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Healthy lifestyle and breast cancer risk: A case-control study in Morocco

Mohamed Khalis[a,b,c,*], Véronique Chajès[d], Aurelie Moskal[d], Carine Biessy[d], Inge Huybrechts[d], Sabina Rinaldi[d], Laure Dossus[d], Hafida Charaka[e], Nawfel Mellas[f], Chakib Nejjari[g], Joan Dorn[c], Amr S. Soliman[c], Isabelle Romieu[d], Karima El Rhazi[a], Barbara Charbotel[b]

[a] Department of Epidemiology, Faculty of Medicine and Pharmacy, Fez, Morocco
[b] University of Lyon, UCBL, Ifsttar, UMRESTTE, Lyon, France
[c] Department of Community Health and Social Medicine, City University of New York, School of Medicine, NY, USA
[d] Nutrition and Metabolism Section, International Agency for Research on Cancer, Lyon, France
[e] Department of Research and Development, Hassan II University Hospital of Fez, Morocco
[f] Department of Oncology, Hassan II University Hospital of Fez, Morocco
[g] Mohammed VI University of Health Sciences, Casablanca, Morocco

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ABSTRACT

Background: Some modifiable risk factors have been independently associated with breast cancer (BC) risk in Moroccan women, but no studies have investigated their joint association. This study aimed to investigate the association between a Healthy Lifestyle Index (HLI) score and BC risk among Moroccan women.

Methods: In this case–control study, 300 incident BC cases and 300 controls, matched by age and area of residence were recruited. Cases were women newly-diagnosed with histopathologically–confirmed BC at the University Hospital in Fez, Morocco. Controls were randomly selected healthy women recruited from 6 primary health centers in Fez. HLI scores developed within this study were assigned to participants based on 11 factors (red and processed meat, white meat, cream, cheese, fish, fruit and vegetables, physical activity, BMI, smoking, alcohol consumption, and breastfeeding), where 0 was given to unhealthy and 0.5 or 1 to healthy levels of each factor. Conditional and unconditional logistic regression models were used to assess the association between HLI scores and BC risk.

Results: Mean of HLI scores were 8.1 (± 1.1) and 9.0 (± 0.9) in cases and controls, respectively, $p < 0.01$. After adjusting for potential confounders, one-point increment in the HLI score was associated with 56% (95% CI, CI: 39–68%), 49% (95% CI: 30–63%), and 59% (95% CI: 40–72%) lower risks of BC in all, premenopausal, and postmenopausal women, respectively.

Conclusion: High HLI scores were associated with decreased risk of BC in Moroccan women. These findings suggest that BC prevention policies should include strategies for engaging Moroccan women in healthy lifestyles.

1. Introduction

Breast cancer (BC) is the most common cancer among women worldwide [1]. Although BC incidence rates are still highest in high-income countries [2], in many low- and middle-income countries (LMIC) cancer incidence and mortality rates are rising rapidly. The rising rates are linked to ongoing societal and economic development and lifestyles approaching western lifestyles (e.g. increase in smoking, excess body weight, and physical inactivity) [3]. In Morocco, BC represents a major public health concern as it accounts for 35.8% of all incident female cancers with an age-standardized rates of 49.5/100 000 women [4]. In 2012, 2878 BC deaths were estimated in Morocco [5].

Numerous risk factors for female BC have been identified, including older age, reproductive and hormonal factors (e.g., early menarche, late age at first pregnancy, late menopause, and nulliparity), hereditary predisposition (family history of BC and high-penetrance genetic mutations), high breast density and adult attained height [6–9]. Additionally, there is a considerable evidence that several modifiable lifestyle factors such as physical inactivity [10,11], body fatness (obesity in postmenopausal women) [12,13], dietary factors [14,15], alcohol consumption [16] and

Abbreviations: BC, breast cancer; LMIC, low-income and middle-income countries; HLI, healthy lifestyle index; BMI, body mass index; METs, metabolic equivalents; OR, odds ratio; CI, confidence intervals; SD, standard deviation

* Corresponding author at: Department of Community Health and Social Medicine, The City University of New York School of Medicine, 160 Convent Avenue, New York, NY, 10031, USA.
E-mail address: khalis.mohamed79@gmail.com (M. Khalis).

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tobacco smoking [17,18], are individually associated with the risk of BC. As behavioral factors and lifestyle pattern are often clustered [19–21], it is important to consider these lifestyle factors simultaneously and to take into account their joint effects.

Consistent positive associations have been reported in several studies between healthy behavioral patterns or combined lifestyle factors and lower risk of chronic diseases [22–25], including some cancers [26–30], as well as cause-specific and total mortality [31–33]. The association between combined lifestyle factors and the risk of developing BC has been investigated [34–38], and a healthy lifestyle was related to a decreased risk of BC. In fact, Parkin DM et al. reported that at least 17% of BC cases could be prevented from an overall healthy lifestyle [39]. However, the above BC studies were conducted only among western populations.

In contrast, less information is available on the association of combined lifestyle factors with the risk of BC in developing countries. To the best of our knowledge, no previous studies have investigated this association among women in Morocco. Therefore, it is important to investigate whether the association between these lifestyle factors and BC risk observed in western countries exists in LMIC countries, like Morocco.

The purpose of this study was to investigate the association between a healthy lifestyle index (HLI) score as previously defined [35], including diet, physical activity, body mass index (BMI), smoking, alcohol consumption and breastfeeding combined, and the risk of developing BC in Moroccan women. Based on the findings of previous studies, we hypothesized that a higher HLI score is associated with a lower risk for BC.

2. Methods

2.1. Study population

The BreCaFez Study is a case–control study, conducted in the Fez region- Morocco, from February 2016 until August 2017. A total of 300 incident BC cases and 300 controls were recruited in the study.

Incident BC cases were recruited from the Medical Oncology Center of the University Hospital in Fez, which is a referral center for BC for other hospitals in the region. The oncology center receives patients with all types and stages of BC from the entire region of Fez. The inclusion criteria of the cases were: a) newly-diagnosed histologically-confirmed in situ or invasive BC, b) had not received any treatment, such as radiotherapy, chemotherapy or anti-estrogens (e.g., tamoxifen), c) were not suffering from chronic kidney failure, d) were not pregnant or nursing during the study, and e) were able to give informed consent. The response rate for cases was 96.7% (300/310). The reasons for refusal were mainly lack of time for interview or feeling tired.

Controls were randomly selected healthy women with no previous history of cancer, visiting one of six outpatient primary health centers (three urban and three rural) in the Fez region. These centers provide several health services and receive women representative of the general population, in terms of socio-demographic characteristics. Women who accompanied patients with any type of cancer were excluded from this study. Control subjects were matched individually to the cases by age (± 5 years) (72% of pairs matched by 1-year age) and area of residence (urban vs. rural). The response rate for controls was 87.9% (300/341). The reasons for refusal were mainly lack of interest or lack of time for interview.

2.2. Data collection and measurements

Participants were interviewed at enrolment in the study by four trained and standardized interviewers and data were collected using an in depth questionnaire, including information about sociodemographic characteristics, lifestyle habits, general health, etc. and a detailed dietary questionnaire.

2.2.1. The general questionnaire

The general questionnaire collected data on sociodemographic characteristics, occupational history, anthropometric characteristics, family history of cancer including BC, menstrual and reproductive history (e.g., age at menarche, age at first full-term pregnancy, parity, menopausal status, age at menopause, history of breastfeeding), hormone use, smoking, alcohol consumption, and physical activity.

Socio-economic status of participants was assessed using a validated wealth score based on household assets including electricity, television, cell phone, refrigerator, indoor bath or shower, indoor tap, flush toilet, washing machine, car and landline phone [40]. This score was developed and evaluated in eight developing countries including Morocco. The scores were calculated for each participant by assigning points of 0 or 1 to each asset ownership question. The total score ranges between 0 (low level) and 10 (high level).

To assess physical activity, participants were asked to provide information on the total number of hours spent in occupational, recreational and household physical activity from Monday through Sunday in a typical week that reflects physical activities in the past 12 months. Physical activities were categorized based on their intensity by using metabolic equivalents (METs) values listed in the Compendium of Physical Activities [41]. Intensity was classified into three categories according to guidelines for physical activity [42,43]: light-intensity physical activities with METs < 3.0; moderate-intensity physical activities with METs between 3.0 and 5.9; and vigorous-intensity physical activities with METs ≥6.0. Definitions and examples were provided for each intensity level by type of activity. In this study, we used moderate and vigorous-intensity physical activities in hours per week of all activities combined, including occupational, recreational, and household activities.

Current weight and height were measured by interviewers at recruitment according to the recommendations of Lohman et al. [44]. The BMI was calculated as weight (kg) / height^2 (m^2).

Postmenopausal status was defined as self-reported absence of menstruation in the last 12 months.

2.2.2. The dietary intake questionnaire

Usual dietary intake of participants during the previous 12 months was assessed using a previously validated Food Frequency Questionnaire [45]. This questionnaire included 255 food items giving details of 32 main Moroccan-specific food groups. For each food item, a standard portion size was given and study subjects were asked to choose from nine frequency response options, ranging from “never” to “six or more times a day”. The reproducibility and validity of this FFQ have been assessed on 105 healthy Moroccan adults, and the results showed a good relative validity (de-attenuated correlations range from 0.24 for fiber to 0.93 for total monounsaturated fatty acids) and a good reproducibility (intra-class correlation coefficient range from 0.69 for fat to 0.84 Vitamin A [45].

2.3. Lifestyle index score

The lifestyle index score used in this study was generated according to public health and cancer prevention recommendations [46–48]. It was based on eleven factors: intake of red and processed meat, white meat, cream, cheese, fish, fruit and vegetables (excluding potatoes), physical activity, BMI, smoking, alcohol consumption, and breastfeeding, as described elsewhere [35].

For each participant, we calculated a HLI score based on eleven factors by assigning 0, 0.5 or 1 point to categories of each factor. As presented in Table 1, the healthy lifestyle behaviors were defined as limiting intake of red meat and avoiding processed meat (red and processed meat < 500 g/week and processed meat intake < 3 g/day), consuming more white meat (≥2 times per week), consuming more fish (≥2 times per week), high fruit and vegetable consumption (at least 5 servings per day), no cream or cheese consumption, no alcohol

Table 1
Individual components of the healthy lifestyle index score and their distribution among cases and controls (N (%)).

Health recommendations & index component	Index points	Cases n (300)	Controls n (300)	*P difference*
Limit intake of red meat and avoid processed meat				
Marker: Red meat and processed meat				0.03
Red and processed meat ≥500 g/wk or processed meat intake ≥50 g/d	0	7 (2.3)	4 (1.3)	
Red and processed meat < 500 g/wk and processed meat intake 3 to < 50 g/d	0.5	26 (8.7)	12 (4.0)	
Red and processed meat < 500 g/wk and processed meat intake < 3 g/d	1	267 (89.0)	284 (94.7)	
Choose a variety of protein foods				
Marker: White meat				< 0.01
< 1 time per week	0	27 (9.0)	11 (3.7)	
1 time per week	0.5	69 (23.0)	53 (17.7)	
≥2 times per week	1	204 (68.0)	236 (78.7)	
Increase the amount and variety of seafood				
Marker: Fish				< 0.01
< 1 time per week	0	63 (21.0)	27 (9.0)	
1 time per week	0.5	91 (30.3)	105 (35.0)	
≥2 times per week	1	146 (48.7)	168 (56.0)	
Limit the consumption of energy-dense foods				
Marker: Cream				0.63
≥2 times per week	0	18 (6.0)	13 (4.3)	
1 time per week	0.5	20 (6.7)	19 (6.3)	
< 1 time per week	1	262 (87.3)	268 (89.3)	
Reduce the intake of calories from solid fats				
Marker: Cheese				< 0.01
≥2 times per week	0	76 (25.3)	64 (21.3)	
1 time per week	0.5	93 (31.0)	155 (51.7)	
< 1 time per week	1	131 (43.7)	81 (27.0)	
Eat mostly foods of plant origin				
Marker: Vegetables & fruits				< 0.01
< 200 g/d	0	43 (14.3)	19 (6.3)	
200 – 400 g/d	0.5	176 (58.7)	63 (21.0)	
≥400 g/d	1	81 (27.0)	218 (72.7)	
Be physically active as part of your everyday life				
Marker: Exercise [a]				< 0.01
< 30 min of moderate exercise or < 15 min of vigorous exercise per day.	0	65 (21.7)	25 (8.3)	
30 to < 60 min of moderate exercise or 15 to < 30 min of vigorous exercise per day.	0.5	66 (22.0)	21 (7.0)	
≥60 min of moderate exercise or ≥30 min of vigorous exercise per day.	1	169 (56.3)	254 (84.7)	
Be as lean as possible without becoming underweight				
Marker: BMI				0.19
≥30 kg/m 2	0	118 (39.3)	97 (32.3)	
25 – 29 kg/m 2	0.5	113 (37.7)	123 (41.0)	
< 25 kg/m 2	1	69 (23.0)	80 (26.7)	
Limit alcoholic drinks				
Marker: Alcohol				0.19
≥10 g/day	0	3 (1.0)	0 (0.0)	
< 10 g/day	0.5	3 (1.0)	2 (0.7)	
Never	1	294 (98.0)	298 (99.3)	
Do not smoke				
Marker: Smoking				0.01
Current	0	7 (2.3)	0 (0.0)	
Former	0.5	6 (2.0)	2 (0.7)	
Never	1	287 (95.7)	298 (99.3)	
Breastfeed infants for at least 24 months [b]				
Marker: Breastfeeding [c]				< 0.01
Never breastfeed	0	76 (25.3)	27 (9.0)	
> 0 – < 24 months	0.5	53 (17.7)	34 (11.3)	
≥24 months	1	171 (57.0)	239 (79.7)	

[a] Physical activities (including occupational, recreational and household activities).
[b] Based on Moroccan public health recommendations (http://www.sante.gov.ma).
[c] Cumulative breastfeeding.

consumption, never having smoked, having a high physical activity level (at least 60 min of moderate or 30 min of vigorous physical activity daily), a healthy BMI (< 25 kg/m^2), and longer cumulative duration of breastfeeding (≥24 months).

We assigned a lifestyle index score to participants by summing the individual scores for each of the lifestyle factors, consequently, the lifestyle index score ranged from 0 (least healthy) to 11 points (most healthy).

Table 2
Selected characteristics of cases and controls (numbers and percentages; mean values and standard deviations).

Characteristics	Cases (n = 300)	Controls (n = 300)	*P difference*
Area of residence			0.53 (Matched)
Urban	204 (68.0)	204 (68.0)	
Rural	96 (32.0)	96 (32.0)	
Marital status			< **0.01**
Single	37 (12.3)	13 (4.3)	
Married	196 (65.3)	238 (79.3)	
Divorced	27 (9.0)	7 (2.3)	
Widowed	40 (13.3)	42 (14.0)	
Educational level			0.47
Illiterate	200 (66.7)	200 (66.7)	
Elementary /Koranic school	51 (17.0)	54 (18.0)	
Secondary school	37 (12.3)	28 (9.3)	
High school /Technical or professional school	12 (4.0)	18 (6.0)	
Menopausal status			0.23
Premenopausal	161 (53.7)	151 (50.3)	
Postmenopausal	139 (46.3)	149 (49.7)	
Age at menopause [a] (year)			< **0.01**
≤47	51 (36.7)	108 (72.5)	
> 47	81 (58.3)	27 (18.1)	
Missing	7 (5.0)	14 (9.4)	
Number of live births			< **0.01**
Nulliparous	69 (23.0)	21 (7.0)	
1 to 3	119 (39.7)	130 (43.3)	
≥4	112 (37.3)	149 (49.7)	
History of oral contraceptive			< **0.01**
Yes	182 (60.7)	107 (35.7)	
No	118 (39.3)	193 (64.3)	
Family history of breast cancer[b]			< **0.01**
Yes	28 (9.3)	12 (4.0)	
No	272 (90.7)	288 (96.0)	
Age at entry (year)	49.7 ± 11.3	49.5 (± 11.5)	0.85 (Matched)
Age at menarche (year)	13.5 ± 1.7	13.7 ± 1.2	0.07
Wealth score [c]	5.9 ± 1.7	7.6 ± 1.6	< **0.01**
Age at first full–term pregnancy [d] (year)	22.9 ± 6.1	20.7 ± 5.1	< **0.01**
Energy intake (kcal/d)	3034.8 ± 745.5	2907.9 ± 690.2	**0.03**
Lifestyle index score	8.1 ± 1.1	9.1 ± 1.0	< **0.01**

[a] Among postmenopausal women.
[b] First- and second-degree relatives.
[c] based on household assets including electricity, television, cell phone, refrigerator, indoor bath or shower, indoor tap, flush toilet, washing machine, car and landline phone.
[d] Among parous women.

2.4. Statistical analysis

Descriptive statistics summarizing subject characteristics were calculated. Conditional and unconditional logistic regression models were used to estimate associations between HLI scores and risk of BC for all women combined and by menopausal status. HLI was modeled as a continuous (1-point increment) and categorical variable (tertiles). The HLI score was categorized into tertiles based on the score distribution of controls, with the lowest tertile (0 to 8.5 points) as the reference group. Multivariate adjusted odds ratios (ORs) and corresponding 95% confidence intervals (CIs) were estimated, adjusting for age (continuous), number of live births (nulliparous, 1 to 3, ≥4), menopausal status combined with age at menopause (premenopausal, postmenopausal ≤47 years, and postmenopausal > 47 years), history of oral contraceptives (yes, no), family history of BC (yes/no), wealth score (continuous), age at first full-term pregnancy (nulliparous, < 20 years, ≥20 years) and energy intake (continuous), when appropriate. In stratified analyses by menopausal status, models were further adjusted for area of residence (urban/rural). None of other potential confounders listed in Table 2 changed our risk estimates by 10% or more. Because the association between BMI and BC risk differs by menopausal status, further analyses were conducted after excluding the BMI component from our HLI score. Sensitivity analyses were also performed with the exclusion of the cream and cheese components from the HLI score respectively. None of these sensitivity analyses materially altered our results (data not shown). Tests for trend were conducted by treating the HIL score as a continuous variable in the regression models. Median values in controls were used as cut-off points for age at menopause and number of live births. Due to the low frequency of postmenopausal hormone use, this variable was excluded from the analysis.

Data analysis was performed using SPSS, version 20 software. In all statistical analyses, p-values were two-sided and considered statistically significant if lower than 0.05.

2.5. Ethical considerations

The study protocol was approved by the Faculty of Medicine and Pharmacy of Casablanca Research Ethics Committee and the National Control Commission for the Protection of Personal Data (No.A-RS-192-2015).

3. Results

Individual components of the HLI scores and their distribution among cases and controls are presented in Table 1. Compared with controls, cases consumed more red and processed meat and cheese, and less white meat, fish, vegetables and fruits, and were less physically active and had lower levels of breastfeeding for at least 24 months. BMI was not significantly different between cases and controls.

The distribution of the selected characteristics of cases and controls are shown in Table 2. The mean age (± SD) of cases and controls were 49.7 (± 11.3) and 49.5 (± 11.5) years, respectively. Compared with controls, cases were more likely to be older at first full–term pregnancy and at age of menopause, and to have a lower number of live births, family history of BC, history of oral contraceptive use, lower wealth score and higher energy intake. The mean of the HLI score (± SD) in cases and controls was 8.1 (± 1.1) and 9.0 (± 0.9) respectively, ($p < 0.01$).

Table 3 presents the multivariate-adjusted ORs and 95% CIs between the HLI score and BC risk for all women, and by menopausal status. After adjustment for potential confounders, a higher HLI score was associated with a lower risk of BC, the adjusted OR comparing the highest to the lowest tertiles was 0.15 (95% CI: 0.07–0.32) for all women, 0.22 (95% CI: 0.10–0.49) for premenopausal women, and 0.11 (95% CI: 0.04–0.30) for postmenopausal women. Modeled as a continuous variable, one-point increment in the HLI score was associated with 56% (95% CI, CI: 39–68%), 49% (95% CI: 30–63%), and 59% (95% CI: 40–72%) lower risk of BC in all, premenopausal, and postmenopausal women, respectively. After excluding the BMI component from the HLI score, the healthy lifestyle remained significantly associated with decreased risk of BC in all, premenopausal, and postmenopausal women.

4. Discussion

This case-control study is the first one in Morocco to evaluate the association between HLI (including healthy diet, high physical activity, low BMI, smoking, alcohol consumption, and longer duration of breastfeeding) and the risk of BC among Moroccan women. The results showed that a high HLI score was inversely associated with risk of BC, in pre- and post-menopausal women.

The findings of our study are in line with previously published studies in other populations that found inverse associations between BC

Table 3
Multivariate-adjusted odds ratios and 95% confidence intervals of breast cancer associated to the healthy lifestyle index score, overall and by menopausal status.

	Overall (300/300)		Premenopausal (161/151)		Postmenopausal (139/149)	
	Ca /Co	OR[a] (95% CI)	Ca /Co	OR[b] (95% CI)	Ca /Co	OR[c] (95% CI)
Healthy lifestyle index (rang = 1-11)						
Tertile 1 (lower)	155/55	Reference	78/28	Reference	77/27	Reference
Tertile 2 (medium)	95/100	0.36 (0.18-0.73)	57/50	0.66 (0.32-1.34)	38/50	0.21 (0.09-0.50)
Tertile 3 (upper)	50/145	0.15 (0.07-0.32)	26/73	0.22 (0.10-0.49)	24/72	0.11 (0.04-0.30)
P trend		< 0.01		< 0.01		< 0.01
1-point increase of score		0.44 (0.32-0.61)		0.51 (0.37-0.70)		0.41 (0.28-0.60)
P-value		< 0.01		< 0.01		< 0.01
Healthy lifestyle index excluding BMI component (rang = 1-10)						
Tertile 1 (lower)	152/47	Reference	82/26	Reference	70/21	Reference
Tertile 2 (medium)	92/116	0.30 (0.15-0.59)	54/58	0.52 (0.25-1.08)	38/58	0.16 (0.06-0.40)
Tertile 3 (upper)	56/137	0.15 (0.06-0.33)	25/67	0.22 (0.09-0.51)	31/70	0.12 (0.04-0.32)
P trend		< 0.01		< 0.01		< 0.01
1-point increase of score		0.39 (0.28-0.55)		0.47 (0.33-0.67)		0.41 (0.28-0.61)
P-value		< 0.01		< 0.01		< 0.01

[a] Odds ratios estimated by conditional logistic regression and adjusted for age (continuous), number of live births (nulliparous, 1–3, ≥4), menopausal status and age at menopause combined (premenopausal, ≤47 years, > 47 years, missing), history of oral contraceptive (yes, no), family history of breast cancer (yes/no), wealth score (continuous), age at first full-term pregnancy (nulliparous, < 20 years, ≥20 years) and energy intake (continuous).

[b] Odds ratios estimated by unconditional logistic regression and adjusted for age (continuous), area of residence (urban/rural), number of live births (nulliparous, 1–3, ≥4), history of oral contraceptive (yes, no), family history of breast cancer (yes/no), wealth score (continuous), age at first full-term pregnancy (nulliparous, < 20 years, ≥20 years) and energy intake (continuous).

[c] Odds ratios estimated by unconditional logistic regression and adjusted for age (continuous), area of residence (urban/rural), age at menopause (≤47 years, > 47 years, missing), number of live births (nulliparous, 1–3, ≥4), history of oral contraceptive (yes, no), family history of breast cancer (yes/no), wealth score (continuous), age at first full-term pregnancy (nulliparous, < 20 years, ≥20 years) and energy intake (continuous).

risk and HLIs. Using the similar definition of our HLI score, a case–control study conducted by McKenzie et al. among Māori women in New Zealand, reported a 53% lower odds of BC for women in the top tertile of the HLI score compared to those in the bottom tertile (OR = 0.47, 95% CI: 0.23–0.94) [35]. Similarly, in the large Women's Health Initiative study, Arthur et al. found that women in the highest quintile level of the HLI score had a 30% reduced risk of BC (HR = 0.70, 95% CI: 0.64–0.76) compared to those in the lowest quintile of the index [37]. More recently, the Canadian Study of Diet found that an increase of a unit in the HLI score was associated with 3% reduction of BC risk among postmenopausal women (HR = 0.97, 95% CI: 0.94–0.99) [38].

In a Mexican case–control study where the HLI was defined as the combined effect of moderate and/or vigorous-intensity physical activity, low consumption of fat, processed foods, refined cereals, complex sugars, never having smoked (or < 100 cigarettes) and never consuming alcohol, women in the highest quintile of the HLI had significantly lower odds of BC risk compared with women in the lowest quintile in both pre- (OR = 0.50, 95% CI: 0.29–0.84) and postmenopausal women (OR = 0.20, 95% CI: 0.11–0.37) [36]. The multinational European Prospective Investigation into Cancer and Nutrition (EPIC) cohort found 26% lower risk of BC among postmenopausal women when the fourth category of the lifestyle index (most healthy) was compared to the second (reference) category of the index score (HR = 0.74, 95% CI: 0.66–0.83) [34]. Their healthiest behaviors were defined as never smoking, no consumption of alcohol, high physical activity, low BMI and healthy diet (high in cereal fiber, fatty fish, folate, with a high ratio of polyunsaturated to saturated fat, high intake of fruits and vegetables and low in margarine/trans-fat and glycemic load). However, the French E3N cohort study, considered healthy index as having a BMI between 18.5 and 25 kg/m^2, consuming at least 5 servings of vegetables and fruit per day, having a recreational physical activity of at least 20 MET-hour per week, being never smoker and drinking less than one alcoholic beverage per day [30], showed a statistically non-significant inverse association between HLI score and BC risk.

Our results are also consistent with the findings of prior studies that used a score based on adherence to the World Cancer Research Fund/ American Institute for Cancer Research (WCRF/AICR) and/ or the American Cancer Society (ACS) recommendations [27,49–52]. For instance, an EPIC study reported that women within the highest category of the WCRF/AICR score had 16% lower risk for developing BC compared with those in the first category of the score (HR = 0.84, 95% CI: 0.78–0.90) [27]. Similarly, the Swedish Mammography Cohort showed that women who met six to seven recommendations of WCRF/AICR had a 51% decreased risk of BC compared to women meeting only zero to two recommendations (HR = 0.49, 95% CI: 0.35–0.70) [52]. The Canadian National Breast Screening Study reported that meeting the ACS guidelines was associated with 31% reduction of BC risk among Canadian women (HR = 0.69; 95% CI: 0.49–0.97) [49].

In this study, the models excluding BMI did not substantially change risk estimates, suggesting that BMI is not the main driver in our HLI score. Similarly, no major change in BC risk was observed in the VITamins And Lifestyle [53] and EPIC [27] cohort studies when BMI was excluded from the index scores. However, a significant reduction in BC risk was observed in the Cancer de Màma study after excluding the BMI component [54]. An important advantage of our study is that weight and height were measured by interviewers and not self-reported.

In this study, the inverse association between healthy lifestyle and the breast cancer risk is intensified compared to that shown in other populations. This may be due to the existence of a bias in exposure assessment in our study. Indeed, given that the majority of breast cancer cases are diagnosed at late stages in Moroccan women [55], the effects of the disease or their symptoms may have affected lifestyles of our cases (e.g. physical activity) toward a less healthy one before their diagnosis of breast cancer.

Our study has some limitations. Due to the retrospective nature of this study, most of the data were reported by participants and could be subject to recall bias. However, we recruited incident cases prior to any treatment and participants were not aware of potential risk factors for BC, and therefore measurement errors are most likely random (non-differential misclassification). Another limitation is the relatively small sample size particularly after stratification by menopausal status. This limitation restricted conducting finer stratification, and testing the contribution of each component of the index in risk reduction of BC.

Future larger studies are needed in the Moroccan population.

In addition, considering that cases were significantly more likely to have a lower wealth score than controls, the possibility of selection bias cannot be ruled out in this study. However, this probable difference between cases and controls on socioeconomic level was shown in our previous study [56] on BC. It is therefore particularly important to investigate the relationship between the socioeconomic level and BC risk in the Moroccan context.

The limitation related to the construction of the index is detailed elsewhere [35]. For instance, the index includes foods for which the consumption could be interrelated. The index could also be imprecise for any vegetarians included in the study, because of the lack of information about alternative protein sources. In addition, the index components were equally weighted, without taking into account the unequal impact of each factor on cancer risk.

Additionally, due to the lack of dietary recommendations specific to the Moroccan population, our HLI score was based on international public health and cancer prevention recommendations. However, there is a clear need for developing dietary guidelines specific to the Moroccan population.

This study has several strengths. First, this is the first epidemiological study to investigate the association between HLI score and BC risk in Morocco and in North Africa. Second, the selection of population-based controls in our study may have improved the representation of the Fez population. Third, the adjustment for potential confounders, including socio-economic level assessed by a validated wealth score. Fourth, a high participation rate in both cases and controls.

In conclusion, the results showed that high HLI score may be associated with a decreased risk of BC in Moroccan women. These findings suggest that future breast cancer prevention efforts should focus on educating the Moroccan population about the benefits of healthy lifestyle including healthy diet, high physical activity, and breastfeeding. Future efforts should also address policies that will help institute interventions for breast cancer and chronic disease prevention.

Authorship contribution

Conception, design and acquisition of data: M. Khalis, H. Charaka, N. Mellas, C. Nejjari, K. El Rhazi, B. Charbotel.

Analysis and interpretation of data: M. Khalis, V. Chajès, A. Moskal, C. Biessy, I. Huybrechts, S. Rinaldi, L. Dossus, A.S. Soliman, I. Romieu, K. El Rhazi, B. Charbotel.

Drafting the article: M. Khalis.

Revising it critically for important intellectual content: M. Khalis, V. Chajès, I. Huybrechts, S. Rinaldi, J. Dorn, A.S. Soliman, I. Romieu, K. El Rhazi, B. Charbotel.

Final approval of the version to be published: M. Khalis, V. Chajès, A. Moskal, C. Biessy, I. Huybrechts, S. Rinaldi, L. Dossus, H. Charaka, N. Mellas, C. Nejjari, J. Dorn, A.S. Soliman, I. Romieu, K. El Rhazi, B. Charbotel.

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Competing interests

There is no conflict of interest or competing financial interests.

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