Public Health Nutrition: 18(18), 3337–3348 doi:10.1017/S1368980015000634

Adherence to the World Cancer Research Fund/American Institute for Cancer Research cancer prevention recommendations and breast cancer risk in the Cancer de Màma (CAMA) study

Anouar Fanidi[1], Pietro Ferrari[1], Carine Biessy[1], Carolina Ortega[2], Angélica Angeles-Llerenas[2], Gabriella Torres-Mejia[2] and Isabelle Romieu[1,*]

[1]Nutrition and Metabolism Section, International Agency for Research on Cancer (IARC), 150 cours Albert Thomas, F-69372 Lyon Cedex 08, France: [2]Instituto Nacional de Salud Publica, Cuernavaca, Mexico

Submitted 31 January 2013: Final revision received 8 October 2014: Accepted 23 January 2015: First published online 25 March 2015

Abstract

Objective: We investigated the association between adherence to the recommendations of the World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR) and breast cancer (BC) risk in the Cancer de Màma (CAMA) study in a Mexican population.

Design: Population-based case–control study.

Subjects: Incident BC cases (*n* 1000) and controls (*n* 1074) matched on age, region and health-care system were recruited.

Setting: In-person interviews were conducted to assess BC risk factors and habitual diet was assessed with an FFQ. Conformity to the WCRF/AICR recommendations was evaluated through a score incorporating seven WCRF/AICR components (body fatness, physical activity, foods and drinks that promote weight gain, plant foods, animal foods, alcoholic drinks and breast-feeding), with high scores indicating adherence to the WCRF/AICR recommendations.

Results: No statistically significant associations between WCRF/AICR score and risk of BC were observed. After excluding BMI from the WCRF/AICR score, the top quartile was associated with a decreased BC risk overall, with $OR_{Q4–Q1} = 0{\cdot}68$ (95 % CI 0·49, 0·92, $P_{trend} = 0{\cdot}03$), and among postmenopausal women, with $OR_{Q4–Q1} = 0{\cdot}60$ (95 % CI 0·39, 0·94, $P_{trend} = 0{\cdot}03$). Inverse associations were observed between BMI and risk of BC overall and among premenopausal women, with OR = 0·57 (95 % CI 0·42, 0·76, $P_{trend} < 0{\cdot}01$) and 0·48 (95 % CI 0·31, 0·73, $P_{trend} < 0{\cdot}01$), respectively. Physical activity level was inversely associated with BC risk.

Conclusions: The WCRF/AICR index was not related with BC risk in the CAMA study. A combination of six components excluding BMI showed strong protective associations, particularly in postmenopausal women. Further prospective studies are required to clarify the role of adherence to WCRF/AICR recommendations, particularly with respect to BMI, in the Mexican population.

Keywords
Breast cancer
Diet
Physical activity
Weight management
Mexican women

Breast cancer (BC) is the leading cause of cancer death in women worldwide[1]. In Western countries, age-standardized incidence rates range between 56·8 and 109·4 per 100 000 women, while lower rates are observed in Asia, Central America and sub-Saharan Africa[2]. Among Mexican women, the age-standardized incidence rate is 26·4 per 100 000 women[3].

Multiple risk factors for BC such as family history, obesity, lactation, adult attained height, and menstrual and reproductive history are well established but are generally difficult to modify[3–7]. A substantial amount of research has explored the influence of modifiable dietary risk factors on BC risk[8–13]. Several foods as well as macro- and micronutrients (e.g. vegetables, dietary fibre and vitamins) have been investigated in relation to BC risk[11,14,15], although no consistent and statistically significant associations have been established. One convincing exception is for alcohol consumption[16].

Most epidemiological studies on diet and cancer have largely been on intakes of individual food items or nutrients[17,18]. This approach, however, does not fully take into account the complexity of human diets, in terms

*Corresponding author: Email romieui@iarc.fr

of the large number of foods consumed by individuals, as well as the inter-correlation between those foods[19]. There has been an increasing interest towards dietary patterns, rather than individual foods, as a way to investigate the aetiology of BC[20–22]. A valuable alternative was constituted by *a priori* scores, defined on dietary guidelines and recommendations. The Healthy Eating Index (HEI), the Diet Quality Index (DQI) and the Recommended Food Score (RFS) are recent examples, but have little or no association with BC risk and/or mortality[21,23,24]. More robust evidence with BC risk and mortality was produced by using scores integrating dietary components with other lifestyle factors such as body fatness, physical activity, alcohol consumption and/or smoking habits[25–27].

In 2007, the World Cancer Research Fund (WCRF) in collaboration with the American Institute for Cancer Research (AICR) summarized the existing scientific evidence on the role of foods, nutrition and physical activity in the aetiology of cancer[4]. Accordingly, a list of recommendations (eight general and two special) on diet, physical activity and weight management were developed in order to reduce the incidence of cancer in the general population.

In the present study, we evaluated the association between the WCRF/AICR recommendations and the risk of BC in a case–control study of Mexican women within the Cancer de Màma (CAMA) study, overall and by menopausal status.

Materials and methods

Study population

CAMA recruitment procedures have been described in detail previously[28]. In brief, 1000 cases and 1074 controls, pre- and postmenopausal women aged 35–69 years, were recruited between January 2004 and December 2007 from three regions in Mexico and their surrounding metropolitan areas (Mexico City, Monterrey and Veracruz). Participants were resident from one of these regions during at least 5 years prior to recruitment in the study. Cases were identified by trained field staff at twelve hospitals from major health-care institutions in Mexico: the Mexican Institute of Social Security (Instituto Mexicano del Seguro Social (IMSS), six hospitals), the Social Security and Services Institute for State Employees (Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado (ISSSTE), two hospitals) and the Ministry of Health (Secretarıade Salud (SS), four hospitals). Inclusion criteria included: (i) patients with a new histologically confirmed diagnosis of BC, regardless of the stage of disease; (ii) patients with no previous treatment such as radiotherapy, chemotherapy or anti-oestrogens such as tamoxifen during the previous 6 months; (iii) patients who were not taking Aromasin® (exemestane), Femara® (letrozole), Arimidex® (anastrozole) or Megace® (megestrol) at the time of the study; and (iv) patients who were not pregnant. Cases known to be HIV-positive (n 1) were excluded from the study. After excluding *in situ* cases (n 20), 980 cases were eligible.

Control subjects were randomly selected by multiple-step random sampling and were frequency-matched to cases according to 5-year age groups, health-care institution and region. The response rate for controls was 87·4 % for Mexico City, 90·1 % for Monterrey and 97·6 % for Veracruz. The study personnel visited the selected households and determined willingness to participate in the study and conducted a face-to-face interview. Finally, an appointment was scheduled for each woman to attend the hospital for anthropometric measurements, mammography and a blood sample. A total of 1074 eligible controls were identified. Natural menopause was defined as twelve consecutive months of amenorrhoea without an obvious cause[29,30].

Ethics statement

Cases and controls provided written informed consent to participate in the study. The study protocol and data collection instruments were reviewed and approved by the Institutional Review Board at the National Institute of Public Health.

Data collection and dietary questionnaire

A trained interviewer administered a questionnaire to each selected participant to collect information on her health, physical activity and diet. The health questionnaire collected data on sociodemographic characteristics; reproductive factors (e.g. age at menarche and menopause, number of full-term pregnancies, pregnancy outcomes, breast-feeding, menopausal status); use of oral contraceptives and hormone replacement therapy; family and individual history of chronic diseases (e.g. hypertension, diabetes mellitus, BC); personal history of sexually transmitted diseases; history of body size, smoking, alcohol consumption; and history of X-ray and mammographic studies.

Information on dietary habits was obtained through questions on food consumption during the 12 months preceding the symptoms (for BC cases) or the recruitment (for controls), using a semi-quantitative FFQ adapted from the Nurses' Health Study[19] for the Mexican population and validated in Mexico City[31,32]. The FFQ included 104 items and ten multiple-choice frequency categories of consumption: '6 or more per day', '4–5 per day', '2–3 per day', '1 per day', '5–6 per week', '2–4 per week', '1 per week', '1–3 per month', 'less than 1 per month' and 'never'. For each food item, the nutrient content per average unit (specified serving size: slice, glass or natural unit) was compiled[33] and women were asked how often they had consumed an amount of each food on average over the previous year. Nutrient intakes were computed

by multiplying the frequency response by the nutrient content of specified portion sizes using Microsoft® Office Access 2007. The database for calculating the nutrient intake took advantage of information from the US Department of Agriculture food composition tables[33] and it was complemented, when necessary, with a nutrient database developed by the National Institute of Nutrition in Mexico[34].

To assess physical activity within the last 12 months, a semi-structured interview-based questionnaire was used to assess individuals' time spent in physical activity (light-, moderate- and vigorous-intensity, as well as sleep) during a regular week. The questionnaire was based on the 7 d recall questionnaire proposed by Sallis *et al.*[35].

World Cancer Research Fund/American Institute for Cancer Research score composition

An index score reflecting adherence to the WCRF/AICR recommendations for cancer prevention was constructed; hereafter referred to as the 'WCRF/AICR score'. Out of ten recommendations (components), the following seven were retained to determine the score in women[36]: body fatness, physical activity, intake of foods and drinks that promote weight gain, intake of plant foods, intake of animal foods, consumption of alcoholic drinks and breast-feeding in women. Information on the construction of the score is detailed below in Table 2.

The score was designed on recent work evaluating the association between WCRF/AICR guidelines and cancer risk in the European Prospective Investigation into Cancer (EPIC) cohort[26]. The score was constructed using quantitative criteria supplied in the WCRF/AICR recommendations. Briefly, for each component, 1 point was assigned when the recommendation was met, 0·5 points when it was partially met and 0 points otherwise. In some cases, arbitrary *a priori* cut-off values were defined for intermediate categories, not based on the distribution of a given variable in our study. For the recommendations including several sub-recommendations (foods and drinks that promote weight gain and plant foods), the final score was the average of each sub-recommendation score. Three recommendations were not implemented in the present work: (i) the recommendation on preservation, processing and preparation of foods because insufficient data were available; (ii) the recommendation on dietary supplements which could not be operationalized in terms of cancer prevention without further assumptions about type or dose of supplementation; and (iii) the special recommendation related to cancer survivors which was outside the scope of the present study. As the WCRF/AICR recommendations were not ranked according to priority, all major recommendations were summed to contribute equally to the total WCRF/AICR score. Therefore, the total WCRF/AICR score ranged from 0 to 7 in the present study, with higher scores indicating greater adherence to the WCRF/AICR recommendations.

Statistical analyses

The *t* test was used to assess differences between cases and controls for continuous variables, i.e. height, weight, waist circumference, waist-to-hip ratio, BMI, age at menarche, age at first pregnancy, number of births, energy intake, breast-feeding, alcohol consumption and physical activity. A χ^2 test was used to test for differences between cases and controls for categorical variables, including socio-economic status, family history of BC, history of fibrocystic disease, use of oral contraceptives, use of hormone therapy, education, smoking and marital status. To estimate the association between the WCRF/AICR score and the risk of BC, conditional logistic regression models were used to compute odds ratios and associated 95 % confidence intervals.

Matching accounted for age category, health-care system and region (model 1). Confounding factors were then included in the model (model 2), i.e. family history of BC (yes/no), age at menarche, age at first pregnancy, parity (number of children born alive), socio-economic status (lower, middle and upper), hormone replacement therapy (yes/no) and total energy consumption (kcal/d). Smoking status and use of oral contraceptive were not included in the different models because their inclusion in the statistical model did not change the results. Analyses were carried out for all women, and separately among pre- and postmenopausal women.

The score was categorized into quartiles based on the distribution of controls. The lowest quartile (from 0 to 3·25 points) was considered as the reference.

Also, the association of each component of the WCRF/AICR recommendations was evaluated in models mutually adjusted for all other components of the score. Tests for trends were computed using a continuous variable with values from 0 to 7 and *P* values were determined (P_{trend}). Throughout the work, $P < 0{\cdot}05$ was considered statistically significant. All analyses were conducted using the statistical software package SAS version 9·2.

Results

Postmenopausal women represented 59 % and 56 % of cases and controls, respectively, as displayed in Table 1. The response rate in control women was high in the three regions (87 %, 90 % and 97 % in Mexico City, Monterrey and Veracruz, respectively). Cases and controls were similar with respect to the frequency of ever smoking, ever use of oral contraceptives and age at menarche. Compared with controls, cases displayed lower BMI values (29·3 kg/m^2 *v.* 30·5 kg/m^2, $P < 0{\cdot}01$), were more likely to have a family history of BC (6 % *v.* 4 %, $P = 0{\cdot}01$), had on average fewer children and were more likely to have children later in life.

The different components of the WCRF/AICR score are described in Table 2. Compared with controls, cases

Table 1 Clinical characteristics of the study participants: women aged 35–69 years, incident BC cases and controls matched on age, region and health-care system, CAMA study, Mexico, January 2004–December 2007

	Cases (*n* 980)		Controls (*n* 1074)		
Categorical variables	*n*	%	*n*	%	*P* value*
Menopausal status					0·19
Premenopausal	405	41	476	44	
Postmenopausal	575	59	598	56	
Socio-economic level					<0·01
Lower	304	31	359	34	
Middle	253	26	357	33	
Upper	423	43	358	33	
Education					0·49
Neither	65	7	90	9	
Primary	70	7	75	7	
Secondary	581	59	615	57	
>Secondary	263	27	294	27	
Marital status					<0·01
Married/living with a partner	613	61	732	68	
Separated or divorced	154	15	125	12	
Widow	107	11	125	12	
Single	126	13	92	8	
Parity					<0·01
Nulliparous	113	12	67	6	
1–2 children	331	34	304	28	
3–4 children	344	35	384	36	
≥5 children	186	19	316	30	
Smoking status					0·03
Ever	242	25	226	21	
Never	732	75	843	79	
Family history of BC					<0·01
No	920	94	1034	96	
Yes	60	6	40	4	
History of fibrocystic disease					<0·01
No	820	84	980	91	
Yes	148	15	83	8	
Unknown	12	1	11	1	
Ever use of oral contraceptives					0·98
No	539	55	594	55	
Yes	438	45	480	45	
Ever use of hormone therapy					<0·01
No	822	85	965	90	
Yes	149	15	106	10	
Alcohol intake†					<0·01
Drinker	322	33	254	24	
Non-drinker	648	67	819	76	
Continuous variables	Mean	P10–P90	Mean	P10–P90	*P* value*
Age (years)	52	39·1–65·8	51	39·2–65·3	0·01
BMI (kg/m^2)	29·3	23·5–36·0	30·5	24·5–37·5	<0·01
Waist-to-hip ratio	0·90	0·82–0·98	0·91	0·83–0·99	0·02
Waist circumference	96·3	82–111	99·4	85–116	<0·01
Age at menarche (years)	12·8	11·0–15·0	12·8	11·0–15·0	0·31
Age at first pregnancy (years)	22·9	17·0–22·0	21·3	16·0–20·0	<0·01
Cumulative lactation (months)‡	25·1	0–66	31·8	0–70	<0·01
Energy intake (kJ/d)	9244	5807–13 239	8110	5066–11 702	<0·01
Energy intake (kcal/d)	2208	1387–3162	1937	1210–2795	<0·01
Physical activity (MET h/week)§	107·9	96·0–119·0	106·2	95·0–118·0	<0·01

BC, breast cancer; CAMA, Cancer de Màma; MET, metabolic equivalent of task; P10–P90, 10th–90th percentile.
*From χ^2 test for categorical variables and *t* test for continuous variables.
†Median (interquartile range) among drinkers (330 cases and 254 controls).
‡Among parous women.
§Estimated from 7 d activity diary that queried all activities (working and leisure).

displayed a lower frequency of high physical activity (43 % *v.* 61 %) and of breast-feeding for longer than 6 months (64 % *v.* 74 %), but higher frequency of 'fruits and vegetables' intake larger than 600 g/d (63 % *v.* 48 %) and of 'dietary fibre' intake larger than 25 g/d (62 % *v.* 45 %).

After controlling for confounding factors, the WCRF/AICR score was not associated with risk of BC overall or by menopausal status, with OR comparing the score in the top *v.* bottom quartile ($OR_{Q4–Q1}$) equal to 1·17 (95 % CI 0·75, 1·82, $P_{trend} = 0·26$) and 0·97 (95 % CI 0·64, 1·46,

Table 2 WCRF/AICR recommendations for cancer prevention and operationalization of the WCRF/AICR score in the CAMA study

				Cases (*n* 980)		Controls (*n* 1074)		Overall (*n* 2054)	
WCRF/AICR recommendations	Personal recommendations	Operationalization†	Scoring	*n*	%	*n*	%	*n*	%
1. Body fatness: Be as lean as possible without becoming underweight	1a. Ensure that body weight through childhood and adolescent growth projects towards the lower end of the normal BMI range at age 21	Insufficient data available	NA						
	1b. Maintain body weight within the normal range from age 21	BMI = 18·5–24·9 kg/m^2	1	181	19	144	13	325	16
		BMI = 25–29·9 kg/m^2	0·5	411	43	413	39	824	41
		BMI ≥ 30·0 kg/m^2	0	363	38	505	48	868	43
	1c. Avoid weight gain and increases in waist circumference throughout adulthood	Insufficient data available	NA						
2. Physical activity: Be physically active as part of your everyday life*	2a. Be moderately physically active, equivalent to brisk walking, for at least 30 min every day	Insufficient data available	NA						
	2b. As fitness improves, aim for 60 min or more of moderate PA or for 30 min or more of vigorous PA every day	Moderate PA: ≥ 35 (MET h/week)	1	419	43	652	61	1071	52
		Moderate PA: 17·5–34·9 (MET h/week)	0·5	208	21	119	11	327	16
		Moderate PA: 0–17·4 (MET h/week)	0	352	36	303	28	655	32
	2c. Limit sedentary habits such as watching television	Insufficient data available	NA						
3. Foods and drinks that promote weight gain: Limit consumption of ED foods, avoid sugary drinks†	3a. Consume ED foods sparingly	ED: 0–124·9 kcal/100 g per d	1	18	2	5	1	23	1
		ED: 125–225 kcal/100 g per d	0·5	476	49	443	41	919	45
		ED: > 225 kcal/100 g per d	0	472	49	623	58	1095	54
	3b. Avoid sugary drinks	Sugary drink intake: 0 g/d	1	10	1	13	1	23	1
		Sugary drink intake: ≤250 g/d	0·5	289	30	298	28	587	29
		Sugary drink intake: >250 g/d	0	671	69	762	71	1433	70
	3c. Consume fast foods sparingly, if at all	Insufficient data available							
4. Plants foods: Eat mostly foods of plant origin†	4a. Eat at least five portions/servings (at least 600 g) of a variety of non-starchy V&F every day	V&F intake: ≥600 g/d	1	606	63	507	48	1113	54
		V&F intake: 200–599 g/d	0·5	315	32	499	46	814	40
		V&F intake: <200 g/d	0	49	5	67	6	116	6
	4b. Eat relatively unprocessed cereals (grains) and/or pulses (legumes) with every meal	Dietary fibre intake: ≥25 g/d	1	599	62	490	45	1089	53
		Dietary fibre intake: 12·5–24·9 g/d	0·5	313	32	523	49	836	41
		Dietary fibre intake: 0–12·4 g/d	0	58	6	60	6	118	6
	4c. Limit refined starchy foods	Insufficient data available	NA						
	4d. People who consume starchy roots or tubers as staples should also ensure sufficient intake of non-starchy vegetables, fruits and pulses (legumes)	Not applicable to this population	NA						
5. Animal foods: Limit intake of RM and avoid PM	5a. People who eat RM to consume less than 500 g/week, very little if any to be processed	RM & PM <500 g/week and PM <3 g/d	1	217	22	194	18	411	20
		RM & PM <500 g/week and PM 3 to <50 g/d	0·5	639	66	749	70	1388	68
		RM & PM >500 g/week and PM ≥50 g/d	0	114	12	130	12	244	12

Table 2 *Continued*

WCRF/AICR recommendations	Personal recommendations	Operationalization†	Scoring	Cases (*n* 980)		Controls (*n* 1074)		Overall (*n* 2054)	
				n	%	*n*	%	*n*	%
6. Alcoholic drinks: Limit alcoholic drinks	6a. If alcoholic drinks are consumed, limit consumption to no more than two drinks a day for men and one drink a day for women	Alcohol intake: 0–10 g/d	1	939	97	1060	98	1999	98
		Alcohol intake: 10·1–20 g/d	0·5	17	2	7	1	24	1
		Alcohol intake: >20 g/d	0	14	1	6	1	20	1
7. Preservation, processing, preparation: Limit consumption of salt. Avoid mouldy cereals (grains) or pulses (legumes)	7a. Avoid salt-preserved, salted or salty foods; preserve foods without using salt	Insufficient data available	NA						
	7b. Limit consumption of processed foods with added salt to ensure an intake of less than 6 g (2·4 g Na)/d	Insufficient data available	NA						
	7c. Do not eat mouldy cereals (grains) or pulses (legumes)	Insufficient data available	NA						
8. Dietary supplements: Aim to meet nutritional needs through diet alone	8a. Dietary supplements are not recommended for cancer prevention	Not applicable to this population	NA						
WCRF/AICR special recommendations									
S1. Breast-feeding: Mothers to breast-feed; children need to be breast-fed	S1a. Aim to breast-feed infants exclusively up to 6 months and continue with complementary feeding thereafter	Cumulative breast-feeding: ≥6 months	1	629	64	796	74	1425	69
		Cumulative breast-feeding: <6 months	0·5	119	12	109	10	228	11
		Cumulative breast-feeding: 0 months	0	232	24	169	16	401	20
S2. Cancer survivors: Follow the recommendations for cancer prevention	S2a. All cancer survivors to receive nutritional care from an appropriately trained professional	Not applicable to this population							
	S2b. If able to do so, and unless otherwise advised, aim to follow the recommendations for diet, healthy weight and physical activity	Not applicable to this population							

WCRF/AICR, World Cancer Research Fund/American Institute for Cancer Research; CAMA, Cancer de Màma; ED, energy-dense; RM, red meat; PM, processed meat; PA, physical activity; V&F, vegetables and fruits; MET, metabolic equivalent of task; NA, not available.
*Using the moderate physical activity (MET h/week) that combines recreational and occupational activities.
†The score for recommendations 3 and 4 was the result of averaging the scores of each sub-recommendation (3a and 3b; 4a and 4b).
‡ED food was calculated as energy (kcal; 1 kcal = 4·1868 kJ) from foods (solids foods and semi-solid or liquid foods such as soups) divided by the weight (g) of these foods. Drinks (including water, tea, coffee, juice, soft drinks, alcoholic drinks and milk) were not included in the calculation[27]. Sugary drinks included both soft drinks and fruit and vegetable juices.

Table 3 Multivariate-adjusted odds ratios and 95 % confidence intervals between WCRF/AICR score and BC risk, overall and by menopausal status, among women aged 35–69 years, incident BC cases and controls matched on age, region and health-care system, CAMA study, Mexico, January 2004–December 2007

	Cases		Controls		Overall (*n* 936/1047)*		Premenopausal (*n* 387/468)*		Postmenopausal (*n* 549/579)*	
	n	%	*n*	%	OR	95 % CI	OR	95 % CI	OR	95 % CI
Model 1†										
Quartile 1	264	27	266	25	1·00	Reference	1·00	Reference	1·00	Reference
Quartile 2	315	33	354	33	0·87	0·69, 1·11	1·11	0·73, 1·66	0·81	0·59, 1·11
Quartile 3	200	20	233	22	0·80	0·61, 1·04	1·06	0·70, 1·59	0·63	0·45, 0·90
Quartile 4	199	20	221	20	0·84	0·65, 1·10	1·05	0·90, 1·24	0·72	0·50, 1·03
P_{trend}						0·03		0·52		0·003
Model 2‡										
Quartile 1	264	27	266	25	1·00	Reference	1·00	Reference	1·00	Reference
Quartile 2	315	33	354	33	1·04	0·81, 1·35	1·14	0·77, 1·68	0·99	0·69, 1·42
Quartile 3	200	20	233	22	1·05	0·78, 1·40	1·32	0·84, 2·06	0·91	0·61, 1·36
Quartile 4	199	20	221	20	1·04	0·78, 1·41	1·17	0·75, 1·82	0·97	0·64, 1·46
P_{trend}						0·96		0·26		0·39

WCRF/AICR, World Cancer Research Fund/American Institute for Cancer Research; BC, breast cancer; CAMA, Cancer de Màma.
*Frequencies of case and control participants, only includes participants from informative case sets.
†Assessed by analysing BC cases and their individual matched controls by conditional logistic regression, conditioning for matching factors (age, region and health-care institution).
‡Further adjusted for age at first pregnancy, number of full-term pregnancies, energy intake, socio-economic status, age at menarche, hormone therapy and family history of BC (no/yes).

$P_{trend} = 0·39$) in pre- and postmenopausal women, respectively (Table 3).

Sensitivity analyses were carried out by excluding, in turn, each component of the WCRF/AICR recommendations (Table 4) from the overall score. Notably, the exclusion of the BMI component resulted in a marked reduction of BC risk overall, with $OR_{Q4–Q1} = 0·68$ (95 % CI 0·49, 0·92, $P_{trend} = 0·03$), and among postmenopausal women, with $OR_{Q4–Q1} = 0·60$ (95 % CI 0·39, 0·94, $P_{trend} = 0·03$). Two individual components were significantly associated with BC risk, as shown in Table 5. An inverse association was observed between BMI and risk of BC, with OR comparing obese *v.* normal-weight women equal to 0·57 (95 % CI 0·42, 0·76, $P_{trend} < 0·01$) and 0·48 (95 % CI 0·31, 0·73, $P_{trend} < 0·01$) overall and among premenopausal women, respectively. Women with high physical activity levels (≥35 MET h/week) compared with low physical activity (≤17·5 MET h/week; MET = metabolic equivalent of task) displayed OR equal to 0·61 (95 % CI 0·49, 0·76, $P_{trend} < 0·01$) and 0·42 (95 % CI 0·31, 0·59, $P_{trend} < 0·01$) overall and among postmenopausal women, respectively.

Discussion

In a case–control study conducted in Mexico we observed that an index of adherence to the WCRF/AICR cancer prevention recommendations was not associated with the risk of BC. However, after excluding BMI, the WCRF/AICR score index was inversely associated with BC risk overall and among postmenopausal women, while a marginal effect was observed among premenopausal women.

Two prospective studies assessing the impact of the WCRF/AICR recommendations on BC have been published to date[26,37]. Within the EPIC cohort, women within the highest WCRF/AICR score were 16 % less likely to develop BC compared with those in the first category of the score (with a similar operationalization to our score) with hazard ratio equal to 0·84 (95 % CI 0·78, 0·90)[26]. The VITamins And Lifestyle (VITAL) study cohort found that postmenopausal women meeting at least five of the WCRF/AICR recommendations had 60 % lower BC risk (hazard ratio = 0·40; 95 % CI 0·25, 0·65) compared with women not meeting any recommendation[37]. A possible explanation is that in our study BMI was differentially associated with BC risk compared with the EPIC and VITAL cohorts. No major change in BC risk was observed in both EPIC and VITAL studies after excluding BMI from their respective index scores, indicating that BMI played only a partial role in the observed associations. Moreover, when physical activity was removed from the index, the WCRF/AICR score was associated with an increase in BC risk. We believe that the observed association might be due to the major role that BMI plays in the WCRF/AICR score related to BC risk.

In our study, when BMI was excluded from the WCRF/AICR score, a statistically significant inverse association between the WCRF/AICR score and BC risk was observed overall and among postmenopausal women. BMI was inversely associated with BC risk overall and among premenopausal women. A weak non-statistically significant decrease in BC risk was also observed among postmenopausal women. These findings are in contrast with positive relationships between BMI and BC risk consistently observed among postmenopausal women[38–41]

Table 4 Odds ratios and 95 % confidence intervals for BC risk according to WCRF/AICR score and after alternate subtraction of each of its components, overall and by menopausal status, among women aged 35–69 years, incident BC cases and controls matched on age, region and health-care system, CAMA study, Mexico, January 2004–December 2007

	Cases		Controls		Overall* (*n* 936/1047)†		Premenopausal* (*n* 387/468)†		Postmenopausal* (*n* 549/579)†	
	n	%	*n*	%	OR	95 % CI	OR	95 % CI	OR	95 % CI
WCRF/AICR‡										
Quartile 1	264	27	266	25	1·00	Reference	1·00	Reference	1·00	Reference
Quartile 2	315	33	354	33	1·04	0·81, 1·35	1·14	0·77, 1·68	0·99	0·69, 1·42
Quartile 3	200	20	233	22	1·05	0·78, 1·40	1·32	0·84, 2·06	0·91	0·61, 1·36
Quartile 4	199	20	221	20	1·04	0·78, 1·41	1·17	0·75, 1·82	0·97	0·64, 1·46
P_{trend}						0·96		0·26		0·39
WCRF/AICR – BMI§,‖										
Quartile 1	312	32	273	26	1·00	Reference	1·00	Reference	1·00	Reference
Quartile 2	321	33	379	35	0·85	0·66, 1·10	0·82	0·56, 1·21	0·84	0·58, 1·20
Quartile 3	217	22	249	23	0·84	0·63, 1·12	0·87	0·57, 1·33	0·77	0·52, 1·14
Quartile 4	121	13	173	16	0·68	0·49, 0·92	0·85	0·50, 1·44	0·60	0·39, 0·94
P_{trend}						0·03		0·51		0·03
WCRF/AICR – Physical activity§,¶										
Quartile 1	253	26	296	28	1·00	Reference	1·00	Reference	1·00	Reference
Quartile 2	208	21	307	29	0·92	0·70, 1·21	0·86	0·57, 1·29	0·98	0·66, 1·45
Quartile 3	251	26	263	24	1·27	0·96, 1·69	1·10	0·72, 1·69	1·46	0·98, 2·18
Quartile 4	267	27	208	19	1·74	1·29, 2·35	1·61	1·03, 2·53	1·97	1·29, 3·02
P_{trend}						<0·01		0·03		<0·01
WCRF/AICR – Foods that promote weight gain§										
Quartile 1	234	24	212	20	1·00	Reference	1·00	Reference	1·00	Reference
Quartile 2	255	36	402	37	0·93	0·71, 1·21	1·23	0·81, 1·86	0·78	0·54, 1·13
Quartile 3	205	21	251	23	0·92	0·68, 1·24	1·31	0·81, 2·11	0·73	0·49, 1·10
Quartile 4	186	19	209	20	0·92	0·67, 1·27	1·29	0·79, 2·10	0·71	0·46, 1·10
P_{trend}						0·67		0·21		0·09
WCRF/AICR – Plant foods§										
Quartile 1	254	26	245	23	1·00	Reference	1·00	Reference	1·00	Reference
Quartile 2	336	34	364	34	1·26	0·97, 1·64	1·68	1·12, 2·54	1·09	0·76, 1·57
Quartile 3	215	22	229	21	1·27	0·94, 1·71	1·72	1·09, 2·73	1·06	0·71, 1·58
Quartile 4	175	18	236	22	0·99	0·72, 1·35	1·12	0·69, 1·82	0·93	0·61, 1·43
P_{trend}						0·57		0·51		0·20
WCRF/AICR – Meat§										
Quartile 1	265	27	262	24	1·00	Reference	1·00	Reference	1·00	Reference
Quartile 2	331	34	369	34	1·06	0·82, 1·36	1·18	0·79, 1·75	1·02	0·72, 1·44
Quartile 3	213	22	265	25	0·90	0·68, 1·20	1·10	0·71, 1·72	0·81	0·55, 1·19
Quartile 4	171	17	178	17	1·02	0·75, 1·40	1·27	0·80, 2·03	0·86	0·56, 1·33
P_{trend}						0·34		0·51		0·08
WCRF/AICR – Alcohol§										
Quartile 1	253	26	262	25	1·00	Reference	1·00	Reference	1·00	Reference
Quartile 2	321	33	355	33	1·09	0·84, 1·41	1·21	0·82, 1·80	1·01	0·70, 1·45
Quartile 3	200	20	231	21	1·11	0·83, 1·49	1·38	0·88, 2·17	0·95	0·63, 1·42
Quartile 4	204	21	226	21	1·08	0·80, 1·46	1·30	0·83, 2·05	0·94	0·63, 1·43
P_{trend}						0·48		0·07		0·48
WCRF/AICR – Breast-feeding§,**										
Quartile 1	214	22	252	24	1·00	Reference	1·00	Reference	1·00	Reference
Quartile 2	224	23	273	25	1·01	0·76, 1·34	1·25	0·81, 1·92	0·87	0·60, 1·28
Quartile 3	270	27	277	26	1·17	0·89, 1·54	1·81	1·18, 2·78	0·84	0·58, 1·22
Quartile 4	271	28	272	25	1·15	0·87, 1·51	1·56	0·96, 2·41	0·94	0·65, 1·37
P_{trend}						0·49		0·11		0·52

WCRF/AICR, World Cancer Research Fund/American Institute for Cancer Research; BC, breast cancer; CAMA, Cancer de Màma.
*Assessed by analysing BC cases and their individual matched controls by conditional logistic regression, conditioning for matching factors (age, region and health-care institution) and adjusted for age at first pregnancy, number of full-term pregnancies, energy intake, socio-economic status, age at menarche, hormone therapy and family history of BC (no/yes).
†Frequencies of case and control participants, only includes participants from informative case sets.
‡Total WCRF/AICR score range: 0–7.
§The WCRF/AICR score minus one component ranged from 0 to 6.
‖Statistical model was further adjusted for BMI.
¶Statistical model was further adjusted for physical activity.
**Statistical model was further adjusted for breast-feeding.

and with inverse relationships among premenopausal women in Caucasian populations[39,42–44]. Few studies have investigated the association of BMI and BC risk in women from Hispanic origin and results have been conflicting[45–47]. While, in a case–control study, delays in ascertainment of cancer onset may possibly lead to an underestimation of habitual weight among cases, this is unlikely to explain our results given that BC does not

Table 5 Mutually adjusted odds ratios and 95 % confidence intervals for BC risk associated with the components of the WCRF/AICR score, overall and by menopausal status, among women aged 35–69 years, incident BC cases and controls matched on age, region and health-care system, CAMA study, Mexico, January 2004–December 2007

		Overall* (*n* 936/1047)†		Premenopausal* (*n* 387/468)†		Postmenopausal* (*n* 549/579)†	
WCRF/AICR score	Case/control participants	OR	95 % CI	OR	95 % CI	OR	95 % CI
BMI							
1	181/144	1·00	Reference	1·00	Reference	1·00	Reference
0·5	411/413	0·82	0·61, 1·09	0·75	0·50, 1·11	0·86	0·56, 1·31
0	363/505	0·57	0·42, 0·76	0·48	0·31, 0·73	0·67	0·42, 1·02
P_{trend}		<0·01		<0·01		0·10	
Physical activity							
1	419/652	0·61	0·49, 0·76	0·84	0·64, 1·17	0·42	0·31, 0·59
0·5	208/119	1·18	0·92, 1·66	1·47	0·98, 2·24	1·08	0·70, 1·59
0	352/303	1·00	Reference	1·00	Reference	1·00	Reference
P_{trend}		<0·01		0·01		<0·01	
Foods that promote weight gain							
1	0/0	–		–		–	
0·75	15/7	3·16	1·12, 8·76	2·59	0·51, 13·21	3·98	1·02, 13·63
0·5	156/140	1·32	0·92, 1·99	1·27	0·73, 2·21	1·34	0·89, 2·34
0·25	466/476	1·17	0·89, 1·56	1·08	0·78, 1·51	1·24	0·87, 1·92
0	333/450	1·00	Reference	1·00	Reference	1·00	Reference
P_{trend}		0·10		0·24		0·03	
Plant foods							
1	506/386	1·00	Reference	1·00	Reference	1·00	Reference
0·75	184/220	0·80	0·60, 1·05	0·80	0·53, 1·22	0·77	0·53, 1·13
0·5	208/372	0·75	0·53, 1·02	0·74	0·48, 1·12	0·69	0·47, 1·04
0·25	46/68	1·01	0·60, 1·68	0·75	0·33, 1·68	1·21	0·60, 2·44
0	26/27	1·37	0·67, 2·78	1·34	0·44, 4·04	1·64	0·62, 4·36
P_{trend}		0·25		0·33		0·69	
Red and processed meat							
1	217/194	1·00	Reference	1·00	Reference	1·00	Reference
0·5	639/749	0·67	0·52, 0·87	0·63	0·39, 1·01	0·68	0·50, 0·94
0	114/130	0·57	0·38, 0·85	0·54	0·29, 1·00	0·58	0·33, 1·02
P_{trend}		0·40		0·57		0·35	
Alcohol intake							
1	939/1060	1·00	Reference	1·00	Reference	1·00	Reference
0·5	17/7	1·18	0·46, 3·01	1·24	0·27, 5·63	1·17	0·34, 4·03
0	14/6	1·33	0·44, 4·01	4·45	0·5, 39·89	0·63	0·16, 2·42
P_{trend}		0·16		0·10		0·99	
Breast-feeding							
1	629/796	1·00	Reference	1·00	Reference	1·00	Reference
0·5	119/109	1·16	0·84, 1·61	1·43	0·90, 2·27	0·96	0·6, 1·53
0	232/169	1·12	0·8, 1·57	1·14	0·68, 1·92	1·06	0·66, 1·7
P_{trend}		0·27		0·67		0·35	

WCRF/AICR, World Cancer Research Fund/American Institute for Cancer Research; BC, breast cancer; CAMA, Cancer de Màma.
*Assessed by analysing BC cases and their individual matched controls by conditional logistic regression, conditioning for matching factors (age, region and health-care institution) and adjusted for age at first pregnancy, number of full-term pregnancies, energy intake, socio-economic status, age at menarche, hormone therapy, family history of BC (no/yes) and all the other WCRF/AICR components simultaneously.
†Frequencies of case and control participants, only includes participants from informative case sets.

usually lead to loss of weight and that only incident cases were included in the study. The lack of positive association between BMI and BC among postmenopausal women, which has been observed in many studies conducted among Caucasian populations, might be explained by the different fat distribution of Hispanic women[48].

Studies in the USA show that American women of African or Hispanic origin are more likely to be obese than Caucasian women[49]. In our Mexican study population, 85 % of women were overweight or obese, whereas in the EPIC and VITAL cohorts, the frequencies were 61 % and 52 %, respectively[26,37]. This observation may suggest that the thresholds of BMI customarily used to identify normal-weight, overweight and obese individuals may not adapt to populations other than in Europe and North America[50,51]. A WHO expert consultation addressed this issue in Asian populations and considered whether population-specific cut-off points for BMI were necessary[52]. To the best of our knowledge, there is no similar debate around Latin American populations. Therefore, adaptation of the WCRF/AICR recommendations outside Caucasian populations may need to consider other markers of adiposity or weight gain.

Several studies have shown that regular physical activity is beneficial to control weight and may also decrease the risk of some types of cancer, including BC[53–56]. Recently, moderate-intensity physical activity for 3 h/week was associated with a lower risk of BC in both pre- and

postmenopausal women, also suggesting differential associations with respect to menopausal status[57]. Other recent epidemiological studies have shown that BC risk reduction in relation to physical activity was greater in post- than in premenopausal women[55,57–60]. In our study, high physical activity was heterogeneously associated with BC risk compared with low physical activity level, with a 16 % and 58 % BC risk reduction among pre- and postmenopausal women, respectively. These results call for further investigation on the role of lack of physical activity as a risk factor in Latin American populations, possibly using prospective cohort studies.

Several limitations of the present study should be considered in interpreting our findings. Recall bias is a source of misclassification in case–control studies assessing diet through self-reported questionnaire measurements, possibly differentially expressed among cases and controls. However, interviewing women close to the time of diagnosis may have reduced the impact of potential changes in dietary and other lifestyle habits, likely to occur in cancer patients. The fact that in Mexico there is limited awareness about lifestyle risk factors related with BC may have attenuated the extent of differential classification. FFQ in general are subject to measurement error and this may have limited our ability to accurately measure relevant dietary components. The questionnaire measurements were validated and shown to perform reasonably well[31]. Not all WCRF/AICR recommendations were included in our score, either because of a lack of available data or because they were not applicable to the study population. This refers mostly to processing and preservation of foods, salt intake and vitamin supplementation. In addition, while epidemiological studies showed that abdominal adiposity such as waist circumference may be a better predictor of some cancer types, such as colorectal or pancreatic[61,62], waist circumference was not part of the WCRF/AICR recommendations. However, additional analyses including waist circumference in the WCRF/AICR score instead of BMI produced very similar results.

In conclusion, adherence to the WCRF/AICR recommendations was not related to the risk of BC in the CAMA study. However, after exclusion of BMI from the original index, a statistically significant inverse association between the WCRF/AICR score and BC risk was observed. Further large prospective studies are required to clarify the role and relevance of adherence to the WCRF/AICR recommendations, and the role of adiposity, on BC risk in the Mexican population.

Acknowledgements

Acknowledgements: The authors would like to acknowledge the funders for the financial support provided for this work and deeply thank all physicians responsible for the project in the different participating hospitals: Dr Germán Castelazo (IMSS, Hospital de la Raza, Ciudad de México, DF), Dr Sinhué Barroso Bravo (IMSS, Hospital siglo XXI, Ciudad de México, DF), Dr Fernando Mainero Ratchelous (IMSS, Hospital de Gineco-Obstetricia No 4 'Luis Castelaco Ayala',' Ciudad de México, DF), Dr Hernando Miranda Hernández (SS, Hospital General de México, Ciudad de México, DF), Dr Joaquín Zarco Méndez (ISSSTE, Hospital 20 de Noviembre, Ciudad de México, DF), Dr Edelmiro Pérez Rodríguez (Hospital Universitario, Monterrey, Nuevo León), Dr Jesús Pablo Esparza Cano (IMSS, Hospital No. 23 de Ginecologìa, Monterrey, Nuevo León), Dr Heriberto Fabela (IMSS, Hospital No. 23 de Ginecologìa, Monterrey, Nuevo León), Dr José Pulido Rodríguez (SS, Hospital Metropolitano Dr 'Bernardo Sepulveda', Monterrey, Nuevo León), Dr Manuel de Jesús García Solis (SS, Hospital Metropolitano Dr 'Bernardo Sepulveda', Monterrey, Nuevo León), Dr Fausto Hernández Morales (ISSSTE, Hospital General, Veracruz, Veracruz), Dr Pedro Coronel Brizio (SS, Centro Estatal de Cancerología 'Dr Miguel Dorantes Mesa', Xalapa, Veracruz), Dr Vicente A. Saldaña Quiroz (IMSS, Hospital Gineco-Pediatría No 71, Veracruz, Veracruz) and M.C. Teresa Shamah Levy (INSP, Cuernavaca, Morelos). *Financial support:* This work was supported by Consejo Nacional de Ciencia y Tecnologia (CONACyT; grant number 2002-C01-7462) and the National Institutes of Health (grant number 1U54CA13238). The funding organizations had no role in design and conduct of the study; collection, management, analysis and interpretation of the data; or preparation, review and approval of the manuscript. *Conflict of interest:* None. *Author contributions:* I.R. initiated, acquired the main funding and designed this investigation. A.F. conducted the statistical analysis under supervision of P.F. A.F. drafted the first version of the manuscript with important contributions from P.F. and I.R. All authors were involved with collection of data, data interpretation, critical revisions of the paper, and approval of the final version. I.R. had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Ethics of human subject participation:* The study protocol and data collection instruments were reviewed and approved by the Institutional Review Board at the National Institute of Public Health. Cases and controls provided written informed consent to participate in the study.

References

1. Jemal A, Siegel R, Ward E *et al.* (2008) Cancer statistics, 2008. *CA Cancer J Clin* **58**, 71–96.
2. Ferlay J, Shin HR, Bray F *et al.* (2010) Estimates of worldwide burden of cancer in 2008: GLOBOCAN 2008. *Int J Cancer* **127**, 2893–2917.
3. Tavani A, Gallus S, La Vecchia C *et al.* (1999) Risk factors for breast cancer in women under 40 years. *Eur J Cancer* **35**, 1361–1367.
4. Coughlin K (2007) A global perspective on cancer prevention. *Br J Nurs* **16**, 1252.

5. Huo D, Adebamowo CA, Ogundiran TO *et al.* (2008) Parity and breastfeeding are protective against breast cancer in Nigerian women. *Br J Cancer* **98**, 992–996.
6. Jernstrom H, Lubinski J, Lynch HT *et al.* (2004) Breastfeeding and the risk of breast cancer in BRCA1 and BRCA2 mutation carriers. *J Natl Cancer Inst* **96**, 1094–1098.
7. Li CI, Littman AJ & White E (2007) Relationship between age maximum height is attained, age at menarche, and age at first full-term birth and breast cancer risk. *Cancer Epidemiol Biomarkers Prev* **16**, 2144–2149.
8. Franceschi S, Favero A, Decarli A *et al.* (1996) Intake of macronutrients and risk of breast cancer. *Lancet* **347**, 1351–1356.
9. Howe GR, Hirohata T, Hislop TG *et al.* (1990) Dietary factors and risk of breast cancer: combined analysis of 12 case–control studies. *J Natl Cancer Inst* **82**, 561–569.
10. Lof M, Sandin S, Lagiou P *et al.* (2007) Dietary fat and breast cancer risk in the Swedish women's lifestyle and health cohort. *Br J Cancer* **97**, 1570–1576.
11. Smith-Warner SA, Spiegelman D, Yaun SS *et al.* (2001) Intake of fruits and vegetables and risk of breast cancer: a pooled analysis of cohort studies. *JAMA* **285**, 769–776.
12. Toniolo P, Riboli E, Protta F *et al.* (1989) Calorie-providing nutrients and risk of breast cancer. *J Natl Cancer Inst* **81**, 278–286.
13. Wakai K, Tamakoshi K, Date C *et al.* (2005) Dietary intakes of fat and fatty acids and risk of breast cancer: a prospective study in Japan. *Cancer Sci* **96**, 590–599.
14. Gandini S, Merzenich H, Robertson C *et al.* (2000) Meta-analysis of studies on breast cancer risk and diet: the role of fruit and vegetable consumption and the intake of associated micronutrients. *Eur J Cancer* **36**, 636–646.
15. Michels KB, Mohllajee AP, Roset-Bahmanyar E *et al.* (2007) Diet and breast cancer: a review of the prospective observational studies. *Cancer* **109**, 2712–2749.
16. Lof M & Weiderpass E (2009) Impact of diet on breast cancer risk. *Curr Opin Obstet Gynecol* **21**, 80–85.
17. Donaldson MS (2004) Nutrition and cancer: a review of the evidence for an anti-cancer diet. *Nutr J* **3**, 19.
18. Key TJ, Schatzkin A, Willett WC *et al.* (2004) Diet, nutrition and the prevention of cancer. *Public Health Nutr* **7**, 187–200.
19. Willett W (1998) *Nutritional Epidemiology*, 2nd ed. New York: Oxford University, Press.
20. Baglietto L, Krishnan K, Severi G *et al.* (2011) Dietary patterns and risk of breast cancer. *Br J Cancer* **104**, 524–531.
21. Fung TT, Hu FB, McCullough ML *et al.* (2006) Diet quality is associated with the risk of estrogen receptor-negative breast cancer in postmenopausal women. *J Nutr* **136**, 466–472.
22. Mannisto S, Dixon LB, Balder HF *et al.* (2005) Dietary patterns and breast cancer risk: results from three cohort studies in the DIETSCAN project. *Cancer Causes Control* **16**, 725–733.
23. Cade JE, Taylor EF, Burley VJ *et al.* (2011) Does the Mediterranean dietary pattern or the Healthy Diet Index influence the risk of breast cancer in a large British cohort of women? *Eur J Clin Nutr* **65**, 920–928.
24. Kim EH, Willett WC, Fung T *et al.* (2011) Diet quality indices and postmenopausal breast cancer survival. *Nutr Cancer* **63**, 381–388.
25. Harnack L, Nicodemus K, Jacobs DR Jr *et al.* (2002) An evaluation of the Dietary Guidelines for Americans in relation to cancer occurrence. *Am J Clin Nutr* **76**, 889–896.
26. Romaguera D, Vergnaud AC, Peeters PH *et al.* (2012) Is concordance with World Cancer Research Fund/American Institute for Cancer Research guidelines for cancer prevention related to subsequent risk of cancer? Results from the EPIC study. *Am J Clin Nutr* **96**, 150–163.
27. Sanchez-Zamorano LM, Flores-Luna L, Angeles-Llerenas A *et al.* (2011) Healthy lifestyle on the risk of breast cancer. *Cancer Epidemiol Biomarkers Prev* **20**, 912–922.
28. Beasley JM, Coronado GD, Livaudais J *et al.* (2010) Alcohol and risk of breast cancer in Mexican women. *Cancer Causes Control* **21**, 863–870.
29. Bassol Mayagoitia S (2006) La edad de la menopausia en Mexico. *Rev Endocrinol Nutr* **14**, 133–136.
30. Salazar-Martinez E, Lazcano-Ponce EC, Gonzalez Lira-Lira G *et al.* (1999) Reproductive factors of ovarian and endometrial cancer risk in a high fertility population in Mexico. *Cancer Res* **59**, 3658–3662.
31. Hernandez-Avila M, Romieu I, Parra S *et al.* (1998) Validity and reproducibility of a food frequency questionnaire to assess dietary intake of women living in Mexico City. *Salud Publica Mex* **40**, 133–140.
32. Romieu I, Parra S, Hernandez JF *et al.* (1999) Questionnaire assessment of antioxidants and retinol intakes in Mexican women. *Arch Med Res* **30**, 224–239.
33. US Department of Agriculture, Agricultural Research Service (2009) Nutrient Data Laboratory home page. http://www.ars.usda.gov/ba/bhnrc/ndl (accessed November 2012).
34. Morales de Leon J, Babinsky J, Bourges H *et al.* (2000) *Tables of Composition of Mexican Foods, Vol. CD-ROM Interactive Multimedia*. México, DF: INCMNSZ.
35. Sallis JF, Haskell WL, Wood PD *et al.* (1985) Physical activity assessment methodology in the Five-City Project. *Am J Epidemiol* **121**, 91–106.
36. Ledikwe JH, Blanck HM, Khan LK *et al.* (2005) Dietary energy density determined by eight calculation methods in a nationally representative United States population. *J Nutr* **135**, 273–278.
37. Hastert TA, Beresford SA, Patterson RE *et al.* (2013) Adherence to WCRF/AICR cancer prevention recommendations and risk of postmenopausal breast cancer. *Cancer Epidemiol Biomarkers Prev* **22**, 1498–1508.
38. Cheraghi Z, Poorolajal J, Hashem T *et al.* (2012) Effect of body mass index on breast cancer during premenopausal and postmenopausal periods: a meta-analysis. *PLoS One* **7**, e51446.
39. Renehan AG, Tyson M, Egger M *et al.* (2008) Body-mass index and incidence of cancer: a systematic review and meta-analysis of prospective observational studies. *Lancet* **371**, 569–578.
40. Suzuki R, Orsini N, Saji S *et al.* (2009) Body weight and incidence of breast cancer defined by estrogen and progesterone receptor status – a meta-analysis. *Int J Cancer* **124**, 698–712.
41. van den Brandt PA, Spiegelman D, Yaun SS *et al.* (2000) Pooled analysis of prospective cohort studies on height, weight, and breast cancer risk. *Am J Epidemiol* **152**, 514–527.
42. Ma H, Bernstein L, Ross RK *et al.* (2006) Hormone-related risk factors for breast cancer in women under age 50 years by estrogen and progesterone receptor status: results from a case–control and a case–case comparison. *Breast Cancer Res* **8**, R39.
43. Palmer JR, Adams-Campbell LL, Boggs DA *et al.* (2007) A prospective study of body size and breast cancer in black women. *Cancer Epidemiol Biomarkers Prev* **16**, 1795–1802.
44. Weiderpass E, Braaten T, Magnusson C *et al.* (2004) A prospective study of body size in different periods of life and risk of premenopausal breast cancer. *Cancer Epidemiol Biomarkers Prev* **13**, 1121–1127.
45. John EM, Sangaramoorthy M, Phipps AI *et al.* (2011) Adult body size, hormone receptor status, and premenopausal breast cancer risk in a multiethnic population: the San Francisco Bay Area breast cancer study. *Am J Epidemiol* **173**, 201–216.
46. Sarkissyan M, Wu Y & Vadgama JV (2011) Obesity is associated with breast cancer in African-American women but not Hispanic women in South Los Angeles. *Cancer* **117**, 3814–3823.

47. Sexton KR, Franzini L, Day RS *et al.* (2011) A review of body size and breast cancer risk in Hispanic and African American women. *Cancer* **117**, 5271–5281.
48. Amadou A, Torres Mejia G, Fagherazzi G *et al.* (2014) Anthropometry, silhouette trajectory, and risk of breast cancer in Mexican women. *Am J Prev Med* **46**, 3 Suppl. 1, S52–S64.
49. Wang Y & Beydoun MA (2007) The obesity epidemic in the United States – gender, age, socioeconomic, racial/ethnic, and geographic characteristics: a systematic review and meta-regression analysis. *Epidemiol Rev* **29**, 6–28.
50. Deurenberg P, Deurenberg-Yap M & Guricci S (2002) Asians are different from Caucasians and from each other in their body mass index/body fat per cent relationship. *Obes Rev* **3**, 141–146.
51. Liu A, Byrne NM, Kagawa M *et al.* (2011) Ethnic differences in the relationship between body mass index and percentage body fat among Asian children from different backgrounds. *Br J Nutr* **106**, 1390–1397.
52. WHO Expert Consultation (2004) Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* **363**, 157–163.
53. Anon. (1996) Summary of the Surgeon General's report addressing physical activity and health. *Nutr Rev* **54**, 280–284.
54. Begum P, Richardson CE & Carmichael AR (2009) Obesity in post menopausal women with a family history of breast cancer: prevalence and risk awareness. *Int Semin Surg Oncol* **6**, 1.
55. Friedenreich CM & Orenstein MR (2002) Physical activity and cancer prevention: etiologic evidence and biological mechanisms. *J Nutr* **132**, 11 Suppl., 3456S–3464S.
56. Slattery ML, Sweeney C, Edwards S *et al.* (2006) Physical activity patterns and obesity in Hispanic and non-Hispanic white women. *Med Sci Sports Exerc* **38**, 33–41.
57. Angeles-Llerenas A, Ortega-Olvera C, Perez-Rodriguez E *et al.* (2010) Moderate physical activity and breast cancer risk: the effect of menopausal status. *Cancer Causes Control* **21**, 577–586.
58. Gammon MD, John EM & Britton JA (1998) Recreational and occupational physical activities and risk of breast cancer. *J Natl Cancer Inst* **90**, 100–117.
59. Peters TM, Schatzkin A, Gierach GL *et al.* (2009) Physical activity and postmenopausal breast cancer risk in the NIH-AARP diet and health study. *Cancer Epidemiol Biomarkers Prev* **18**, 289–296.
60. Vainio H, Kaaks R & Bianchini F (2002) Weight control and physical activity in cancer prevention: international evaluation of the evidence. *Eur J Cancer Prev* **11**, Suppl. 2, S94–S100.
61. Berrington de Gonzalez A, Spencer EA, Bueno-de-Mesquita HB *et al.* (2006) Anthropometry, physical activity, and the risk of pancreatic cancer in the European prospective investigation into cancer and nutrition. *Cancer Epidemiol Biomarkers Prev* **15**, 879–885.
62. Pischon T, Lahmann PH, Boeing H *et al.* (2006) Body size and risk of colon and rectal cancer in the European Prospective Investigation Into Cancer and Nutrition (EPIC). *J Natl Cancer Inst* **98**, 920–931.