brunner E, Marmot M (2003). Socioeconomic differences in dietary patterns among middle-aged men and women. *Soc Sci Med* **56**, 1397–1410.

Nusser SM, Carriquiry AL, Dodd K, Fuller WA (1996). A semiparametric transformation approach to estimating usual daily intake distributions. *J Acoust Soc Am* **91**, 1440–1449.

Ponce X, Ramirez E, Delisle H (2006). A more diversified diet among Mexican men may also be more atherogenic. *J Nutr* **136**, 2921–2927.

Popkin BM (2002). An overview on the nutrition transition and its health implications: the Bellagio meeting. *Public Health Nutr* **5**, 93–103.

Ritenbaugh C, Szathmary EJ, Goodby CS, Feldman C (1996). Dietary acculturation among the Drogib Indians of the Canadian Northwest Territories. *Ecol Food Nutr* **35**, 81–94.

Ruel MT (2003). Operationalizing dietary diversity: a review of measurement issues and research priorities. *J Nutr* **133**, S3911–S3926.

Savy M, Martin-Prével Y, Sawadogo P, Kameli Y, Delpeuch F (2005). Use of variety/diversity for diet quality measurement: relation with nutritional status of women in a rural area in Burkina Faso. *Eur J Clin Nutr* **59**, 703–716.

Sodjinou RS (2006). Evaluation of food composition tables commonly used in Benin: limitations and suggestions for improvement. *J Food Compos Anal* **19**, 518–523.

Song Y, Joung H, Engelhardt K, Yoo SY, Paik HY (2005). Traditional vs modified dietary patterns and their influence on adolescents' nutritional profile. *Br J Nutr* **93**, 943–949.

Stunkard AJ (2000). Factors in obesity: currents views. In: M Pena, J Bacallao (eds). *Obesity and Poverty: A New Public Health Challenge*. Pan American Health Organization: Washington, DC, pp 23–28.

Szathmary EJ, Ritenbaugh C, Goodby CS (1987). Dietary changes and plasma glucose levels in an Amerindian population undergoing cultural transition. *Soc Sci Med* **24**, 791–804. (abstract).

Thiam I, Samba K, Lwanga D (2006). Diet related chronic disease in the West Africa Region. *SCN News* **33**, 6–10.

Torheim LE, Ouattara F, Diarra MM, Thiam FD, Barikmo I, Hatloy A *et al.* (2004). Nutrient adequacy and dietary diversity in rural Mali: association and determinants. *Eur J Clin Nutr* **58**, 594–604.

Villegas R, Salim A, Collins MM, Flynn A, Perry IJ (2004). Dietary patterns in middle-aged Irish men and women defined by cluster analysis. *Public Health Nutr* **7**, 1017–1024.

WHO/FAO (2003). *Diet, nutrition and prevention of chronic diseases*. Report of a joint WHO/FAO expert consultation. Report no. 916. WHO: Geneva.

WHO (2007). Obesity and overweight. WHO web site. Available at http://www.who.int/dietphysicalactivity/publications/facts/obesity/en/(Accessed February 2007).

Willet W (1998). *Nutritional Epidemiology* 2nd edn. Oxford University Press: New York.