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Major dietary patterns and differentiated thyroid cancer

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SUMMARY

Background: Differentiated Thyroid Cancer (DTC) is the most common endocrine cancer with an increasing trend worldwide. Dietary pattern as a modifiable factor may be associated with DTC.
Objective: The present study aimed to evaluate the association between major dietary patterns and risk of DTC.
Methods: A case control study was conducted among 309 clinic-based participants in northeast of Iran. Dietary data were then collected by a validated Food Frequency Questionnaire (FFQ). Further, codified data were analyzed by factor analysis and logistic regression analysis to identify the dietary patterns and to examine the association between dietary patterns and DTC, respectively.
Results: According to our results, four major dietary patterns including western dietary pattern, traditional dietary pattern, transitional dietary pattern, and healthy dietary pattern were identified. The western dietary pattern was associated with increased odds of DTC after adjustment for potential confounders (OR = 2.79, 95% CI: 1.01–7.74). However, there was no association between other dietary patterns and DTC after adjustment.
Conclusions: In conclusion, the findings showed that western dietary pattern might be associated with DTC. Further studies are recommended to provide more conclusive evidences about the association between dietary patterns and DTC.

1. Introduction

Differentiated Thyroid Cancer (DTC) is one of the most common endocrine carcinoma [1,2] which has rapidly increased worldwide during the past three decades. Iran was also faced with this prevailing cancer [3]. The risk of thyroid cancer may be related to multiple factors including radiation, genetics, thyroid disorders, hormonal and reproductive factors, body mass index, diet, and etc. [2,4–24]. Most of the studies conducted in this realm have investigated the risk of DTC in relation to single dietary factors, such as food items or nutrients. Some studies have shown that some foods especially fish and other iodine-rich foods [1,2], vegetables, and fruits [1,2,10,17,23] might have protective effects on DTC. However, high consumption of chicken, mutton, lamb [4], pork, and poultry [23,25] was associated with higher risk of DTC. Although, a protective effect was observed between nutrients such as beta-carotene as well as vitamins C and E against cancer in a study carried out in northern Italy [26], in the National Institutes of Health–American Association of Retired Persons (NIH-AARP) Diet and Health Study. There were not found any relation between dietary micronutrients including selenium, β-carotene, folate, vitamin E, calcium, magnesium, and zinc [27]. Likewise, there are not any conclusive evidences about the relation between dietary supplements; vitamins A, C, E, B complex, D, β-carotene, iodine, calcium, zinc, magnesium, iron and DTC in a resent systematic review [24]. Because of the complex interactions among individual nutrients and foods, nutritional epidemiologists suggested that dietary pattern approach in investigating diet–disease relations. This approach can provide a more comprehensive new insight into relations among diet-diseases [28]. Previous studies were carried

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out on the association between dietary patterns and various cancers [29–31]. For instance, consumption of western/unhealthy dietary patterns was associated with higher risk of breast [29], gastric [31], and colorectal [30] cancers. However, there are just few data that link dietary patterns to DTC [18,23,32]. Furthermore, earlier studies often focused on assessing the relation between some food items or nutrients and DTC [1,2,4–10,12,13,16,17,21,23–27]. In a study on Greek adults, consumption of dietary patterns including fruits and mixed raw vegetables were associated with lower risk of DTC, while, a dietary pattern containing high amounts of fish and cooked vegetables increased the risk of papillary thyroid cancer [23]. In addition, there was no significant association between the western and traditional dietary patterns on the one hand and DTC on the other hand among a group of population in French Polynesia [18]. Also, Liang J. et al. found that a dietary pattern including high consumption of fruits and vegetables are significantly associated with decreased risk of cancer. While, the dietary pattern consisting of many starchy foods and desserts was related to increased risk of cancer in men, but an inverse association was found in women. Furthermore, no significant association was observed between frequent consumption of proteins and fats and risk of cancer [32]. Nevertheless, the available findings on dietary patterns and DTC have been derived from western populations [18,23,32] and sufficient data are not available in non-western countries especially in Middle Eastern populations where the dietary patterns are different from western populations. Although a case–control study was conducted in the Middle East, in Kuwait, it did not evaluate the relation between dietary patterns and DTC. The object of the mentioned study was to examine the association between dietary factors and DTC. Its findings further indicated that higher intake of processed fish products, fresh fish, and chicken were related to higher risk of DTC [4]. So, to the best of our knowledge, there have been no conclusive evidences on evaluation of dietary patterns and DTC, also no studies have been found in Middle Eastern populations especially among Iranian participants. Thus, the aim of this study was to evaluate the association between dietary patterns and DTC in northeastern Iran.

2. Methods

2.1. Study population

We selected our population from a thesis conducted in Mashhad, Iran in 2013 approved by the local Ethics Committee (approval number: 89177). The main study was a large-scale research with a total number of 600 participants (300 patients with DTC and 300 controls) and its object was to evaluate the association between dietary factors and DTC. Patients (cases) were selected from thyroid cancer clinic in Ghaem hospital of Mashhad. Inclusion criteria for the case group were diagnosed DTC, not being under drug withdrawal or on iodine depletion diet for the last 3 months, and being under treatment in nuclear medicine department after thyroidectomy. The control group comprised of individuals with no history of diseases who accompanied patients referring to Ghaem hospital for reasons other than thyroid problems. Exclusion criteria included pregnancy, lactation, being on a special diet, and having history of chronic diseases (including cardiovascular disease, diabetes, hypertension, thyroid disorders, and cancer) based on medical records and self-reports of cases and controls, respectively. Then, written informed consents were obtained from all participants.

In the present survey, we identified new cases among the examined total patients and considered them as the case group. The reason was that prevalence cases could have changed their diets after disease diagnosis and information bias is a potential threat.

In this regard, the number of controls was estimated 4 times more than the number of cases.

So, a total number of 309 participants (including 41 patients with DTC and 268 control participants) were investigated in the current study. The power of this study was approximately 83% using odds ratio of disease for adherence to western dietary pattern, probability of exposure among controls, and an α of 0.05.

2.2. Data collection and dietary assessment

Followed by a general questionnaire administered to collect demographic data, a validated Iranian Food Frequency Questionnaire (FFQ) was distributed among participants to assess their diet during the past year and obtain dietary information [33]. The anthropometric indices including weight and height were also measured and Body mass index (BMI) was accounted using the following formula: weight (kg) divided by squared height $(m)^2$. The characteristics of the patients were obtained from their medical records.

FFQ consisted of 160 food items which was designed and validated specifically for Iranian population [33]. Participants were then instructed about the size and portion of each food item by a number of pictures. For each item on questionnaire, individuals were required to give their amount of consumption (i.e., the number of servings per month, week, or day depending on the food item) before diagnosis. After completing FFQs, they were initially scanned, read, and then analyzed by a specifically designed software.

The amount of daily consumption for each food item was obtained based on frequencies and serving sizes. However, the administered FFQ did not include any information about intake of dietary supplements. The values of daily energy and macronutrients' intakes were estimated using the daily food consumptions, local recipes, and nutrient content of those foods. The amounts of crude and adjusted nutrients were calculated based on the total energy intake [34]. The adjustment was conducted through the residual method to control confounding effects of total energy intake and to remove its extraneous variation. Later, regression analysis was used to calculate residuals of nutrient intake. In this method, the nutrient intake achieved through adjustment indicates the difference between actual intake and intake predicted by total energy intake [35–37]. Total energy-adjusted nutrients intakes were obtained as the residuals from the regression model, with absolute nutrient intake as the dependent variable and total energy intake as the independent variable [35].

To identify dietary patterns, food items were categorized into 31 predefined food groups based on nutrients' similarity and evidences about their association with DTC. In this way, each food item was assigned to one of these groups (Table 1).

2.3. Statistical analysis

Principal component analysis (PCA) (correlation matrix) was applied to identify major dietary patterns based on 31 food groups and factors were rotated by varimax rotation. The dietary patterns were generated from the controls and a change point in the Scree plot determined the number of remained factors (dietary patterns). The derived factors were labeled based on data interpretation and results of the previous studies. For dietary patterns, the score for each factor was calculated by summing the weights of consumed food groups which were weighted by their factor loadings. Therefore, each participant received a factor score for each identified dietary pattern. The individuals were then categorized according to tertiles of dietary pattern scores. Descriptive analysis was used for data representation and Kolmogorov–Smirnov test was applied to

Table 1
Food grouping used in the dietary pattern analysis.

Food groups	Food items
1. Beef offal	Heart and liver, Other byproducts of Sheep's head and hooves.
2. Fish	Fried or grilled fish, canned fish.
3. Fried or roasted meat	Shishlik Kebab (skewered meat), Koobide Kebab (grilled minced meat), Bakhtiari Kebab (A combination of chicken kebab and beef or lamb meat), Fried and roasted meat.
4. Olivier salad	Olivier salad.
5. Potato	Potatoes and yogurt, mashed potatoes.
6. High fat dairy	high fat milk, high fat yogurt, cream cheese, Chocolate milk, cream, ice cream, milk, bananas, Shallot yogurt.
7. Snacks	Biscuit, Snack, Chips, Gum, Fruit roll-ups, Qarehqurut (Black whey), Tamarind.
8. Tea and coffee	Tea, coffee.
9. Sugar	Khir, Sholezard (saffron rice pudding dessert), Persian rose water ice, Ice pop, Rice pudding, jelly, Cubic sugar, Sugar, Honey, Jam, Rock candy, Sugar halva (Tahini and sugar), Sohan (Persian saffron brittle toffee) or Gaz (Persian nougat), Cotton candy, Candy, Chocolate, Gummi candy, Juice, Different Compotes, Cookie, Creamy pastry.
10. Nuts	Nuts.
Fesenjan (stew)	Fesenjan (Pomegranate Walnut Stew).
12. Āsh (Soup)	Noodle soup, wheat or rice soup, butter milk soup, Hodge-Podge soup, noodles soup, barley soup, other soups.
13.Gheimeh	Gheymeh Stew (Persian Yellow split pea stew), Gheymeh Bademjan Stew (Yellow split pea plus eggplants).
14. Vegetable Stew	Ghormehsabzi (Persian Herb Stew), Celery stew, Pumpkin stew, Eggplant Stew, Okra stew.
15. Broth	Broth.
16. Eshkeneh (Persian Onion Soup)	Whey Eshkeneh, Egg Eshkeneh.
17. Rice Koofteh (Herbed Meat & Rice Balls), Dolma (Stuffed Grape Leaves)	Rice Koofteh, Dolma.
18. Pickle	Different kinds of pickles, Pickled cucumber, Olives.
19. Kotlet (Persian Cutlet), Kookoo Sabzi (Persian Herbed Omlete)	Kotlet (Persian Cutlet), Kookoo (Persian Herbed/potato Omelet), Shami kebab, Potato Kookoo.
20. Egg	Boiled egg, Omelets, Scrambled egg.
21. Refined grains	Lavash bread, Euphorbia helioscopia bread, usual bread, Rice Lasagna, Mexican corn, pasta, rice, baguette bread.
22. Poultry	Chicken, poultry, chicken barbecue.
23. Low fat dairy	Low fat milk, low fat yogurt, cheese, dough.
24. Sweetened drinks (Soft drinks)	Regular soda, diet soda, Delester.
25. Fruit juice	Fruit juice, Cantaloupe juice, Cantaloupe rose water ice.
26. Side dishes	Persian meat and potato stew, Indian side dish, Mushroom side dish, Lentil and beans side dish.
27. Mixed rice	Persian tomato rice, Barberry rice, Vegetable rice, Broad bean rice, Beans, rice, dill rice, lentils rice, Tomato rice, Other types of rice, Chicken Tahchin (at the bottom layers), Meat Tahchin (at the bottom layers).
28. Dried fruits	Dried fruit.
29. Fruits	Banana, cucumber, orange, Tangerine, apple, kiwi, dates, Quince.
30. Vegetables	Vegetables, Tomato, Carrot, Salad, Shirazi Salad (Persian cucumber and tomato salad).
31. Whole grains	Barbari bread (a thick flat bread), Sangak bread (whole wheat leavened flat bread), Taftoon bread (Persian flat bread with added herbs (saffron and cardamom)), Oat bread.

test the normal distribution of data. Participants of case and control groups were matched in terms of gender and age (within ±5 years), so these two confounding factors were controlled from the beginning of study. Further, unconditional logistic regression was applied to analyze the association between dietary patterns and DTC in different models. Age and gender were initially controlled by matching, then total energy intake (Continuous: kcal/d), history of smoking (Yes (ex-smoker, current smoker), No (Non-smoker)), education level (Illiterate, Elementary school, Secondary school to Diploma, Graduated diploma, Bachelors, Masters or higher), and BMI (Continuous) were adjusted. These potential confounders adjusted in the analyses were determined based on earlier literature. The first tertile of dietary pattern scores was considered as a reference in all analyses. The overall trend of odds' ratios across increasing tertiles of dietary pattern scores was tested by analysis of tertile categories as ordinal variables. The statistical software IBM SPSS Statistics version 16·0 was applied to analyze data. The significance level was also set at $P < 0.05$.

3. Results

3.1. Characteristics of the study population

The general characteristics of participants (socio-demographics variables, type of differentiated thyroid, gender, age, BMI) are shown in Table 3. Age mean scores (±SD) for the patient and control groups were 38.31 (±12.52) and 41.82 years (±13.15), respectively. No significant difference was observed between the two groups in terms of age and gender ($p > 0.05$). However, frequency of participants with smoking history was significantly higher in the case group in comparison with controls ($p = 0.01$). Moreover, descriptive analysis indicated that higher educated participants were significantly more frequent in controls than cases ($p = 0.008$), whereas, no significant differences were observed between cases and controls in other general characteristics ($p > 0.05$). The frequencies of papillary, follicular, and medullar thyroid cancers were 80.5%, 14.6%, and 4.9%, respectively. The findings of dietary assessment among patients and controls are presented in Table 4.

Before adjustment based on total energy intake, the median for daily intakes of energy, carbohydrate, and protein were significantly higher among patients in comparison with controls ($p = 0.002$, $p < 0.001$, and $p = 0.001$, respectively). But, no significant difference was observed in fat intake between the two groups ($p > 0.05$).

After adjusting based on total energy intake, the results did not alter in carbohydrate consumption. The difference between protein intake was not significant ($p > 0.05$). Additionally, the median of daily fat consumption was higher in control group than case group ($p < 0.001$).

3.2. Description of dietary patterns

Four major dietary patterns were identified as [1]: Western dietary pattern that was rich in beef offal, fish (mainly canned fish),

Table 2
Factor loading matrix for the main dietary patterns identified among control group.

Food group	Dietary pattern			
	Western dietary pattern	Traditional dietary pattern	Transitional dietary pattern	Healthy dietary pattern
Beef offal	0.62	–	–	–
Fish	0.6	–	–	–
Fried or roasted meat	0.58	–	–	–
Olivier salad	0.54	–	–	–
Potato	0.53	–	–	–
High fat dairy	0.52	–	–	–
Snacks	0.45	–	–	–
Tea and coffee	−0.39	–	0.36	–
Sugar	0.38	–	0.38	–
Nuts	0.38	–	–	–
Fesenjan (Pomegranate Walnut Stew)	0.35	–	–	–
Āsh (Soup)	–	0.64	–	–
Gheimeh Stew	–	0.57	–	–
Vegetable Stew	–	0.56	–	0.31
Broth	–	0.54	–	–
Eshkeneh (Persian Onion Soup)	–	0.54	−0.3	–
Rice Koofteh (Herbed Meat and Rice Balls), Dolma (Stuffed Grape Leaves)	–	0.43	–	–
Pickle	–	0.42	–	−0.34
Kotlet (Persian Cutlet), Kookoo (Persian Herbed/potato Omelet)	–	0.37	–	–
Egg	–	0.34	–	–
Refined grains	–	–	0.6	–
Poultry	–	–	0.5	–
Low fat dairy	–	–	0.45	–
Drinks	–	–	0.42	–
Fruit juice	–	–	0.41	–
Side dishes	–	–	0.37	–
Mixed rice	–	–	0.36	–
Dried fruits	–	–	–	0.61
Fruits	–	–	–	0.57
Vegetables	–	–	–	0.53
Whole grains	–	–	–	0.3
Percentage of variance explained	10.74	8.92	7.55	5.83

Only items with correlation coefficients ≥0·30 are presented.

fried or roasted meat, olivier salad, potato, high-fat dairy, snacks, tea and coffee, sugars, nuts, and Fesenjan (Pomegranate Walnut Stew), [2]. Traditional dietary pattern with frequent consumption of Āsh (Soup), Gheimeh Stew (chickpeas, meat, potato, tomato paste, salt, seasoning, oil, and dried limes), Vegetable Stew, Broth, Eshkeneh (Persian Onion Soup), Rice Koofteh (herbed Meat & Rice Balls), Dolma (Stuffed Grape Leaves), Pickle, Kotlet (Persian Cutlet), Kookoo (Persian Omelet), and egg, [3]. A transitional dietary pattern that was high loaded by refined grains, poultry, low fat dairy, sweetened drinks (soft drinks), fruit juice, Khoraks (side dishes), and mixed rice, [4]. A healthy dietary pattern that was high in dried fruits, fruits, vegetables, as well as whole grains (Table 2).

Table 3
Participants' descriptive characteristics.

Variable		Cases (n = 41)		Controls (n = 268)		Total		p-value
		Mean	SD	Mean	SD	Mean	SD	
Gender[a]	Male	5 (12.2%)		40 (14.9%)		45 (14.6%)		0.64
N (%)	Female	36 (87.8%)		228 (85.1%)		264 (85.4%)		
Type of differentiated thyroid cancer	Papillary	33 (80.5%)						
N (%)	Follicular	6 (14.6%)						
	Medullar	2 (4.9%)						
Smoking history[b]	Yes	5 (12.2%)		8 (3%)		13 (4.2%)		0.01*
N (%)	No	36 (87.8%)		260 (97%)		296 (95.8%)		
Education level[a]	Illiterate	7 (17.1%)		44 (16.4%)		51 (16.5%)		0.008*
N (%)	Elementary school	17 (41.5%)		45 (16.8%)		62 (20.1%)		
	Secondary school to diploma	9 (22%)		90 (33.6%)		99 (32%)		
	graduated diploma	3 (7.3%)		17 (6.3%)		20 (6.5%)		
	Bachelors	4 (9.8%)		46 (17.2%)		50 (16.2%)		
	Masters or higher	1 (2.4%)		26 (9.7%)		27 (8.7%)		
Age[c]		38.31	12.52	41.82	13.15			0.11
BMI[d] (kg/m^2)		25.91		26.13				0.39
Median and (QT)		(23.7–27.34)		(23.2–29.35)				

The P-values were calculated by Manne- Whitney U[d] or Independent sample T[c] or Pearson chi-square[a] or Fisher's exact[b] test.
*P < 0.05 was considered significant.

Table 4
Energy and macronutrients' intakes in the cases and controls.

Dietary intakes		Cases (n = 41)		Controls (n = 268)		p-value
		Mean	SD	Mean	SD	
Energy[2] (kcal/d)		2733.72	899.05	2307.05	800.08	0.002*
Carbohydrate (gr/d)	Crude[a]	353.58	137.92	276.35	106.99	p < 0.001*
	Adjusted by total energy[a]	339.55	52.66	317.5	37.23	0.001*
Protein (gr/d)	Crude[a]	98.8	30.92	82.29	29.81	0.001*
	Adjusted by total energy[b] Median and (QT)	94.11 (84.3–103.75)		91.31 (85.59–97.54)		0.13
Fat (gr/d)	Crude[a]	105.54	37.65	98.89	35.86	0.27
	Adjusted by total energy[b] Median and (QT)	106.73 (95.02–113.62)		113.49 (106.27–121.97)		p < 0.001*

The P-values were calculated by Manne- Whitney U[b] or Independent sample T[a]-test.
*P < 0.05 was considered significant.

These dietary patterns explained 33.06% of the whole variance found in dietary intakes.

3.3. Dietary patterns and differentiated thyroid cancer

Table 5 shows multivariable-adjusted odds ratios for DTC across tertiles of dietary pattern scores. Results showed that individuals in the higher tertile of the western dietary pattern had 2.85 times more chance for DTC in comparison with those in the first tertile after adjustment for total energy intake (OR = 2·85, 95% CI: 1.15–7.06). This relationship remained significant even after further adjustment for additional confounding factors including history of smoking and education (OR = 3·02, 95% CI: 1.09–8.36). These results persist even after more adjustment for BMI (OR = 2.79, 95% CI: 1.01–7.74). But, no significant association was found between traditional dietary pattern and odds of DTC after adjusting for all potential confounders. Also, the findings showed no significant relationship between transitional dietary pattern and DTC after adjustments for confounders. Further, there was no significant association between healthy dietary pattern and DTC after adjustments.

4. Discussion

We identified four dietary patterns, i.e., western, traditional, transitional, and healthy, in the current case control study. This study showed a significant relationship between western dietary pattern and increased odds of DTC. However, there were no associations between traditional, transitional, healthy dietary patterns, and DTC in the current study.

To the best of our knowledge, it is the first survey on the association between dietary patterns and DTC in a Middle Eastern country. DTC is one of the most common cancers in the endocrine system and its incidence has risen during the past decades. This study indicated that the highest adherence to western dietary pattern increased the DTC chance. This relation remained significant after multivariate models' adjustment for potential confounders. Earlier researches have mainly evaluated the relation between isolated food items, food groups, or nutrients and DTC, but few studies have been carried out to investigate the association between dietary patterns and DTC [18,23,32]. For instance, in contrast with our results, Cléro E. et al. found no association between the western dietary pattern including high intake of meat and cooked pork meat, eggs, Chinese food, cereals, starchy food, cabbage and other vegetables, cakes, sweet drinks, alcohol, coffee, and DTC [18]. Also, dietary patterns consisted of high protein and fat intake did not have any relationship with risk of cancer in study of Liang J [32]. The variety in ingredients of the mentioned study's dietary patterns with those of this study as well as methods of patients' inclusion might have led to this discrepancy. The study of Cléro E. et al. has included the prevalence cases of DTC, but our

Table 5
Multivariable-adjusted odds' ratio of the associations between dietary patterns and differentiated thyroid cancer.

Dietary pattern scores		M1		M2		M3		M4	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Western dietary pattern scores	T1	1 (reference)							
	T2	1.33	0.61–2.9	1.33	0.6–2.92	1.34	0.58–3.09	1.33	0.57–3.08
	T3	2.85*	1.15–7.06	2.74*	1.09–6.9	3.02*	1.09–8.36	2.79*	1.01–7.74
	P-trend	0.12							
Traditional dietary pattern scores	T1	1 (reference)							
	T2	1.35	0.57–3.2	1.11	0.46–2.72	1.32	051–3.42	1.33	0.51–3.45
	T3	1.64	0.66–4.02	1.4	0.55–3.54	2.04	0.74–5.62	2.08	0.75–5.73
	P-trend	0.97							
Transitional dietary pattern scores	T1	1 (reference)							
	T2	0.59	0.22–1.6	0.51	0.18–1.42	0.58	0.2–1.67	0.61	0.21–1.74
	T3	0.54	0.18–1.66	0.5	0.16–1.56	0.47	0.14–1.57	0.55	0.16–1.88
	P-trend	0.01							
Healthy dietary pattern scores	T1	1 (reference)							
	T2	1.29	0.55–3.03	1.25	0.52–2.96	1.35	0.54–3.35	1.25	0.5–3.12
	T3	2.13	0.82–5.54	1.91	0.72–5.06	2.24	0.77–6.47	1.95	0.66–5.7
	P-trend	0.81							

Multivariate logistic regression models were used to estimate odds ratios with 95% confidence intervals for the association between Differentiated Thyroid Cancer (DTC) and dietary factors scores.
M1: adjusted for total energy intake; M2: adjusted for total energy intake, smoking history; M3: adjusted for total energy intake, smoking history, education; M4: adjusted for total energy intake, smoking history, education, BMI.
The comparisons were made in reference to the first tertile (T) of the corresponding pattern.
*P < 0.05 was considered significant.

study was conducted among the incidence cases. Inclusion of prevalence cases may have resulted in information bias, because they could change their diets due to disease diagnosis.

Similar to our findings, Markaki I. et al. reported that the dietary pattern which included high intake of fish was related to increased risk of cancer [23]. Moreover, in another study, the dietary pattern identified with high consumption of starchy foods and desserts was related to increased risk of cancer among men [32].

The literature shows that there is a relationship between dietary pattern and overall risk of cancer. For example, Iranian population studies found a significant association between western dietary pattern and increased risk of prostate [38], oesophageal squamous cell [39], and colorectal [40] cancers. However, the precise mechanisms through which dietary factors or dietary patterns might affect DTC are still unclear. Studies indicated that cooking or processing of red meat at a high temperature produces carcinogenic compounds, such as heterocyclic amines (HCA), polycyclic aromatic hydrocarbons (PAH), and N-nitroso compounds. These compounds can promote carcinogenesis via increasing in proliferation of cells and result in increasing of overall cancer risk [1,41].In the same way, the results of a study showed that the high consumptions of mutton and lamb were associated with increased risk of DTC [4]. In addition, a recent meta-analysis found that high intake of fish was associated with increased risk of DTC in the areas without iodine deficiency [20]. Fish is one of the dietary iodine sources. Iodine is an essential mineral for synthesis and regulation of thyroid hormones. Both iodine deficiency and iodine excess may disrupt the production of thyroid hormones and thus increase the risk of thyroid cancer [42]. In this regard, it was reported in a study that high consumption of cheese and butter is significantly associated with increased risk of DTC particularly in the endemic goiter areas in Sweden and Norway [8]. The fried or roasted meat, fish (particularly canned fish), and high fat dairy are loaded on western dietary pattern. Therefore, the positive association between high adherence of western dietary pattern and increased risk of DTC found in this study might be explained by loading of these ingredients in the western dietary pattern.

No association was observed between traditional, transitional, healthy dietary patterns and DTC in the present research. Similar to our results, Cléro E. et al. found no significant relationship between the Polynesian dietary pattern (as a traditional pattern) and DTC. In contrast to our results, the findings of another study showed that the dietary pattern characterized by high intakes of fruits and vegetables had a protective effect against cancer [32]. In addition, Markaki I. et al. observed that the dietary patterns characterized by high consumption of fruits, high intake of raw vegetables, and high consumption of mixed raw vegetables and fruits were associated with reduced cancer risk among a Greek population [23]. The different ingredients of their dietary patterns and lack of control for several confounders including smoking history and education in study of Markaki I. et al. might have contributed to the discrepancy.

The current study enjoys from some strengths. To the best of our knowledge, it is the first survey on the association between dietary patterns and DTC in a Middle Eastern country. Moreover, a wide range of confounding factors (including gender, age, and total dietary energy intake, history of addiction, education, and BMI) that might have influence on thyroid cancer were controlled. Additionally, new cases were assessed in this study; so the possibility of recall bias is low. Furthermore, a valid local dish-based FFQ was provided according to Iranian diet and included Iranian traditional foods. Also, the number of food items in this FFQ was more than other studies. However, there have also been some limitations. First, the exposure to radiation and physical activity were not controlled and evaluated as confounders among participants. The measurement error was another limitation which is an identified feature of any dietary assessment method. Further, the current study cannot fully explain causality because of its case control design. So, the achieved results need to be confirmed by prospective studies in the future.

5. Conclusion

In conclusion, it was found that the western dietary pattern significantly increases the odd of DTC. But, the traditional, transitional, healthy dietary patterns did not have any association with DTC. Further studies are recommended to provide new information and more conclusive evidences for explanation of the relationship between dietary patterns and DTC as well as their possible mechanisms.

Conflict of interest statement

The authors declare that there is no conflict of interests regarding the publication of this paper.

Authors' contributions

Seyed Rasoul Zakavi, Abdolreza Norouzy and Mohammad Safarian designed the research.

Zohreh Sadat Sangsefidi, Fateme Ghafouri-Taleghani, Roxana Kashanifar and Raheleh Pourbaferani collected data.

Zohreh Sadat Sangsefidi and Mahdieh Hosseinzadeh analyzed and interpreted data.

Zohreh Sadat Sangsefidi, Fateme Ghafouri-Taleghani, Roxana Kashanifar, Raheleh Pourbaferani and Mohammad Safarian wrote the draft of manuscript.

Mahdieh Hosseinzadeh, Seyed Rasoul Zakavi and Abdolreza Norouzy critically revised the manuscript and approved the final version of it to be submitted.

All authors read and approved the final version of article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2019.05.015.

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