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Influence of acculturation among Tunisian migrants in France and their past/present exposure to the home country on diet and physical activity

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Abstract

Objective: To study how dietary patterns and physical activity vary with acculturation and with past and current exposure to socio-cultural norms of the home country among Tunisian migrants.
Design: A retrospective cohort study was conducted using quota sampling (n 150) based on age and residence. Dietary intake was assessed using a validated FFQ. Physical activity level and dietary aspects were compared according to length of residence (acculturation), age at migration (past exposure) and social ties with the home country (current exposure).
Subjects and setting: Tunisian migrant men residing in the South of France.
Results: Migrants who had lived in France for more than 9 years had a higher percentage contribution of meat to energy intake ($P = 0{\cdot}04$), a higher Na intake ($P = 0{\cdot}04$), a lower percentage contribution of sugar and sweets ($P = 0{\cdot}04$) and a lower percentage of carbohydrates ($P = 0{\cdot}03$) than short-term migrants. Men who migrated before 21 years of age had a higher Na intake than 'late' migrants ($P = 0{\cdot}02$). Men who had distant social ties with Tunisia had a lower physical activity level ($P = 0{\cdot}01$) whereas men who had close ties had a higher percentage of fat ($P = 0{\cdot}01$) and a higher ratio of MUFA to SFA ($P = 0{\cdot}02$).
Conclusions: Acculturation led to a convergence of some characteristics to those of the host population, while some results (meat and salt consumption) were at variance with other acculturation studies. Past and current exposure to the home country helped maintain some positive aspects of the diet. Nevertheless, present dietary changes in Tunisia could soon lessen these features.

Keywords
Migrants
Lifestyle
Length of residence
Age at migration

Over the last few decades, more and more developing countries have been undergoing a marked shift in the overall structure of their dietary pattern, with an increase in nutrition-related non-communicable diseases (CVD, diabetes and obesity)[1]. This major dietary change, known as 'Westernisation' of the diet, includes a considerable increase in the consumption of fat, particularly saturated fat, and added sugar and sweets in the diet[2]. It also leads to a marked increase in the consumption of animal food products contrasted with a reduction in the consumption of fruit, vegetables and total cereals, and in fibre intake.

Over the same period, migration from developing countries to more industrialised ones has been continuous. In this context, migrant studies contribute important knowledge relating to the ways in which changes in environmental, dietary and lifestyle behaviours affect health and disease status. Indeed, migration and acculturation are associated with significant changes in dietary patterns[3]. Several studies have shown that migrants adopt the dietary patterns of their new host country, resulting in negative consequences for health[4–6]. However, the extent of these changes varies with each ethnic group[7].

Acculturation is defined as 'the process by which immigrants adopt the attitudes, values, customs, beliefs, and behaviours of a new culture'[8]. Health-related behaviours, such as dietary patterns and physical activity, of migrants are likely to be affected by the process of acculturation[9]. For example, the length of residence in the new environment, which is one of the indicators of acculturation, is likely to lead to changes in diet and in physical activity[9–12]. On the other hand, past and current exposure to the socio-cultural norms of the home country could underplay the influence of the new environment. Lifestyles that are related to these norms, such as dietary

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patterns, alcohol consumption or tobacco use, may be retained to a greater or lesser extent in the new place of residence[13].

In France, adult migrants from southern Europe and North Africa reported dietary practices consistent with the typical Mediterranean diet, which is well known for its positive effects on health[14,15]. Also, a previous study of Tunisian migrant men in France showed that these migrants exhibited better diet quality than their French counterparts, while their diet profile was very similar to that of non-migrant Tunisians[16]. Moreover, an active lifestyle was more prevalent among Tunisian migrant men than among local-born French and non-migrant Tunisians[17]. Thus, in spite of a rapid nutrition transition in their home country[18,19], Tunisian migrants appear to have conserved some healthy behaviours. However, the question arises as to what the respective degree of influence of acculturation and of strength of ties with the country of origin has been in relation to these features over the last 20 years. This last dimension is particularly interesting in the context of North African migration in France. As the two countries are geographically close and have a common historical context, the maintenance of ties with the home country among Tunisian migrants is relatively common and could potentially influence lifestyles related to health. The aim of the current study was to explore the potential associations of dietary patterns and physical activity levels among Tunisian migrant men with their degree of acculturation in France and with their past and current exposure to socio-cultural norms of their home country.

Methods

Design and sampling

The current study presents an analysis of data from a retrospective cohort study which compared Tunisian migrant men aged ≥18 years and two non-migrant male groups: local-born French individuals and non-migrant Tunisians[16,17]. In the present study, the subjects were those from the migrant group: migrants were defined as individuals who were native of Tunisia and who had been residing in the South of France (Languedoc-Roussillon region) for more than 1 year at the time of the survey. As French law does not allow access to nominative files with ethnic status, random sampling was not possible. Thus, using the French National Institute of Statistics (INSEE) database, we performed quota sampling based on age and place of residence. The number of migrants surveyed (*n* 150) was based on power calculations for comparison of the three groups in the first study.

The research complied with the principles of the Helsinki Declaration. The protocol was approved by the French National Commission of Information Technology and Freedom (CNIL). All interviewees gave their free written informed consent.

Data collection

Data were collected in 2004 in France by interviewers who were bilingual in French and Arabic. We specifically trained and standardised interviewers for physical activity and food consumption measurements.

Assessment of economic factors

To assess economic status, correspondence analysis was performed on the matrix of indicator variables coding characteristics of dwelling, utilities and appliances. The score of each household on the first principal component was used as a summary index of household wealth[20,21] and the latter was introduced in analyses after breakdown into tertiles of increasing economic level (low, medium and high).

Assessment of acculturation and exposure to socio-cultural norms of the home country

The potential degree of acculturation was assessed by an exposure indicator: length of residence in France, which was derived from the year of arrival. We categorised length of residence in such a manner that there was a substantive variation in length of residence between groups (≤9 years, 10–29 years and ≥30 years) and a minimum sample size in each group.

To evaluate the different periods of past exposure to socio-cultural norms of the home country, age at migration was used. Age at migration was also classified into three groups: ≤20 years old, 21–29 years old and ≥30 years old.

Current exposure to socio-cultural norms of the home country was assessed by an index of social ties with the home country, based on five variables: (i) remittance behaviour for family in the country of origin; (ii) language preference; (iii) home ownership in Tunisia; (iv) having returned to the home country for a holiday during the past year; and (v) projecting to return to the home country after retirement. This summary index was built in a similar way to the economic index by correspondence analysis. It was also categorised into three levels (tertiles): distant, moderate and close ties with the home country.

Assessment of dietary intake

To assess usual dietary intake during the past month, a validated quantitative FFQ[22] was adapted to Tunisian habits. After creation of a food composition table from a database compiled from the US Department of Agriculture's food composition database[23] and the French food composition table[24], which was relevant for both France and Tunisia, dietary intake data were converted into nutrient data using the ESHA Food Processor software version 8·3 (ESHA Research Inc., Salem, OR, USA).

As there is no internationally acknowledged recommendation for the classification of food groups, we defined eleven food groups: cereals; vegetables; fruits; nuts/beans; fats; sugar/sweets; milk products; meat; fish; eggs; and others (coffee, tea and condiments). The percentage contributions of these eleven food groups to total energy intake were calculated from the mean daily intake (g) of each food group.

Assessment of physical activity level

To evaluate the physical activity level (PAL), we used a frequency questionnaire that assessed the time spent on different current activities: occupational habits, home activities, recreational activities, sports and travel to and from places during the last month, with specific attention to working days and holidays. Total daily physical activity (PA) (MET-h/d) was estimated by adding the product of the time reported for each item by a MET value specific to each category of PA using a published compendium of physical activities[25] and expressed as a daily average MET score (where MET is metabolic energy equivalent task; 1 MET = 1 kcal/kg per h). We estimated the BMR from the weight, height and age of each person using the Henry equation[26]. We then calculated the total energy expenditure (TEE; kcal/d) from BMR and total daily PA. The PAL, expressed as a BMR multiple, was assessed by PAL = TEE/BMR.

Statistical analyses

Effects of length of residence, age at migration and social ties with the home country on physical activity level, percentage of time spent in leisure-time activities, percentage of time spent in occupational activities and dietary characteristics were assessed using general linear models. Dietary characteristics included percentage contributions of food groups and macronutrients to total energy intake, quantities of selected components, ratio of PUFA to SFA and ratio of MUFA to SFA. In the first set of models, effects were adjusted for age and economic level and the models relating to dietary data were also adjusted for energy intake. Then, the effect of length of residence, age at migration and social ties with the home country were also adjusted for each other to control for potential confounding. These potential confounding factors were added sequentially in the models. For example, the effect of length of residence was first adjusted for age at migration, then for social ties with the home country. In order to reduce residual confounding, length of residence and age at migration were used as continuous confounding variables[27].

The type I error rate was set at 0·05. Data entry and quality checks were performed using the Epidata software version 3·1 (Epidata Association, Odense, Denmark); data management and statistical analyses were performed using the Statistical Analysis Systems statistical software package version 9·1 (SAS Institute, Cary, NC, USA).

Results

As three surveyed migrants subsequently withdrew their consent, the final total of subjects used in the analyses was 147.

Table 1 General characteristics of Tunisian migrants, South of France, 2004

	Mean or %	SD
Age (years)	50·2	13·2
Length of residence (years)	23·0	12·0
Age at migration (years)	28·2	10·2
Currently working (%)	70·7	
Married (%)	72·8	
Educational level (%)		
None or primary	38·1	
Secondary	42·2	
University	19·7	
Currently smoking (%)	28·6	
Alcohol consumption (%)	19·1	
BMI (kg/m^2)	26·2	
Overweight (BMI ≥ 25 kg/m^2) (%)	5·1	
Central obesity (waist	46·9	
circumference ≥ 94 cm) (%)	45·5	

General characteristics of Tunisian migrants

The mean age of migrants was 50·2 (SD 13·2) years, their mean length of residence and age at migration were respectively 23·0 (SD 12·0) years and 28·2 (SD 10·2) years (Table 1).

More than two-thirds (70·7 %) of migrants reported they were currently working, 72·8 % were married and 38·1 % had a low education level. By construction, subjects were evenly split between the three categories of the economic index. Prevalence of smoking was 28·6 % and only 19·1 % of migrants were alcohol consumers (Table 1). The mean BMI of the sample was 26·2 (SD 5·1) kg/m^2. Over 40 % of the subjects were above the cut-off values for BMI and waist circumference.

Effects of length of residence

Compared with men who had lived in France for less than 10 years, migrants who had been in France for longer presented a higher percentage contribution of meat to energy intake ($P = 0·04$) and higher Na intake ($P = 0·04$), both before and after adjustment for age at migration and ties with the home country (Table 2). They also consumed a lower percentage contribution of sugar and sweets ($P = 0·04$) and a lower percentage of carbohydrates ($P = 0·03$) than short-term migrants.

There was an effect of length of residence on physical activity level ($P = 0·04$), mean percentage contribution of fats ($P = 0·02$), mean percentage contribution of lipids ($P = 0·03$), fibre intake ($P = 0·03$) and MUFA:SFA ratio ($P = 0·0005$) but the effect disappeared after adjustment for age at migration (Table 2). The difference in the mean percentage contribution of protein was no longer significant after adjustment for social ties with the home country ($P = 0·07$).

Effects of age at migration

Men who migrated to France before 21 years of age had a significantly higher Na intake than migrants who were older than 21 when they arrived, whether before

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Table 2 Physical activity and dietary characteristics according to length of residence: Tunisian migrants, South of France, 2004

	All (*n* 147)		*P* value	*P* value	≤9 years (*n* 31)		10–29 years (*n* 71)		≥30 years (*n* 45)		*P* value
	Mean	SE	model 1*	model 2†	Mean	SE	Mean	SE	Mean	SE	model 3‡
Physical activity											
Physical activity level	1·75	0·18	0·04	0·09	1·77	0·04	1·79	0·02	1·70	0·04	0·08
% of time spent in leisure-time activities	16·27	0·64	0·22	0·44	16·57	1·54	15·60	0·74	17·34	1·35	0·37
% of time spent in occupational activities	22·19	0·77	0·18	0·18	22·21	1·49	21·62	0·67	23·92	1·23	0·20
Food groups (% of total energy)											
Cereals	27·6	0·84	0·08	0·15	25·02	2·54	29·40	1·76	26·69	2·24	0·29
Vegetables	9·42	0·30	0·12	0·20	9·39	0·98	8·79	0·46	10·08	0·87	0·27
Fruit	9·97	0·47	0·33	0·88	9·68	1·45	10·30	0·68	9·61	1·28	0·79
Nuts/beans	4·99	0·37	0·55	0·25	7·25	1·39	4·74	0·65	4·07	1·22	0·30
Fats	19·86	0·68	0·02	0·16	14·89	1·63	17·61	0·76	18·55	1·43	0·34
Sugar/sweets	5·58	0·54	0·0008	0·04	3·98	0·91	5·89	0·42	6·25	0·80	0·04
Dairy products	10·08	0·67	0·61	0·08	12·32	1·39	9·76	0·65	8·25	1·22	0·21
Meat	11·27	0·49	0·01	0·03	13·16	1·39	9·76	0·65	10·56	1·23	0·04
Fish	2·46	0·16	0·98	0·98	2·24	0·49	2·37	0·23	2·44	0·43	0·97
Eggs	1·51	0·13	0·19	0·54	1·77	0·40	1·42	0·18	1·20	0·35	0·69
Others	0·10	0·01	0·36	0·45	0·09	0·02	0·09	0·01	0·12	0·02	0·40
Nutrient characteristics											
Protein (%)	15·40	0·26	0·06	0·03	16·38	0·64	14·69	0·30	14·70	0·57	0·07
Lipids (%)	36·89	0·64	0·03	0·25	39·66	1·66	39·29	0·78	36·30	1·47	0·21
Carbohydrates (%)	47·71	0·66	0·02	0·03	43·96	1·67	49·02	0·78	49·00	1·48	0·03
Fibre (g/d)	44·57	1·26	0·03	0·51	40·73	3·91	44·77	1·83	46·30	3·45	0·66
PUFA:SFA	0·62	0·02	0·66	0·73	0·56	0·06	0·64	0·03	0·65	0·06	0·63
MUFA:SFA	1·56	0·04	0·0005	0·07	1·44	0·11	1·66	0·05	1·65	0·10	0·24
Na (g/d)	3·37	0·11	0·34	0·04	4·16	0·32	3·19	0·15	2·89	0·28	0·04
Cholesterol (g/d)	0·48	0·02	0·05	0·08	0·59	0·07	0·42	0·03	0·41	0·06	0·11

*Model 1 adjusted for age, economic level, energy intake (only food groups and nutrient characteristics).
†Model 2 adjusted for age, economic level, energy intake (only food groups and nutrient characteristics) and age at migration.
‡Model 3 adjusted for age, economic level, energy intake (only food groups and nutrient characteristics), age at migration and social ties with the home country.

($P=0{\cdot}01$) or after adjustment for length of residence and ties with the home country ($P=0{\cdot}02$) (Table 3).

On the other hand, the effect of age at migration on the mean percentage contribution of cereals ($P=0{\cdot}03$), fats ($P=0{\cdot}04$), sweets ($P=0{\cdot}01$), meat ($P=0{\cdot}003$), cholesterol intake ($P=0{\cdot}004$) and on MUFA:SFA ratio ($P=0{\cdot}0001$) was no longer significant after adjustment for length of residence (Table 3).

Effects of social ties with the home country

The mean physical activity level (1·75 (SD 0·18)) was within the 'active lifestyle' range. Compared with men who had closer social ties with their home country, men who maintained distant ties had a lower physical activity level and a lower percentage of time spent in occupational activities after adjustment for length of residence ($P=0{\cdot}01$ and $P=0{\cdot}008$, respectively) (Table 4). Concerning food groups, men who had close social ties with their home country had a higher percentage of energy from fats and a higher MUFA:SFA ratio both before ($P=0{\cdot}0006$ and $P=0{\cdot}0006$, respectively) and after adjustment for age at migration ($P=0{\cdot}009$ and $P=0{\cdot}02$, respectively) and length of residence ($P=0{\cdot}01$ and $P=0{\cdot}02$, respectively) than men who had moderate or distant ties with Tunisia (Table 4).

By contrast, the difference in the percentage contribution of cereals ($P=0{\cdot}04$) was no longer significant after adjustment for age at migration ($P=0{\cdot}18$). The effect of social ties on percentage of dairy products ($P=0{\cdot}02$) did not remain significant after adjustment for length of residence ($P=0{\cdot}13$) (Table 4).

Discussion

The originality of our study lies in the use of age at migration and of social ties to evaluate past and current exposure to the home country. Age of migration has been widely taken into account in research on cancer epidemiology, in order to disentangle exposure in early life from the influence of the new environment[13,28]. This variable has also been used in studies relating to other diseases[29] or lifestyles[30–33]. To our knowledge, no study has measured current exposure to socio-cultural norms of the country of origin. Owing to geographical proximity and historical and economic links between France and Tunisia, the context of North African migration in France facilitated the measurement of this dimension.

Influence of acculturation

With increasing length of residence, migrants had a higher consumption of carbohydrates and a lower Na intake. Detailed analysis showed that the increase in carbohydrates was due to increasing consumption of sugar and sweets with length of residence, whereas the contribution of sources of complex carbohydrates (cereals and beans) remained stable. The lower Na intake among long-term migrants was linked to their lower consumption of meat. A French national survey revealed a change in eating patterns with increasing consumption of sweets and sodas and decreasing consumption of meat[34]. Thus, it seems there was a convergence of the consumption of these food groups to that of the host population along with acculturation. These results are in concordance with other studies that showed a diet higher in simple sugars and sweets with increasing acculturation[10,35,36], but disagree with other results with respect to salt and meat consumption[32,37,38].

Acculturation to the dominant diet appears to occur mainly through the addition of new food items (sugar and sweets) to an existing traditional diet. Moreover, acculturation appears to induce the adoption of French consumer behaviours related to meat consumption. However, this dietary change affected only a few food items and dietary components. Indeed, in spite of a better overall diet quality among Tunisian migrants than their French counterparts, there were few differences between the two groups[16]. Not surprisingly, Tunisian migrants and local-born French, all natives of the Mediterranean basin, appear to share certain dietary characteristics.

Influence of past exposure to Tunisian socio-cultural norms

The timing of immigration appears to be important in determining Na intake. Detailed results showed that the lower salt intake among 'late' migrants was due to their lower consumption of processed meats, which contain large amounts of Na[39]. The effect of age at migration on processed meat consumption could be explained by major differences between Tunisia and France with respect to changes in the patterns of consumption of this food group. To our knowledge, there has been no study of Tunisian consumption of processed meats. However, we know that, in Tunisia, meat availability has remained low since 1961, whereas in France there has been a major increase in the consumption of meat, highlighting a clear trend towards a Western diet[40]. Moreover, a previous study showed that the Na intake of migrants was lower than that of local-born French and similar to that of non-migrant Tunisians[16]. Thus, Tunisian migrants who come to France after the age of 20 may bring with them traditional Tunisian dietary habits (low consumption of processed meats and low Na intake), which do not change much after their arrival, whereas in migrants who come when they are younger, these Tunisian habits may not be so well established because of shorter past exposure to Tunisian socio-cultural norms. Likewise, detailed analysis showed that conservation of the observance of the religious restriction on alcohol consumption was reinforced by longer exposure to the Tunisian context.

Table 3 Physical activity and dietary characteristics according to age at migration: Tunisian migrants, South of France, 2004

	All (*n* 147)		*P* value model 1*	*P* value model 2†	≤20 years (*n* 33)		21–30 years (*n* 64)		≥30 years (*n* 50)		*P* value model 3‡
	Mean	SE			Mean	SE	Mean	SE	Mean	SE	
Physical activity											
Physical activity level	1·75	0·18	0·70	0·56	1·78	0·03	1·76	0·02	1·72	0·03	0·58
% of time spent in leisure-time activities	16·27	0·64	0·37	0·66	17·16	1·15	16·17	0·74	16·42	1·20	0·76
% of time spent in occupational activities	22·19	0·77	0·07	0·12	20·79	1·08	22·86	0·70	23·08	1·11	0·23
Food groups (% of total energy)											
Cereals	27·6	0·84	0·03	0·17	28·18	1·87	26·22	1·20	29·77	1·95	0·24
Vegetables	9·42	0·30	0·19	0·06	7·82	0·71	9·71	0·46	10·24	0·74	0·06
Fruit	9·97	0·47	0·40	0·64	9·34	1·06	10·48	0·68	10·34	1·11	0·65
Nuts/beans	4·99	0·37	0·31	0·31	4·32	1·02	5·81	0·65	5·04	1·06	0·40
Fats	19·86	0·68	0·04	0·82	17·04	1·23	16·48	0·79	16·72	1·29	0·92
Sugar/sweets	5·58	0·54	0·01	0·70	5·88	0·67	5·93	0·43	5·26	0·70	0·73
Dairy products	10·08	0·67	0·65	0·58	10·79	1·03	9·73	0·66	9·82	1·07	0·67
Meat	11·27	0·49	0·003	0·11	12·58	1·03	11·23	0·66	9·14	1·08	0·13
Fish	2·46	0·16	0·66	0·59	2·28	0·36	2·50	0·23	2·13	0·37	0·65
Eggs	1·51	0·13	0·12	0·54	1·52	0·30	1·64	0·20	1·31	0·31	0·64
Others	0·10	0·01	0·99	0·30	0·08	0·02	0·10	0·01	0·13	0·02	0·31
Nutrient characteristics											
Protein (%)	15·40	0·26	0·05	0·40	15·61	0·48	15·33	0·31	14·71	0·50	0·51
Lipids (%)	36·89	0·64	0·72	0·73	33·64	1·22	37·04	0·79	35·95	1·28	0·70
Carbohydrates (%)	47·71	0·66	0·98	0·42	46·75	1·24	47·63	0·80	49·33	1·30	0·44
Fibre (g/d)	44·57	1·26	0·10	0·38	47·06	2·90	45·66	1·86	40·81	3·03	0·37
PUFA:SFA	0·62	0·02	0·98	0·97	0·62	0·05	0·62	0·03	0·64	0·05	0·95
MUFA:SFA	1·56	0·04	0·0001	0·16	1·52	0·09	1·50	0·06	1·68	0·09	0·25
Na (g/d)	3·37	0·11	0·01	0·01	4·02	0·24	3·36	0·16	2·89	0·25	0·02
Cholesterol (g/d)	0·48	0·02	0·004	0·07	0·57	0·05	0·48	0·03	0·38	0·05	0·09

*Model 1 adjusted for age, economic level, energy intake (only food groups and nutrient characteristics).
†Model 2 adjusted for age, economic level, energy intake (only food groups and nutrient characteristics) and age at migration.
‡Model 3 adjusted for age, economic level, energy intake (only food groups and nutrient characteristics), age at migration and social ties with the home country.

Table 4 Physical activity and dietary characteristics according to social ties with the home country: Tunisian migrants, South of France, 2004

	All (*n* 147)		*P* value	*P* value	Distant (*n* 49)		Moderate (*n* 49)		Close (*n* 49)		*P* value
	Mean	SE	model 1*	model 2†	Mean	SE	Mean	SE	Mean	SE	model 3‡
Physical activity											
Physical activity level	1·75	0·18	0·05	0·05	1·69	0·03	1·80	0·03	1·75	0·03	0·01
% of time spent in leisure-time activities	16·27	0·64	0·29	0·23	17·13	0·96	15·25	0·87	17·01	0·94	0·22
% of time spent in occupational activities	22·19	0·77	0·01	0·007	21·60	0·90	24·41	0·76	21·14	0·89	0·008
Food groups (% of total energy)											
Cereals	27·6	0·84	0·04	0·15	26·98	1·67	27·05	1·40	30·56	1·53	0·18
Vegetables	9·42	0·30	0·28	0·38	9·78	0·65	9·79	0·54	8·68	0·59	0·32
Fruit	9·97	0·47	0·27	0·50	10·34	0·95	10·49	0·79	9·18	0·87	0·49
Nuts/beans	4·99	0·37	0·14	0·18	4·57	0·90	5·94	0·75	4·11	0·83	0·19
Fats	19·86	0·68	0·0006	0·009	16·35	1·06	15·97	0·89	19·63	0·98	0·01
Sugar/sweets	5·58	0·54	0·66	0·77	5·52	0·60	5·85	0·50	5·60	0·55	0·89
Dairy products	10·08	0·67	0·02	0·04	11·11	0·90	9·54	0·76	8·46	0·83	0·13
Meat	11·27	0·49	0·37	0·75	11·16	0·93	11·15	0·78	10·26	0·85	0·70
Fish	2·46	0·16	0·68	0·62	2·48	0·32	2·51	0·27	2·14	0·29	0·61
Eggs	1·51	0·13	0·08	0·30	1·50	0·26	1·48	0·22	1·13	0·24	0·47
Others	0·10	0·01	0·73	0·68	0·12	0·02	0·10	0·01	0·11	0·02	0·53
Nutrient characteristics											
Protein (%)	15·40	0·26	0·06	0·21	15·49	0·43	15·19	0·36	14·56	0·39	0·29
Lipids (%)	36·89	0·64	0·78	0·95	36·51	1·09	37·17	0·92	37·22	1·00	0·88
Carbohydrates (%)	47·71	0·66	0·94	0·86	48·00	1·11	47·64	0·93	48·22	1·02	0·90
Fibre (g/d)	44·57	1·26	0·67	0·48	40·01	2·53	44·53	2·12	45·29	2·32	0·29
PUFA:SFA	0·62	0·02	0·77	0·82	0·64	0·05	0·63	0·04	0·60	0·04	0·80
MUFA:SFA	1·56	0·04	0·0006	0·02	1·48	0·08	1·57	0·06	1·77	0·07	0·02
Na (g/d)	3·37	0·11	0·78	0·99	3·06	0·20	3·25	0·17	3·33	0·19	0·65
Cholesterol (g/d)	0·48	0·02	0·26	0·72	0·45	0·05	0·46	0·04	0·43	0·04	0·87

*Model 1 adjusted for age, economic level, energy intake (only food groups and nutrient characteristics).
†Model 2 adjusted for age, economic level, energy intake (only food groups and nutrient characteristics) and age at migration.
‡Model 3 adjusted for age, economic level, energy intake (only food groups and nutrient characteristics), age at migration and social ties with the home country.

Influence of current exposure to Tunisian socio-cultural norms

The present study provides some evidence that current exposure to Tunisian socio-cultural norms can influence the dietary patterns and physical activity levels of Tunisian immigrants currently residing in the South of France. Migrants who were less exposed to the current Tunisian context were less physically active. This lower physical activity level among men who maintained distant ties with the home country was linked to their lower percentage of time spent in occupational activities.

Detailed results showed that the higher MUFA:SFA ratio among migrants who maintained close ties with their home country was due to higher consumption of olive oil. The increase in the consumption of olive oil and fats with increasing strength of social ties with Tunisia could be explained by the current consumption level of this food group in Tunisia. In this country, the olive oil availability was greater than in France, indicating a major difference in eating patterns for this product between the host country and the home country[40]. Concerning fat consumption, a previous publication showed that there was no difference between Tunisian migrants, local-born French and non-migrant Tunisians[16]. However, the percentage contribution of fats to energy intake has increased greatly in Tunisia in recent decades[41]. Migrants who were the most exposed to the current Tunisian context could conserve some dietary habits such as high consumption of olive oil. At the same time, they also could adapt other habits (high fat consumption) alongside the change in eating patterns in their home country.

A feature of our study was the confounding effect between the ‘acculturation’ and ‘exposure to social norms of the home country’ proxies (length of residence, age at migration and social ties with the home country) on dietary characteristics and physical activity. In fact, these three exposure variables were associated with each other (Table 5). Social ties with the home country and length of residence were not fully independent concepts, given that for example the ‘language preference’ item in the index reflecting the current exposure to Tunisian context is also often used as a proxy for acculturation[42,43]. However, our results showed that the influence of acculturation on outcome variables was not really mediated by current exposure to Tunisian social norms and vice versa, indicating that these proxies were two concomitant but different dimensions that could influence lifestyles. On the other hand, age at migration had a strong confounding effect for the influence of acculturation on many dietary characteristics and physical activity level, whereas this variable only had an independent effect on Na intake. Concerning length of residence, we did find confounding effects for the influence of age at migration on outcome variables and also independent effects of this proxy variable for several dietary variables. Thus, past exposure to the Tunisian context could influence dietary characteristics through acculturation in the new environment.

As for the specific characteristics of the present study, concerning potential selection bias the non-random nature of the sample may be an issue, but the quota sampling strategy was the only possible solution among migrant populations in France. In addition, the sample size was originally calculated for other purposes, i.e. to compare Tunisian migrants with two non-migrant groups and not to make comparisons within the group of migrants. Also, the cross-sectional study design classically precludes the strict inference of causality regarding the relationship between acculturation and lifestyle changes, which would be better assessed by a longitudinal design[9]. Furthermore, data collected using FFQ are not as accurate as data gathered using precise recall methods. However, our aim was not to make a comprehensive assessment of dietary intake. Rather, we were mainly interested in comparing the different groups according to length of residence, age at migration and social ties with Tunisia.

In conclusion, Tunisian migrants adopted some French eating habits while maintaining traditional Tunisian eating habits, rather than rejecting either one of them. The present study supports the view that a greater degree of acculturation can lead to a convergence of eating patterns to those of the host population. In addition, our study indicates that past and current exposure to Tunisian socio-cultural norms likely enabled the maintenance of positive aspects of the traditional Tunisian diet (low Na intake and high MUFA:SFA ratio). Thus, our study

Table 5 Relationships between length of residence, age at migration and social ties with the home country: Tunisian migrants, South of France, 2004

	Social ties with the home country				Age at migration			
	Distant (%)	Moderate (%)	Close (%)	*P* value	≤20 years (%)	21–30 years (%)	≥30 years (%)	*P* value
Length of residence								
≤9 years	61·3	22·6	16·1	0·003	9·7	38·7	51·6	0·008
10–29 years	28·2	31·0	40·8		28·2	35·2	36·6	
≥30 years	22·2	44·4	33·4		22·2	60·0	17·8	
Age at migration								
≤20 years	48·5	30·3	21·2	0·007				
21–30 years	34·4	40·6	25·0					
≥30 years	22·0	26·0	52·0					

emphasises the benefit for dietary patterns of preserving food traditions from the country of origin, particularly a traditional Mediterranean diet which has been associated with greater longevity and reduced mortality and morbidity for CHD and certain cancers[44].

However, along with the rapid nutritional transition in Tunisia[18], these positive aspects could disappear. Indeed, our findings highlighted the fact that, depending on the degree of their current exposure to their home country, Tunisian migrants may modify their traditional diet alongside dietary changes currently underway in Tunisia (fat consumption).

Our work thus suggests that preserving and improving food traditions from the home country and supporting a lifestyle that includes sufficient physical activity should be considered in the development of health promotion activities relating to North African migrant men in France.

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Authors' contributions: C.M. designed the study, carried out the surveys, performed the statistical analysis and drafted the manuscript. P.T. supervised the statistical analysis and participated in drafting the manuscript. S.E.-D. performed data management and statistical analyses and participated in drafting the manuscript. F.D. was involved in drafting the manuscript and gave his expert comments and suggestions to improve it. B.M. was involved in the conception and design of the study, in the interpretation of data and helped draft the manuscript. All authors have read and approved the final manuscript.

References

1. Kim S & Popkin BM (2006) Commentary: understanding the epidemiology of overweight and obesity – a real global public health concern. *Int J Epidemiol* **35**, 60–67.
2. Popkin BM (2001) The nutrition transition and obesity in the developing world. *J Nutr* **131**, 871S–873S.
3. Neuhouser ML, Thompson B, Coronado GD & Solomon CC (2004) Higher fat intake and lower fruit and vegetables intakes are associated with greater acculturation among Mexicans living in Washington State. *J Am Diet Assoc* **104**, 51–57.
4. Cardoso MA, Hamada GS, de Souza JM, Tsugane S & Tokudome S (1997) Dietary patterns in Japanese migrants to southeastern Brazil and their descendants. *J Epidemiol* **7**, 198–204.
5. Mennen LI, Jackson M, Sharma S *et al.* (2001) Habitual diet in four populations of African origin: a descriptive paper on nutrient intakes in rural and urban Cameroon, Jamaica and Caribbean migrants in Britain. *Public Health Nutr* **4**, 765–772.
6. Anderson AS, Bush H, Lean M, Bradby H, Williams R & Lea E (2005) Evolution of atherogenic diets in South Asian and Italian women after migration to a higher risk region. *J Hum Nutr Diet* **18**, 33–43.
7. Misra A & Ganda OP (2007) Migration and its impact on adiposity and type 2 diabetes. *Nutrition* **23**, 696–708.
8. Abraido-Lanza AF, Armbrister AN, Florez KR & Aguirre AN (2006) Toward a theory-driven model of acculturation in public health research. *Am J Public Health* **96**, 1342–1346.
9. Perez-Escamilla R & Putnik P (2007) The role of acculturation in nutrition, lifestyle, and incidence of type 2 diabetes among Latinos. *J Nutr* **137**, 860–870.
10. Bermudez OI, Falcon LM & Tucker KL (2000) Intake and food sources of macronutrients among older Hispanic adults: association with ethnicity, acculturation, and length of residence in the United States. *J Am Diet Assoc* **100**, 665–673.
11. Lv N & Cason KL (2004) Dietary pattern change and acculturation of Chinese Americans in Pennsylvania. *J Am Diet Assoc* **104**, 771–778.
12. Yang EJ, Chung HK, Kim WY, Bianchi L & Song WO (2007) Chronic diseases and dietary changes in relation to Korean Americans' length of residence in the United States. *J Am Diet Assoc* **107**, 942–950.
13. Parkin DM & Khlat M (1996) Studies of cancer in migrants: rationale and methodology. *Eur J Cancer* **32A**, 761–771.
14. Wanner P, Khlat M & Bouchardy C (1995) [Life style and health behavior of southern European and North African immigrants in France]. *Rev Epidemiol Sante Publique* **43**, 548–559.
15. Darmon N & Khlat M (2001) An overview of the health status of migrants in France, in relation to their dietary practices. *Public Health Nutr* **4**, 163–172.
16. Mejean C, Traissac P, Eymard-Duvernay S, El Ati J, Delpeuch F & Maire B (2007) Diet quality of North African migrants in France partly explains their lower prevalence of diet-related chronic conditions relative to their native French peers. *J Nutr* **137**, 2106–2113.
17. Mejean C, Traissac P, Eymard-Duvernay S, El Ati J, Delpeuch F & Maire B (2007) Influence of socio-economic and lifestyle factors on overweight and nutrition-related diseases among Tunisian migrants versus non-migrant Tunisians and French. *BMC Public Health* **7**, 265.
18. Mokhtar N, Elati J, Chabir R, Bour A, Elkari K, Schlossman NP, Caballero B & Aguenaou H (2001) Diet culture and obesity in northern Africa. *J Nutr* **31**, 887S–892S.
19. Bouguerra R, Alberti H, Salem LB, Rayana CB, Atti JE, Gaigi S, Slama CB, Zouari B & Alberti K (2007) The global diabetes pandemic: the Tunisian experience. *Eur J Clin Nutr* **61**, 160–165.
20. Traissac P, Delpeuch F, Maire B & Martin-Prével Y (1997) [Construction of a summary economic index of the household in nutritional surveys. Examples of practical applications in Congo] (abstract). *Rev Epidemiol Sante Publique* **45**, 114–115.
21. Martin-Prevel Y, Traissac P, Delpeuch F & Maire B (2001) Decreased attendance at routine health activities mediates deterioration in nutritional status of young African children under worsening socioeconomic conditions. *Int J Epidemiol* **30**, 493–500.

22. Daures JP, Gerber M, Scali J, Astre C, Bonifacj C & Kaaks R (2000) Validation of a food-frequency questionnaire using multiple-day records and biochemical markers: application of the triads method. *J Epidemiol Biostat* **5**, 109–115.
23. US Department of Agriculture, Agricultural Research Service (2006) USDA National Nutrient Database for Standard Reference Release 19. http://www.ars.usda.gov/Services/docs.htm?docid=8964 (accessed October 2007).
24. Favier JC, Ireland-Ripert J, Toque C & Feinberg M (1995) *Répertoire général des aliments – Tables de composition REGAL (REGAL Food Composition Table).* Paris: Lavoisier.
25. Ainsworth BE, Haskell WL, Whitt MC *et al*. (2000) Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc* **32**, S498–S504.
26. Henry CJ (2005) Basal metabolic rate studies in humans: measurement and development of new equations. *Public Health Nutr* **8**, 1133–1152.
27. Becher H (1992) The concept of residual confounding in regression models and some applications. *Stat Med* **11**, 1747–1758.
28. Andreeva VA, Unger JB & Pentz MA (2007) Breast cancer among immigrants: a systematic review and new research directions. *J Immigr Minor Health* **9**, 307–322.
29. Jaber LA, Brown MB, Hammad A, Zhu Q & Herman WH (2003) Lack of acculturation is a risk factor for diabetes in Arab immigrants in the US. *Diabetes Care* **26**, 2010–2014.
30. Evenson KR, Sarmiento OL & Ayala GX (2004) Acculturation and physical activity among North Carolina Latina immigrants. *Soc Sci Med* **59**, 2509–2522.
31. Wilkinson AV, Spitz MR, Strom SS, Prokhorov AV, Barcenas CH, Cao Y, Saunders KC & Bondy ML (2005) Effects of nativity, age at migration, and acculturation on smoking among adult Houston residents of Mexican descent. *Am J Public Health* **95**, 1043–1049.
32. Nicolaou M, van Dam RM & Stronks K (2006) Acculturation and education level in relation to quality of the diet: a study of Surinamese South Asian and Afro-Caribbean residents of the Netherlands. *J Hum Nutr Diet* **19**, 383–393.
33. Hosper K, Nierkens V, Nicolaou M & Stronks K (2007) Behavioural risk factors in two generations of non-Western migrants: do trends converge towards the host population? *Eur J Epidemiol* **22**, 163–172.
34. Volatier J (2000) *Enquête INCA individuelle et nationale sur les consommations alimentaires (INCA National Food Survey).* Paris: Lavoisier.
35. Hara H, Egusa G & Yamakido M (1996) Incidence of non-insulin-dependent diabetes mellitus and its risk factors in Japanese-Americans living in Hawaii and Los Angeles. *Diabet Med* **13**, S133–S142.
36. Kim J & Chan MM (2004) Acculturation and dietary habits of Korean Americans. *Br J Nutr* **91**, 469–478.
37. Montoya P, Torres A & Torija E (2001) [The feeding of the Moroccan immigrants of the community of Madrid: factors that influence the selection of foods]. *Atencion Primaria* **27**, 264–270.
38. Gilbert PA & Khokhar S (2008) Changing dietary habits of ethnic groups in Europe and implications for health. *Nutr Rev* **66**, 203–215.
39. Pietinen P, Valsta LM, Hirvonen T & Sinkko H (2008) Labelling the salt content in foods: a useful tool in reducing sodium intake in Finland. *Public Health Nutr* **11**, 335–340.
40. Garcia-Closas R, Berenguer A & Gonzalez CA (2006) Changes in food supply in Mediterranean countries from 1961 to 2001. *Public Health Nutr* **9**, 53–60.
41. Ben Hamida A, Fakhfakh R, Miladi W, Zouari B & Nacef T (2005) [Health transition in Tunisia over the past 50 years]. *East Mediterr Health J* **11**, 181–191.
42. Satia-Abouta J, Patterson RE, Neuhouser ML & Elder J (2002) Dietary acculturation: applications to nutrition research and dietetics. *J Am Diet Assoc* **102**, 1105–1118.
43. Lin H, Bermudez OI & Tucker KL (2003) Dietary patterns of Hispanic elders are associated with acculturation and obesity. *J Nutr* **133**, 3651–3657.
44. Serra-Majem L, Roman B & Estruch R (2006) Scientific evidence of interventions using the Mediterranean diet: a systematic review. *Nutr Rev* **64**, S27–S47.