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Dietary transition stages based on eating patterns and diet quality among Haitians of Montreal, Canada

Marie-Claude Désilets[1,2], Michèle Rivard[1,2], Bryna Shatenstein[1,2] and Hélène Delisle[1,2,*]
[1]Département de Nutrition, Université de Montréal, CP 6128 succursale Centre-ville, Montréal, Québec, Canada, H3C 1J7: [2]WHO Collaborating Centre on Nutrition Changes and Development, Department of Nutrition, Faculty of Medicine, University of Montreal, Canada

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Abstract

Objectives: To identify dietary transition stages based on dietary patterns of adult Haitians having lived in Montreal for various lengths of time, and to assess associated dietary quality.
Subjects: One hundred and eighty-one Haitians aged 25–60 years were recruited by the modified random digit dialling method.
Design: Socio-economic, diet and lifestyle variables were documented by questionnaire. Three non-consecutive 24-hour dietary recalls were conducted over a 3-month period. Dietary patterns were studied using cluster analysis, and their association with proportion of lifetime in Canada and with socio-economic status (SES) was examined. Diet quality criteria were micronutrient adequacy and healthfulness based on dietary recommendations of the World Health Organization.
Results: Four dietary phenotypes were identified which could roughly represent stages of dietary transition or acculturation (Traditional, Pre-Western, Western and Modern). Subjects in the 'Traditional' cluster were older and had lived for a significantly lower proportion of their lifetime in Canada; they also tended to be of lower SES. Diet quality was significantly higher in the 'Traditional' than the 'Western' type, particularly with respect to healthfulness. A significantly lower proportion of subjects complying with limited intake of total fat (<30%) and cholesterol (<45%) was observed in the 'Western' compared with other diet phenotypes. Less than 15% of all subjects consumed enough dietary fibre, irrespective of diet type.
Conclusion: Dietary transition stages could be identified on the basis of food patterns of Haitians according to the proportion of their lifetime in Canada. Encouraging the youth to retain the traditional food culture in its positive aspects would appear relevant.

Keywords
Food patterns
Dietary transition
Acculturation
Diet quality
Haitians

Dietary transition is a major feature of the nutrition transition theory, with progressive shifts towards a more atherogenic diet and a more sedentary lifestyle resulting in an increase of chronic disease in populations of developing countries[1–3]. It is suggested that dietary transition occurs in stages, from traditional through more Westernised dietary patterns, and to a conscious healthful diet and lifestyle in the final stage[1–3]. Although nutrition and dietary transitions normally refer to populations in developing countries, they may also apply in migrants from developing countries to industrialised countries in whom changes in diets and lifestyle, combined with genetic predisposition, could increase the risk of cardiovascular disease (CVD)[3–5]. In the case of immigrants, dietary transition is an integral part of the process of acculturation[6]. Dietary transition (or acculturation) is a longitudinal process, but different stages or levels can be identified at one point in time, as was done in some acculturation studies with language spoken at home[7,8]. To our knowledge this has not been done as yet with dietary acculturation.

In the African Diaspora, increasing rates of risk markers of CVD, particularly obesity, hypertension and diabetes, were found from Africans, to Caribbean and to black populations in the UK or USA[9–11], in line with the theory of nutrition transition[1]. Information on concurrent dietary changes, however, is scanty and somewhat inconsistent. One of the few studies showed that the only linear trend in the African Diaspora pertained to protein, with the highest protein intakes in the industrialised country (the UK), while the highest intakes of fat were recorded in Africa (Cameroon) and the highest intakes of carbohydrates in the Caribbean (Jamaica), considered at an intermediate stage of dietary transition[12]. Dietary transition is thus a complex process and its features and pace may vary across population groups. The analysis of dietary patterns can

*Corresponding author: Email helene.delisle@umontreal.ca

help to define dietary 'phenotypes' that are associated with high CVD risk[13] and which may reflect different stages of dietary transition or acculturation.

The present study is part of a larger research endeavour on nutrition transition and CVD risk in population groups of African origin living in Africa, Haiti and Canada. The objectives of this study were:

1. To identify dietary patterns typical of different stages of the dietary transition (or acculturation) process among Haitians of Montreal, using the proportion of their lifetime in Canada as a proxy for the duration of their exposure to the host country's food culture;
2. To assess the nutritional quality of these dietary phenotypes, based on micronutrient adequacy and congruence with dietary recommendations for health and the prevention of chronic diseases.

The hypothesis was that the diet would become less healthful with increasing exposure time to the host country's food culture, even after controlling for socio-economic circumstances, age and sex.

Materials and methods

Study population

A total of 181 subjects of Haitian origin aged between 25 and 60 years were recruited using a modified random digit dialling method (RDD)[14] with the Montreal phone directory. Although it is labour-intensive, this method ensures representativity since only 2.4% of the population of the province of Quebec does not have a home phone[15]. 'Haitian origin' was defined as having both parents of African descent and born in Haiti. Subjects were excluded if they were under medication for diabetes, hypertension or cholesterol as these conditions may have altered diets and lifestyles. Pregnant and lactating women were also excluded. The study was approved by the Ethics Committee of the Faculty of Medicine of the Université de Montréal and a consent form was signed by each participant.

Study variables and assessment methods

Dietary intake

Dietary intake was assessed via three non-consecutive 24-hour food recalls conducted by two trained interviewers using the multiple-pass method[16,17]. The first interview was conducted in person and the others by phone over an average period of 2.5 months. A poster of food portion sizes[18] was used as a visual aid for the interviews. Nutrient and energy intakes were computed with the Canadian Nutrient File 2001[19]. Additional data were sought from fast-food outlets and from the US Department of Agriculture food composition database. The consumption of food supplements (vitamin and mineral supplements and meal substitutes) was taken into account when computing daily intake since 42% of subjects reported using these.

Of the total of 181 subjects, 175 had completed three 24-hour food recalls. Two subjects completed only two recalls. The four subjects who only had one food recall were excluded from the analysis. Using SIDE software (Iowa State University, 2002), nutrient and energy intakes were adjusted for the number of recalls completed, the method (in person or by phone), the number of days between the food recalls and the day of the week of each recall. This adjustment is intended to reduce the intra-individual variation of intake.

Eating patterns

Food items consumed by the study participants were grouped into 21 categories based on the literature[20–22] and our empirical knowledge of Haitian food habits (see list in Appendix A). Mean daily intake of every food group per 1000 kcal was computed in order to define food patterns independent of usual energy intakes, as suggested by Newby and Tucker[23]. Cluster analysis was used to classify subjects into mutually exclusive dietary patterns[13,23]. With this method, the square Euclidian distance is used to determine which observations are close enough to belong to the same cluster. Ward's clustering approach was used to separate subjects into non-overlapping groups. Data were transformed into standard deviation scores to ensure that cluster creation was not influenced by food groups with very high or very low variance. The procedure was applied several times in order to identify different cluster solutions ranging from three to five clusters, as previously described[24]. In our study, we found four fairly homogeneous clusters which allowed nutritional interpretation[25,26]. To test robustness of the clusters, the procedure was repeated three times with three random sets of 75% of subjects; this cut-off of 75% was used to retain enough statistical power for the analysis. The results were similar to those of the whole sample (data not shown).

Diet quality

Diet quality was assessed using two scores, one based on recommended intakes of micronutrients (Food and Agriculture Organization (FAO)/WHO[27]) and the other on WHO dietary recommendations for health and the prevention of chronic diseases[4]. For the 'micronutrient adequacy' score, percentage adequacy ratio was first computed for 10 micronutrients (calcium, magnesium, iron, thiamin, riboflavin, vitamin B_6, folic acid, vitamin B_{12}, vitamin C and vitamin A). Each item was then coded 1 if intake was 100% or more of the reference value and 0 if it was under 100%, for a total score ranging from 0 to 10. For the 'healthfulness' score, nine items from the WHO dietary recommendations were used: total lipids, saturated fatty acids, omega-6 ($n-6$) and omega-3 ($n-3$) fatty acids, sugar, protein, cholesterol, fibre, and fruit and vegetable

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intakes. Each item was coded 1 if the recommendation was met and 0 if it was not. Variety, defined as the number of different food items as proposed by Ruel[28] and computed over the recall days, was added as a tenth item. The first tertile of dietary variety was considered as a monotonous diet (coded 0) and the other two tertiles as a varied diet (coded 1). The healthfulness score also had a maximum value of 10.

Socio-economic data

A questionnaire provided information on socio-economic variables such as the proportion of lifetime lived in Canada, based on age and length of stay in Canada, which was divided into tertiles for the purpose of analysis. A socio-economic status (SES) score was built from education level, family income bracket, employment status at the time of the interview and housing status (owner or tenant). The score ranged from 0 to 6, with a lower score reflecting lower SES (Cronbach's $\alpha = 0.60$).

Statistical analysis

Mean daily intakes were transformed using the square root in order to normalise the distribution. Intakes of the 21 food groups, diet quality scores and demographic and socio-economic characteristics were compared between food type clusters using analyses of variance with age and sex as covariates where appropriate (and Tukey *post hoc* test) in the case of continuous variables, and Pearson's chi-square tests for categorical variables. Data were analysed with SPSS 11.0 (SPSS Inc.), using 5% as level of statistical significance.

Results

The participation rate in the study was 34.2%. With RDD, such a participation rate is deemed acceptable[29], particularly when the study requires more than just a telephone interview and involves blood sampling and lengthy in-person interviews. There were more women than men among the non-participants (207 women vs. 141 men) as more women answered the phone. However, no age difference was noted between participants (40.7 ± 10.2 years) and non-participants (39.9 ± 9.6 years). According to the most recent census data, the study subjects were representative of the Haitian community of Montreal for most characteristics (citizenship, place of birth, employment, income, marital status, type of transportation)[30], except for a higher level of education: 46% of study participants had a university degree compared with 15% according to the census (data not shown).

Table 1 shows mean daily intakes of 21 different food groups in the four dietary pattern clusters. 'Traditional' and 'Pre-Western' phenotypes included the majority of subjects (44 and 39%, respectively) whereas the 'Western' and 'Modern' clusters represented together 17% of the sample. Significant differences or trends ($0.1 > P > 0.05$) were observed for all food groups except vegetables and full-fat dairy products. 'Traditional' and 'Western' clusters were the most clearly delineated. The highest intakes of fruits, grains, breakfast cereal and also white bread were found in the 'Traditional' type, which corresponds to typical Haitian eating patterns as described in Appendix B. Low-fat dairy products and sandwiches were also lowest in the 'Traditional' cluster. In the 'Western' pattern, in contrast,

Table 1 Mean daily intake of food groups by dietary phenotype (g/1000 kcal) (mean ± standard deviation)

	Cluster 1 ($n = 78$) Traditional	Cluster 2 ($n = 69$) Pre-Western	Cluster 3 ($n = 16$) Western	Cluster 4 ($n = 14$) Modern	*P*-value
Fruits	**126.2 ± 25.3**[a]	86.9 ± 19.3[ab]	*60.9 ± 26.3*[b]	100.1 ± 45.9[ab]	0.030
Grains	**103.9 ± 10.6**[a]	76.4 ± 9.3[b]	84.6 ± 4.2[ab]	*56.9 ± 19.2*[b]	0.007
Breakfast cereal	**6.7 ± 12.8**[a]	1.6 ± 5.1[b]	*1.5 ± 7.9*[b]	3.6 ± 7.1[ab]	0.049
Fruit beverages	35.1 ± 30.3	23.3 ± 17.9	9.2 ± 16.1	11.3 ± 19.4	0.070
White bread	14.3 ± 5.3[ab]	20.5 ± 6.3[b]	8.8 ± 2.9[ab]	*5.4 ± 6.9*[a]	0.004
Non-fried tubers	3.8 ± 7.2[a]	**14.6 ± 14.6**[b]	*2.2 ± 7.1*[a]	5.1 ± 6.5[ab]	0.002
Hot cereal	0.4 ± 2.8[a]	**5.4 ± 11.8**[b]	*0.2 ± 1.7*[a]	0.7 ± 4.7[ab]	<0.001
Dairy ≤2% milk fat	*4.5 ± 8.9*[a]	**25.8 ± 20.7**[b]	5.8 ± 8.9[ab]	22.2 ± 20.2[ab]	<0.001
Dairy >2% milk fat	5.5 ± 6.6	12.2 ± 15.4	6.3 ± 6.2	5.9 ± 10.3	0.166
Red meat	25.5 ± 11.7	27.1 ± 10.6	13.9 ± 8.4	9.2 ± 13.8	0.076
Fish	3.7 ± 4.9	9.6 ± 10.5	5.9 ± 11.3	3.3 ± 3.9	0.066
Fast foods	2.3 ± 5.4[a]	*0.3 ± 2.2*[b]	**22.5 ± 15.1**[c]	1.1 ± 4.6[ab]	<0.001
Soft drinks	16.1 ± 18.7[a]	*3.7 ± 9.9*[b]	**65.1 ± 46.7**[c]	6.4 ± 15.3[ab]	<0.001
Fried tubers	2.9 ± 4.9[a]	1.7 ± 3.7[a]	**27.9 ± 6.9**[b]	*1.5 ± 4.4*[a]	<0.001
Processed meat	2.4 ± 4.9[a]	0.4 ± 1.4[b]	**2.8 ± 3.3**[a]	*0.1 ± 0.9*[b]	0.003
Poultry	26.0 ± 9.3[ab]	36.5 ± 10.3[a]	**51.4 ± 14.7**[a]	*12.2 ± 11.3*[b]	0.006
Whole-grain bread	1.7 ± 3.3[a]	*1.4 ± 2.8*[a]	1.6 ± 2.3[a]	**11.3 ± 6.9**[b]	0.001
Sandwiches	*0.9 ± 3.6*[a]	1.0 ± 4.8[a]	4.8 ± 9.4[a]	**57.5 ± 12.6**[b]	<0.001
Beans	14.8 ± 8.9	10.4 ± 5.7	5.6 ± 4.8	24.5 ± 31.8	0.074
'Superfluous' food items	13.9 ± 8.1	7.4 ± 4.4	7.6 ± 5.4	18.1 ± 4.4	0.031
Vegetables	49.4 ± 7.5	65.1 ± 10.8	46.2 ± 11.8	52.5 ± 17.2	0.192

Significantly highest mean values are in bold and significantly lowest mean values are in italics.
[a,b,c] Means with common superscript letters were not significantly different.

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the consumption of fruit and breakfast cereal, as well as non-fried tubers and hot cereal, was lowest whereas intakes of fast foods, soft drinks, fried tubers, processed meat and poultry were the highest of all clusters. The 'Pre-Western' diet type was somewhat in between, with high intakes of white bread, non-fried tubers, hot cereal and dairy products, but also the lowest consumption of fast foods and soft drinks (and whole-grain bread) of the four patterns. The 'Pre-Western' and 'Traditional' clusters both tended to have a much higher intake of red meat and fruit drinks compared with the other food types. The fourth cluster was labelled 'Modern' for lack of a better name, because of the highest consumption of whole-grain bread, sandwiches and superfluous items such as cakes and pastries, whereas this pattern featured the lowest intake of grains, white bread, fried tubers, processed meat and poultry.

Table 2 presents subjects' demographic and socio-economic characteristics according to food clusters. Compared with subjects of the 'Western' diet pattern, those in the 'Traditional' group were significantly older. Moreover, these two dietary types included significantly more men than women compared with the 'Pre-Western' and 'Modern' types. The proportion of lifetime in Canada, as well as the SES score, varied significantly between dietary clusters, but there were no differences for separate items of the SES score (education, income, employment and housing status). In addition to being younger, subjects of the 'Western' cluster had lived a significantly greater proportion of their lifetime in Canada than those of the 'Traditional' cluster (55% vs. 48%, $P = 0.02$). Furthermore, 'Western' cluster subjects had a significantly higher SES score (adjusted for age and sex) than those of the 'Pre-Western' diet type (3.1 vs. 2.8, $P = 0.011$). Subjects belonging to the 'Modern' cluster tended to be more educated, with 64% reaching university compared with between 38 and 47% in the other clusters. 'Western' cluster subjects tended to have a better income, with only 38% below $30 000, compared with over 50% in the other clusters. At the time of the study, $30 000 per annum was the low-income cut-off for a household of three people living in Montreal in 2003[31]. Unemployment also tended to be much lower in the 'Western' cluster: 6% compared with 21% or above in the other clusters.

Regarding dietary quality, no significant differences or trends were noted for micronutrient adequacy (Table 3). More than 80% of the subjects met the recommended intake, except for calcium (<43%) and iron (<70%). In contrast, the healthfulness score varied significantly between clusters, as seen in Table 4. The healthfulness score was significantly lower in the 'Western' cluster compared with the 'Traditional' and 'Pre-Western' groups, reflecting in particular higher than recommended intakes of total fat, saturated fat and cholesterol. Irrespective of food patterns, the low proportions of subjects having intakes in line with the recommendations for $n-6$ and $n-3$ fatty acids, free sugars, fibre and fruits and vegetables are noteworthy. Compliance with dietary recommendations as regards total fat, saturated fat and $n-3$ fatty acids was also low in the 'Modern' cluster, although this dietary pattern tended to be more varied, higher in fruits and vegetables, and in fibre.

Table 2 Subjects' demographic and socio-economic characteristics by dietary phenotype ($n = 177$)

		Traditional	Pre-Western	Western	Modern	*P*-value
Age (years)	Mean ± SD	**42.4 ± 10.4**[a]	41.1 ± 9.2[ab]	*34.1 ± 9.2*[b]	38.6 ± 11.9[ab]	0.022
	25–34 years (%)	29.5	27.5	68.8	57.1	0.017
	35–44 years (%)	29.5	37.7	18.8	14.3	
	45 years or more (%)	41.0	34.8	12.5	28.6	
Sex (%)	Men	60.3	36.2	62.5	28.6	0.008
	Women	39.7	63.8	37.5	71.4	
Proportion of lifetime in Canada (%)*	Mean ± SD	*48.0 ± 9.7*[a]	49.9 ± 7.5[ab]	**54.6 ± 8.3**[b]	52.2 ± 9.4[ab]	0.018
	0–44%	39.7	23.2	12.5	28.6	0.021
	45–54%	32.1	52.2	31.3	28.5	
	55–100%	28.2	24.6	56.2	42.9	
Education (%)	≤High school/professional	34.6	31.9	25.0	7.1	0.312
	College/technical	17.9	24.6	37.5	28.6	
	University	47.4	43.5	37.5	64.3	
Annual income (%)	≤$30 000	50.0	56.5	37.5	57.1	0.620
	$30 000–49 999	28.2	17.4	37.5	21.4	
	≥$50 000	21.8	26.1	25.0	21.4	
Employed (%)	Yes	69.2	72.5	93.8	78.6	0.229
	No	30.8	27.5	6.3	21.4	
Housing (%)	Owner	24.7	34.8	25.0	28.6	0.584
	Tenant	75.3	65.2	75.0	71.4	
SES score*	Mean ± SD	2.9 ± 0.3[ab]	*2.8 ± 0.3*[a]	**3.1 ± 0.3**[b]	2.8 ± 0.4[ab]	0.016

SES – socio-economic status; SD – standard deviation.
Significantly highest mean values are in bold and significantly lowest mean values are in italics.
*Adjusted for age and sex.
[a,b] Means with common superscript letters are not significantly different.

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Table 3 Proportion (%) of subjects meeting dietary allowances for micronutrients and mean micronutrient adequacy score by dietary phenotype ($n = 177$)

	Dietary recommendations (FAO/WHO)[27]	Adjusted nutrient intake (mean ± SD)*	Traditional ($n = 78$)	Pre-Western ($n = 69$)	Western ($n = 16$)	Modern ($n = 14$)	*P*-value
Calcium	1000 mg day^{-1} for ♂, 1000 mg day^{-1} for ♀ 19–50 years, 1300 mg day^{-1} for ♀ ≥51 years	791.6 ± 309.9	15.4	21.7	12.5	42.9	0.096
Magnesium	260 mg day^{-1} for ♂, 220 mg day^{-1} for ♀	361.9 ± 119.5	82.1	91.3	68.8	85.7	0.116
Iron	11 mg day^{-1} for ♂, 24 mg day^{-1} for ♀ 19–50 years, 9 mg day^{-1} for ♀ ≥51 years	21.0 ± 21.0†	67.9	49.3	62.5	64.3	0.138
Thiamin	1.2 mg day^{-1} for ♂, 1.1 mg day^{-1} for ♀	6.1 ± 29.9†	83.3	88.4	81.3	92.9	0.654
Riboflavin	1.3 mg day^{-1} for ♂, 1.1 mg day^{-1} for ♀	7.4 ± 39.3†	83.3	92.8	81.3	92.9	0.268
Vitamin B_6	1.3 mg day^{-1} for ♂ and ♀ 19–50 years, 1.7 mg day^{-1} for ♂ ≥51 years, 1.5 mg day^{-1} for ♀ ≥51 years	10.8 ± 47.6†	91.0	92.8	100.0	92.9	0.665
Folic acid	400 FE day^{-1} for all	561.4 ± 181.7	83.3	81.2	68.8	78.6	0.600
Vitamin B_{12}	2.4 μg day^{-1} for all	10.0 ± 16.2†	80.8	92.8	87.5	78.6	0.170
Vitamin C	45 mg day^{-1} for all	245.9 ± 190.9†	100.0	95.7	93.8	100.0	0.200
Vitamin A	600 RE day^{-1} for ♂, 500 RE day^{-1} for ♀	1485.9 ± 810.3	88.5	95.7	87.5	100.0	0.233
'Micronutrient adequacy' score		7.9 ± 2.1	7.8 ± 2.3	8.0 ± 1.9	7.4 ± 2.3	8.3 ± 1.9	0.627

FAO/WHO – Food and Agriculture Organization/World Health Organization; SD – standard deviation; ♂ – males; ♀ – females; FE – folate equivalents; RE – retinol equivalents.
* Adjusted for number of 24-hour food recalls completed, methods, number of days between food recall and day of the week.
† Abnormal distribution.

Table 4 Compliance (%) with WHO dietary recommendations and 'healthfulness' score by dietary phenotype ($n = 177$)

	Dietary recommendations (WHO)[4]	Adjusted nutrient intake (mean ± SD)*	Traditional ($n = 78$)	Pre-Western ($n = 69$)	Western ($n = 16$)	Modern ($n = 14$)	*P*-value
Total fat	15–30% of energy intake	29.1 ± 5.1	64.1	56.5	25.0	28.6	0.006
Saturated fatty acids	<10% of energy intake	8.9 ± 1.9	75.6	75.4	56.3	42.9	0.036
n–6 fatty acids	5–8% of energy intake	4.4 ± 1.2†	19.2	26.2	25.0	21.4	0.789
n–3 fatty acids	1–2% of energy intake	0.7 ± 0.3	5.1	15.9	25.0	0.0	0.022
Cholesterol	<300 mg day^{-1}	290.2 ± 123.0	71.8	55.1	31.3	71.4	0.009
Sugar	<10% of energy intake	11.9 ± 3.4	29.5	36.2	37.5	21.4	0.631
Protein	≥10% of energy intake	18.3 ± 3.4	100.0	98.6	100.0	100.0	0.665
Fibre	≥25 g day^{-1}	18.8 ± 6.0	12.8	10.1	0.0	28.6	0.104
Fruits and vegetables	≥400 g day^{-1}	451.6 ± 311.0†	53.8	44.9	25.0	57.1	0.158
Variety ($n = 175$)	≥24 food items over three 24-hour food recalls	26.7 ± 6.5	67.5	72.5	56.3	84.6	0.367
'Healthfulness' score		4.8 ± 1.4	5.0 ± 1.4[a]	4.9 ± 1.4[a]	3.8 ± 1.2[b]	4.6 ± 1.7[ab]	0.020

WHO – World Health Organization; SD – standard deviation.
* Adjusted for number of 24-hour food recalls completed, interview in person or by phone, number of days between food recall and day of the week.
† Abnormal distribution.
[a,b] Means with common superscript letters are not significantly different.

The proportion of subjects likely underreporting their energy intake could be estimated based on data on resting metabolic rate which were available for a subgroup of 39 subjects (data not shown). The ratio of energy intake to resting metabolic rate according to individual physical activity level was computed as proposed by Mennen *et al.*[32] and the results were extrapolated to the whole sample. We estimated that roughly 26% of subjects likely underestimated their energy intake. Low-energy reporters (LERs) were not different from others in terms of age, sex, body mass index (BMI), SES, alcohol intake and tobacco consumption, although their leisure physical activity level was higher (data not shown).

Discussion

To our knowledge, this is the first study analysing dietary patterns in immigrants as a means of staging their dietary transition or acculturation and linking these dietary patterns with dietary quality. In this cross-sectional study on a representative sample of Haitians living in Montreal, we identified four dietary clusters and these were associated with significant differences in age, sex, length of stay in Canada and SES. The first two clusters ('Traditional' and 'Pre-Western'), which included a large majority of subjects (83% together), somewhat reflect resistance to dietary change, whereas the latter two ('Western' and 'Modern') represent more of an acculturation to dietary habits of the surrounding environment, although the assimilation is only partial. Subjects with a more 'Western' diet type were younger and tended to have spent a higher proportion of their lifetime in Canada; they also had a significantly higher SES score. The quality of their diet was poorer with respect to total fat, saturated fat and cholesterol intakes.

Dietary patterns according to length of stay in Canada and SES

Dietary transition is part of the nutrition transition and it usually refers to changes in diet linked to globalisation, urbanisation, changes in socio-economic level and greater access to industrialised (processed) food items in developing countries[1,2]. As the features of the transition process and its pace may vary widely according to socio-economic and demographic profiles of populations, it would be reasonable to refer to transitions. However, some trends are consistently observed in diverse settings and include increases in fat, dietary cholesterol, sugars and refined cereals, and decreases in dietary fibre and polyunsaturated fat intakes, which are typical of Western dietary patterns. Although some authors consider that dietary transition and Westernisation should be examined as separate entities[33], we contend that they are interchangeable in many settings. Additionally, it is our view that dietary transition as an epidemiological concept is also relevant for immigrant populations from developing countries. Whether described in terms of transition, Westernisation or acculturation, the dietary changes with migration may at first enhance the risk of chronic diseases such as CVD, although, at a later stage, individuals may shift to a more prudent diet out of health concerns, i.e. more fibre, fruits and vegetables, and less fat and animal protein.

We attempted to identify stages of dietary transition by connecting eating patterns with the proportion of lifetime in Canada and with SES, while correcting for age and sex. This is how the 'Western' diet type was observed in subjects who had lived in Canada for a significantly greater proportion of their lifetime compared with those of the 'Traditional' cluster; their SES score was also the highest of all food clusters. However, our analyses showed that dietary patterns are more complex than implied in the dietary transition theory[1]. For instance, we found little evidence for the replacement of traditional Haitian foods by Western-type items when comparing the 'Traditional' and the 'Western' clusters. Traditional dishes were still present in the latter although perhaps in smaller quantities than in the former, and they were complemented by fast foods, soft drinks and French fries. Energy intake was not significantly higher in the 'Western' diet type than in the 'Traditional', suggesting that some degree of substitution of traditional by Western foods has occurred. This is at variance with findings from a study conducted in aboriginal Dogrib communities in the Northwest Territories (Canada)[34]. The authors noted that dietary acculturation to dominant diet and lifestyle occurred mainly through the addition of new food items to an existing traditional diet but little substitution, resulting in increased energy intake. More in line with our results, a study in Bubis[35], a rural immigrant population of African origin living in Madrid (Spain), showed that traditional dietary patterns progressively declined at the expense of more Westernised food habits.

The traditional Haitian meal as described in Appendix B is consistent with the 'Traditional' dietary cluster, wherein a high intake of breakfast cereal was also observed. Breakfast cereal is expensive in Haiti and is therefore considered 'rich' people's food. When income increases with migration, this prestigious food becomes accessible. Hot cereal seems to have somewhat replaced breakfast cereal in the 'Pre-Western' cluster, but cold breakfast cereal consumption is quite high again in the 'Modern' cluster, and the high fibre intake in this last cluster suggests that breakfast cereal rich in fibre may be selected. The high consumption of whole-grain bread (and fruits and vegetables) in the 'Modern' cluster may also contribute to the high fibre intake. In Haiti, white bread is widely consumed while whole-wheat bread is scarce. Except for the 'Modern' cluster, whole-grain bread was little consumed. The traditional Haitian meal is occasionally accompanied by non-fried tubers; this habit was most common in the 'Pre-Western' cluster. The high intake of

dairy foods (low-fat and high-fat) in the 'Pre-Western' cluster is difficult to explain. A high consumption of dairy products, but primarily low-fat, was also seen in the 'Modern' type.

In our study, there was some evidence of a shift towards a traditional but healthier dietary pattern in the 'Modern' cluster, which can be considered the ultimate stage of dietary transition; however, it was not as clear-cut as featured in the nutrition transition theory[1]. Indeed, the 'Modern' diet type included quite high amounts of beans and fruit, and also of less traditional healthy food items such as whole-grain bread, but also sizeable amounts of sandwiches and superfluous food items which are not typically associated with a healthier diet. Moreover, the overall quality of the 'Modern' diet was not significantly higher than that of the other dietary phenotypes.

The changes from traditional food patterns that occurred in this Haitian population living in Canada were quite intricate and subtle, suggesting a more complex process than that described in the nutrition transition theory[1,2]. Our results are more in line with those of Mennen *et al.*[12] who studied three populations of the African Diaspora (Cameroon, Jamaica and Caribbean migrants in Britain) and found, for instance, that total and saturated fat intake was highest in rural Africa, whereas the lowest consumption of fat is expected in this early stage of dietary transition. Yet, African Caribbean men (but not women) living in Britain and following a more traditional diet had a significantly lower intake of energy from fat and saturated fat than less traditional men[36].

One strength of the present study is that we examined the overall nutritional quality of the dietary phenotypes rather than considering individual nutrients as has been done in several studies[37–39]. We found a higher diet quality in terms of compliance with the recommendations for health and the prevention of chronic diseases in the 'Traditional' phenotype and a lower quality in the 'Western' phenotype, but no difference as regards micronutrient intake adequacy. The lower quality of the 'Western' type of diet corroborates the findings of the Framingham study[40] showing that a 'Healthier' diet type was associated with a higher quality and an 'Empty-calorie food items' dietary type with a lower quality.

The use of cluster analysis

There are two main statistical methods available for defining dietary patterns: cluster analysis and factor analysis[13,25,41,42]. Because factor analysis is based on correlations of different food items with one another, it assumes a linear relationship between variables that is not always present[23,25,43]. Many of our food groups were not linearly interrelated so correlation was not an appropriate analytical approach, thus precluding factorial analysis. Cluster analysis is not based on the same statistical precepts since it is a more mathematical method which classifies individuals by their mean intakes in each food group into subgroups maximally separated in a multi-dimensional space[23,25,43]. Both factorial analysis and cluster analysis are *a posteriori* methods based on many subjective decisions such as food grouping or the choice of number of clusters[25,43]. To choose the number of clusters, researchers consider the homogeneity and meaningfulness of the clusters[25,26]. The number of clusters reported in the literature varies from two to eight, and we found four fairly homogeneous and meaningful clusters in this Haitian sample. Cluster analysis (or factorial analysis) is not intended to provide an ideal dietary type; rather, it reflects the food habits in the population under study[25,43]. Comparison with other studies is thus difficult since dietary types depend on cultural and ethnic heritage and other environment factors such as food availability[25,43]. However, it is an informative and interesting means of increasing our understanding of the role of diet in the development of chronic diseases[43].

As a complement to statistical approaches such as cluster analysis for defining dietary types, it is also possible to use indices of overall diet quality which assess several nutrition and health aspects of the diet[25,42–44]. We found significant differences between dietary types in the extent of compliance with dietary recommendations for health and the prevention of chronic diseases (WHO)[4], but not in the adequacy of micronutrient intakes (FAO/WHO)[27]. So diets or dietary types may at the same time be adequate but of poor quality from a healthfulness standpoint.

The high estimated rate of LERs in our study (26%) could introduce bias in the results of the cluster analysis, as amounts of food are affected. Additionally, the diet quality indices may be affected positively or negatively depending on the nutritional profile of the 'forgotten' food items in the 24-hour food recalls. The proportion of LERs is however similar to that found in the British population, although we did not find demographic, socio-economic or BMI differences between LERs and other subjects, unlike Pryer *et al.*[45,46]. Nevertheless, the high proportion of overweight (46%) and obesity (22%) in our sample suggests that many subjects likely consume more energy than they need.

Apart from the small sample size, although deemed adequate for the purposes of the study, a limitation of our study is that the participants had a higher schooling level than the general Haitian population of Montreal, according to census data. Otherwise, the socio-economic profile of the sample was similar to that of the population. In studies based on voluntary participation, samples are frequently of higher education level than the population, owing to self-selection[47]. The fact that participants in such studies are better educated and more interested in the research topic than the non-participants may result in healthier behaviours, better health status or a lower susceptibility to CVD[48]. We found a significant difference in SES score (which included education) across diet types ($P < 0.016$), but no significant difference in education

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level alone, which suggests that food consumption (and nutrient intake) might not be much different in a less educated sample of the same adult population.

Although this study was cross-sectional, the findings suggest that the dietary types reflected different stages of dietary transition (or acculturation). A longitudinal design would indeed have allowed us to identify the dietary and lifestyle changes that individuals make over time.

In conclusion, our results showed that it is possible to stage dietary transition (or acculturation) of migrants from a developing country to an industrialised country on the basis of eating patterns according to length of stay in the host country and taking account of SES (and age and sex). In this study, Westernised dietary patterns were typical of younger Haitians, whereas more traditional diets were observed in older subjects. Relevant dietary interventions based on the results could include the promotion of traditional Haitian food patterns, but with some improvements in order to increase fibre intake through emphasis on fruits and vegetables, whole grains, legumes and non-fried tubers.

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Appendix A – Food groups used in cluster analyses

Food groups	Food items
Fruits	Fruits and 100% fruit juice
Grains	Rice, pasta, corn flour
Breakfast cereal	Cold breakfast cereal
Fruit drinks	Fruit-flavoured crystals, fruit punches
White bread	White bread, bagels, English muffins, pita bread
Non-fried tubers	Non-fried potatoes, sweet potatoes, plantain, cassava and other tubers
Hot cereal	Oatmeal, cream of wheat, corn porridge
Dairy ≤2% milk fat	Milk, condensed milk, cottage cheese, yoghurt
Dairy >2% milk fat	Milk, condensed milk, yoghurt, cheese, sour cream, cream, white sauce
Red meat	Beef, lamb, sheep, pork, veal, goat, shepherd's pie, meat pie, Haitian pâté, cabbage rolls, meat sauce for pasta
Fish	Fish, seafood, fish pie
Fast foods	Hot dog, hamburger, pizza
Soft drinks	Carbonated beverages
Fried tubers	Fried potatoes, plantain and other tubers, *poutine* (mix of French fries, gravy and cheese)
Processed meat	Bacon, ham, liver, pepperoni, salami, sausages
Poultry	Chicken, turkey, partridge, duck, eggs, chicken pie
Whole-grain bread	Whole-wheat bread, whole-wheat bagel, whole-wheat pita
Sandwiches	Sandwiches, submarines
Beans	Beans, soy milk
'Superfluous' food items	Pastries, cakes, cookies, muffins, sweets, chocolate, jam, salted snacks
Vegetables	Vegetables, traditional sauce made with vegetables (excluding meat), vegetable juice

Appendix B – A traditional Haitian meal

White rice with sauce made from fried red meat (or fish or poultry depending on the socio-economic level of the family) which is mixed with vegetables (onions, tomato fresh and/or paste, green pepper, garlic, oil and broth)
The rice dish is habitually served with a puree of red or black beans called *sauce-pois* (or beans mixed and cooked with rice – *riz-collé*)
The rice dish is sometimes accompanied by non-fried tubers
The most common beverages are water and fruit juice (or fruit drinks)
Desserts, if eaten at all, are mostly fruits

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