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Cluster analysis for food group consumption patterns in a national sample of Palestinian schoolchildren: Evidence from HBSC Survey 2013-2014

RESEARCH

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A B S T R A C T

Background: Promoting a healthy diet and lifestyle to reduce the national burden of nutrition-related problems among Palestinians requires an understanding of food consumption trends and patterns. Few studies have examined the food consumption patterns with the macro and micronutrient intakes and nutrition risk factors. The objective of this study was to study the food frequency and nutrient intake consumption patterns of Palestinian schoolchildren and their associations with the socioeconomic and risk factors.This is a national cross-sectional descriptive study conducted on Palestinian schoolchildren from the West Bank. The study examined the food consumption patterns of the macro and micronutrient intakes and nutrition risk factors among 1945 students aged 11-16 years. The data collected using the food frequency questionnaire and 24-hour recall that was administered by trained field workers. Food groups' classification, nutrient intakes, body mass index (BMI) Z-scores, and socioeconomic differences were examined across the food groups' patterns of consumption. We employed Z-score and K-Means cluster analysis to identify food consumption patterns and to examine factors associated with nutrient intakes. The food frequency results identified three food consumption clusters including the traditional, non-traditional, and mixed pattern. A total of 796 students (41%) were in traditional cluster, 458 (23.5%) in non-traditional cluster, and 691(35.5%) in mixed cluster. The nutrient intakes identified three clusters (High, Moderate, and Low consumption patterns) out of macronutrient, vitamins, and minerals categories. Most of the students located in the low consumption cluster for macronutrient, vitamins, and minerals clusters (66.9%, 67.7%, and 64 %) respectively. The traditional cluster was associated with healthy, non-obese, and physically active students and the non-traditional cluster was associated with unhealthy and obese students, but both shown significantly different across the identified clusters. Imbalance in dietary intakes among schoolchildren reflects a lack of dietary diversity. High sugar, fats and oils, and beverages consumption, low consumption of grains, fruits, beans and legumes, and meat are noticed in Palestinian schoolchildren. The findings indicated the importance of considering the food groups' intake variations among Palestinian schoolchildren. As the segments relate to children's health, nutrition diet programs should consider the high scores of non-traditional and mixed food consumption among schoolschildren.

Keywords: Cluster analysis; consumption patterns; nutrients; socioeconomic status; diet, food group patterns, schoolchildren.

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Introduction

Diet and lifestyle are major determinants of the health and development of chronic diseases. An unhealthy diet and sedentary lifestyle contribute to the increasing prevalence of obesity and non-communicable diseases like diabetes, hypertension, and cardiovascular

diseases, especially when adopted in childhood and early adolescence.(Farpour-Lambert et al. 2015; Mehio Sibai et al. 2011; Nishtar, Gluckman, and Armstrong 2016; Waters et al. 2014; James 2008). The consumption of an unhealthy diet is becoming more frequent due to the global rapid food intake transition (Salameh et al. 2014). This transition affecting the developing countries including Palestine. Change in socioeconomic status is associated with a transition in food consumption patterns across developing countries, where traditional healthy diets, including the Mediterranean diet, are being changed into more westernized dietary patterns. Moreover, in –society economic variation displays a difference in food consumption patterns. Individuals with high income consume more meat, poultry, fruits, and vegetables than those with lower income, who consume more saturated fats and carbohydrates(Heng and House 2018; Grieger, Scott, and Cobiac 2012; Nguyen et al. 2013; Alavian et al. 2008; Salameh et al. 2014). Schoolchildren and adolescents have been affected by the food consumption transition, a shift in diet consumption pattern is observed including high consumption rate of energy drinks, soft drinks, fast food, sweets and chocolates, and low consumption rate of fruits, and vegetables(Al et al. 2009; Aounallah-Skhiri et al. 2011; Williamson et al. 2020; Mehio Sibai et al. 2011). Several studies show that nutrition transition caused a high increase in childhood overweight and obesity rates. It has been found that unhealthy food is the leading source of calories, while healthy food such as fruits and vegetable intakes has decreased(Rahman et al. 2020; Aounallah-Skhiri et al. 2011; Williamson et al. 2020). Palestine is also subjected to nutritional transition (Abdeen et al. 2012; Aboul-Enein, Bernstein, and Neary 2017; Nubani-Husseini et al. 2016; Mikki et al. 2009). Similar to eastern Mediterranean countries, Palestine reported a high prevalence of overweight and obesity rates(Elessi and Albaraqouni 2019).

There are limited data on dietary intakes of Palestinian schoolchildren. Several studies have been conducted for assessing Palestinians eating habits, food consumption, and lifestyle including schoolchildren (Roblin 2007; Shah et al. 2019; Tariq, Shahid, and Tariq 2018; Zhou et al. 2016; Nubani-Husseini et al. 2016; Aboul-Enein, Bernstein, and Neary 2017). Investigation of transitions in food consumption and their relation to various sociodemographic variables is of paramount importance to analyze determinants of health and wellbeing among the population. Moreover, focusing on children and adolescents is important as this period is critical for adopting lifelong health behaviors. To date, limited information is available on food groups' consumption patterns among Palestinian schoolchildren. No published studies were found in which the food groups' consumption patterns were clustered and analyzed. This study acts as the first baseline study in which energy and nutrient intakes, lifestyle, and socioeconomic variables are compared according to dietary patterns for schoolchildren.

In Palestine, there is also limited information on the food groups' types and frequency that schoolchildren consume over a single week using FFQ data and over a single day using 24-hour recall data. Therefore, the present study aimed to (i) define the dietary clusters based on the frequency of consumption of food groups across a single week; (ii) define dietary clusters based on food group consumption across single day using 24-hour recall data (iii) compare energy and nutrient intakes clusters and lifestyle and physical activity variables between clusters.

Methods

Data were obtained from the national survey conducted in West Bank as a part of the Health Behavior in School aged Children (HBSC) survey in 2013-2014. The study aimed at improving the nutrition, physical and mental health of Palestinian children. Study subjects are Palestinian students in grades 5-9 (age 11-16) who were randomly selected from 100 schools in West Bank. The schools were randomly selected and stratified by school

type (55% Public and 45% UNRWA) and weighted according to population size. A random sample of 2000 students was selected from the baseline database weighted for gender and grades, out of 2000 students, 1945 students have accomplished the study criteria, the 55 students were excluded due to the incomplete data variables. Sampling procedures and methods have been described elsewhere in detail (Ziad Abdeen et al. 2018). The study received ethical approval from the Ministry of Education and Al-Quds University Institutional Review Board (IRB). The data were collected, entered, and cleaned by the Ministry of Education under the supervision of Al-Quds Nutrition and Health research institute (ANAHRI) at Al-Quds University.

Measure

The main outcomes of this analysis were the clusters of food consumption based on food frequency data and food intake and nutrient analysis. Dietary intake information was collected using face to face 24-hour food recall of one day intake and the validated food frequency questionnaire (FFQ) (Mikki et al. 2010). The 24-hour recall includes in-depth information about the food consumed during the last 24 hours. The participants were asked to recall the detailed descriptions of each food item consumed over the last 24 h including the quantity, time, and cooking descriptions. The food consumption quantities were identified using the recipes consumption weight book developed by ANAHRI. The participants' food intakes were entered and analyzed using the Nutribase V.9(Lee 1997), USDA, and the Palestinian Food Recipes databases. The Nutrient intake (Macro and Micronutrients) were computed using the Nutribase V.9 software. The dietary data collected from the 24-hour food recall generated a very large number of foods. The food items and recipes were classified according to the USDA food groups. Overall, the consumed foods were classified into standard food groups. The recipes were grouped by their main ingredients and depending on the ingredient that has the highest caloric value the food group was determined. As before this, the food group categorization methodology was determined based on a previous paper depending on the macronutrient composition of a food item, and 13 groups were set for this research purpose(Ahuja et al. 2012).

The classification produced 13 food groups: 1) vegetables; 2) fruits; 3) grains; 4) meat; 5) poultry and eggs; 6) fish and seafood; 7) beans and legumes; 8) dairy products; 9) sugar and sweets; 10) beverages; 11) fat and oils; 12) nuts and seeds; 13) Miscellaneous or others.

For the food frequency data, the food items were grouped into 8 categories based on similarity in nutrient profile (Frank et al. 1992). These categories were: 1) vegetables; 2) fruits; 3) milk and other dairy products; 4) sweets and chocolate; 5) soft drinks; 7) beverages (Juices with sugar); 8) energy drinks. Response categories were (1)never, (2) 1-2 times a week, (3) 3-4 times a week, and (4) 5-7 times a week (almost daily). As part of the HBSC survey, healthy and unhealthy nutritional practices were assessed using a frequency scale to obtain information on the nutritional status and variations among schoolchildren. Three items were considered indicators of "healthy nutritional practices", these items included the frequency of consumption of fruits, vegetables, and milk, respectively. Three other items were considered indicators on "unhealthy nutritional practices", these included frequencies of consumption of sweets, soft drinks, sugary juices, and energy drinks. Consumption frequency for all items was obtained over a week's duration.

The Demographic and other risk factors variables were collected using the HBSC unified tool(Al et al. 2009). The nutrient values were analyzed and compared to the USDA recommended Allowances (RDA) values for children aged 11-16 years old. The in-class administrative interview method was used for collecting the data. Students reported high response rates (97%) after excluding the cases with missing data.

Cluster Analysis

To identify dietary consumption patterns, we applied the K-Means clusters analysis to the data from the FFQ and the 24-hour recall. The consumption patterns were analyzed using the K-Means clustering algorithm for finding the segments of participants' food consumption. The K-means clustering defined the segments of data sets and assigned each observation into one K- distinct cluster, the algorithm identified the smallest variation within each data cluster, and the numbers of clusters were repeated until we found the best clustering match with the minimized square error between empirical means of the cluster and the points in the cluster. To identify the FFQ and energy and nutrient intakes clusters with similar patterns, the z-scores were calculated to standardize the nutrient data before clustering.

A non-hierarchical k-Means clustering procedure was used, with the random seed and 10 iterations to refine and optimize the classifications. The final cluster solution was selected based on interpretability and the percent of the study population in each cluster.

Statistical analysis

The statistical analysis was conducted using the IBM Statistical Package for Social Science V21. Furthermore, the dietary consumption patterns were analyzed for each cluster and descriptive comparison analysis was conducted between the consumption clusters for finding the patterns and the differences between clusters. K-Means cluster analysis was performed using SPSS V21. for Windows.

Chi-squared tests were used to assess differences between categorical data. Continuous data were assessed for normality and, if required, normalized with natural log transformation. One-way analysis of variance (ANOVA) was used to test for significant differences in mean nutrient and gram intakes between the clusters.

Results

Characteristics of respondents

The description characteristics of the study sample are presented in Table 1. A total sample of 1945 students was collected from the West Bank, Palestine. Among these participants around (47%) boys and (52.7%) girls. The mean age was 13.5 years, ranging from 11 to 16 years. The sample was selected from Public and UNRWA (Refugee) Schools. UNRWA represented (45%), and public schools represent (55%) of the study sample.

Table 1: The sample characteristics of schoolschildren 11-16 years old by gender.

Age in Years	Boys(n=920)	Girls(n=1025)	Total
		n (%)	
11-12	(38.6)355	(40.4)414	(39.5)769
13-14	(38.6)355	(37.7)386	(38.1)741
15- 16	(22.8)210	(22)225	(22.4)435
School Type			
Public	(48.7)448	(60.9)624	(55.1)1072
UNRWA	(51.3)472	(39.1)401	(44.9)873
Economic Status			
Low Income	(38)350	(31.7)325	(34.7)675
Moderate Income	(52.9)487	(57)584	(55.1)1071
High Income	(9)83	(11.3)116	(10.2)199
Living Place			
Refugee	(41.7)384	(27.4)281	(34.2)665
Non-Refugee	(58.3)536	(72.6)744	(65.8)1280
Father Education			
Secondary => School	(62.1)323	(69)459	(66)782
Secondary < School	(37.9)197	(31)206	(34)403
Mother Education			
Secondary => School	(62.3)294	(71.1)468	(67.4)762
Secondary < School	(37.7)178	(28.9)190	(32.6)368

Results in Table 2 show the lifestyle patterns of schoolchildren; the physical activity lifestyle was categorized into three levels (Low activity, Active and High activity) (17.1%, 56.5%, and 26.5%) respectively. Boys reported higher activity levels than girls (38%, 16%) respectively. About (72%) of boys spending more than 1 hour/day leisure time activity, compared to (68%) of girls spending >1H/day. Students reported higher poor healthy food than good healthy food consumption (53%, 47%) respectively. About (10%) of students smoking Nargila or cigarettes, boys were higher smokers than girls (14.7%, 5.5%) respectively. About (14%) of students were overweight and obese.

Table 2: Lifestyle characteristics of schoolchildren by gender.

Item	Boys(n=920)	Girls(n=1025)	Total
		n (%)	
Physical activity			
Low activity	89(9.7)	243(23.7)	332(17.1)
Active	480(52.2)	618(60.3)	1098(56.5)
High activity	351(38.2)	164(16)	515(26.5)
Leisure time activity			
<1hour/day	256(27.8)	368(35.9)	624(32.1)
1-2hours/day	396(43)	447(43.6)	843(43.3)
>3hour/day	268(29.1)	210(20.5)	478(24.6)
Healthy Food Consumption			
Poor	508(55.2)	522(50.9)	1030(53)
Good	412(44.8)	503(49.1)	915(47)
Smoking			
Yes	135(14.7)	56(5.5)	191(9.8)
No	785(85.3)	969(94.5)	1754(90.2)
BMI			
Underweight	62(6.7)	45(4.4)	107(5.5)
Normal	764(83)	804(78.4)	1568(80.6)
Overweight	66(7.2)	122(11.9)	188(9.7)
Obese	28(3)	54(5.3)	82(4.2)

The prevalence of overweight and obesity among boys and girls was (7.2%, 3%), and (12%, 5.3%) respectively. More than half of participants (55%) had moderate family income; (34.7%) had low family income and (10.2%) had high family income. In terms of living place, about (34.2%) living in refugee, and (65.8%) in non-refugee residence. Students reported the father and mother education with higher than secondary school were (66% and 67.4%) respectively, while father and mother education less than secondary school were (34% and 32.6%) respectively.

Energy and Macronutrient intake and food groups' consumption

The mean energy and macronutrient intake of Palestinian schoolchildren is reported in table 3. The overall mean energy consumption of boys was 2552 Kcal and 2064 Kcal for girls. The average consumption of protein for boys and girls was (89.2g, 69.6 g), respectively. The carbohydrate and fat average consumption for boys and girls were (360.3g, 292.9g) and (87.4g, 71.4g) respectively. The mean vitamins and minerals intake of Palestinian schoolchildren reported in Table 4. In the case of vitamins, boys is reported higher average consumption than girls in vitamin B1, B2, B3, B5, B6, B9, and B12 ((0.8,0.7); (1.2,0.9); (13.6,11.2); (3.9,3.1); (1.6,1.2); (273.4, 243.2); (301.1, 243.2); (3.3, 2.5)) (boys, girls) respectively.

The girls reported higher consumption of vitamin A and C than boys ((5.2, 5); (113.8, 99.6)) respectively. In the case of mineral consumption, boys reported higher average mineral consumptions including Calcium, Magnesium, Phosphorus, Potassium, Sodium, Iron, Manganese and Zinc. The boys in the age group (13-14 years) had a higher mineral consumption among boys. While girls in the age group 11-12 years had higher mineral consumption among girls.

Table 3: Mean (SE) of daily Intake of Energy and Macronutrients of Palestinian Schoolchildren.

Macronutrient	Boys(n=920)				Girls(n=1025)			
	11-12	13-14	15-16	All Ages	11-12	13-14	15-16	All Ages
Calories (Kcal)	2475(792.3)	2645.8(1109.9)	2525.4(843.3)	2552.4(940.2)	2133.9(712)	2025.3(725.6)	2002.5(720.6)	2064.2(720.7)
Protein(g)	87.6(35.8)	92(36.9)	87.5(38.1)	89.2(36.8)	72.2(30.1)	67.4(30.5)	68.6(31.6)	69.6(30.6)
% Protein	14(3.7)	13.8(3.5)	13.7(3.6)	13.9(3.6)	13.3(3.5)	12.9(3.2)	13.4(3.8)	13.2(3.5)
Carbs(g)	346.9(117.5)	376(230.3)	356.6(127.2)	360.3(172)	302.4(101.6)	286.8(102.3)	285.7(122.8)	292.9(107)
%Carbs	55.8(8.7)	55.6(8.2)	56.3(8.8)	55.9(8.5)	56.5(7.9)	56.5(7.9)	56.5(8.9)	56.5(8.1)
Fat(g)	85.2(37.3)	90.4(36.3)	85.9(38.2)	87.4(37.2)	73.8(33.1)	70.9(32.9)	68(27.5)	71.4(31.9)
%Fat	30.2(7.4)	30.5(7.3)	30(7.8)	30.3(7.4)	30.1(6.8)	30.6(6.8)	30.1(7.5)	30.3(7)
SatFat(g)	21.4(10.9)	23.4(11.7)	22.8(11.8)	22.5(11.4)	20.1(10.5)	19.2(11.3)	18.1(9.3)	19.3(10.6)
TransFat(g)	0.3(0.8)	0.3(0.8)	0.2(0.8)	0.3(0.8)	0.3(0.9)	0.3(0.9)	0.4(1.1)	0.3(1)
TransMonoFat(g)	0.1(0.3)	0.1(0.5)	0(0.3)	0.1(0.4)	0.1(0.3)	0(0.2)	0.1(0.3)	0.1(0.3)
MonoFat(g)	31.9(20)	33.6(18.9)	29.4(19)	32(19.4)	26.5(15.7)	24.8(15.4)	23.8(12.2)	25.3(14.9)
PolyFat(g)	17.9(10.1)	19(9.7)	19.6(10.9)	18.7(10.1)	15.6(8.8)	15.2(8.4)	15.6(8.3)	15.4(8.5)

Carbs: Carbohydrates, SatFat: Saturated Fatty Acids, TransFat: Trans-Unsaturated Fatty Acids, MonoFat: Monosaturated Fatty Acids, PolyFat: Polysaturated Fatty Acids.

Cluster Analysis

The food group consumption patterns were identified using the K-Means cluster analysis method. Several runs were conducted to identify the best pattern for nutrient intake and food frequency intake data. The nutrients intake was divided into three groups (macronutrient, vitamins, and minerals) clusters in addition to the FFQ clusters. The percentage distribution of clusters as described in table 5. Three clusters were found for each category. The FFQ clusters were identified as Traditional, non-Traditional, and Mixed. A total of 796 students (41%) were in traditional cluster, 458 (23.5%) in non-traditional cluster, and 691(35.5%) in mixed cluster. The nutrients intake clusters were identified as high, moderate, and low consumption (g/day or ml/day). Most of the students located in the low consumption cluster for macronutrient, vitamins, and minerals clusters (66.9%, 67.7%, and 64 %) respectively. The students in the moderate clusters were (26.4%,26.7%, and 26.2%). The students in the high consumption clusters were (6.6%, 5.6%, and 7.8%) respectively. The mean consumption of food groups in FFQ clusters is shown in table 6. The traditional cluster had the highest mean intakes of fruits, vegetables, milk, and milk products consumption. The Non-Traditional cluster had the highest mean intake of soft drinks, beverages, and energy drinks. The Mixed cluster had a high mean intake of soft drinks and sweets and chocolate groups. The univariant analysis shows the mean intakes of food groups varied significantly across the clusters. Table 7 shows the mean intakes of nutrients by FFQ clusters. Nutrient intakes varied significantly across the clusters. Students in the

Table 4: Mean (SE) daily Intake of Micronutrients (Vitamins and Minerals) of Palestinian schoolchildren

	Boys (n=920)				Girls (n=1025)			
Micro-nutrient	11-12	13-14	15-16	All Ages	11-12	13-14	15-16	All Ages
VitA(mcg)	330.7(67.6)	270.6(41.6)	164.4(12.6)	269.5(30.8)	189.7(32.3)	178.6(31.1	434(152.2)	239.2(37.8)
VitB1(mg)	0.8(0)	0.9(0)	0.8(0)	0.8(0)	0.8(0)	0.7(0)	0.7(0)	0.7(0)
VitB2(mg)	1.1(0)	1.2(0.1)	1.1(0)	1.2(0)	0.9(0)	0.9(0)	1(0)	0.9(0)
VitB3(mg)	13(0.5)	14.2(0.6)	13.4(0.7)	13.6(0.3)	11.1(0.4)	10.8(0.4)	11.8(0.6)	11.1(0.2)
VitB5(mg)	3.8(0.1)	4.1(0.2)	3.8(0.1)	3.9(0.1)	3(0.1)	3(0.1)	3.3(0.1)	3.1(0.1)
VitB6(mg)	1.3(0)	1.7(0.2)	1.6(0.1)	1.5(0.1)	1.1(0)	1.1(0)	1.2(0.1)	1.2(0)
VitB9(mcg)	286.5(10.5)	332.1(14.1)	273.4(11.3)	301.1(7.3)	246.2(8.4)	236.4(9)	243.2(12.6)	241.8(5.5)
VitB12(mcg)	3.8(0.6)	3.3(0.3)	2.5(0.2)	3.3(0.3)	2.4(0.3)	2.1(0.3)	3.4(0.6)	2.5(0.2)
VitC(mg)	92.1(5.3)	112.5(7.5)	90.8(5.7)	99.6(3.8)	117.1(6.9)	111.6(7)	111.5(9.5)	113.8(4.3)
VitD(IU)	57.8(3.1)	60.9(3.3)	75(5.5)	62.9(2.2)	57.8(3.1)	52.6(3.1)	52.3(4.2)	54.6(1.9)
Vit(EIU)	4.5(0.2)	4.9(0.2)	5.1(0.2)	4.8(0.1)	4(0.2)	4(0.2)	4.1(0.2)	4(0.1)
Ca (mg)	679.1(23.4)	692.2(25.1)	653.9(27.6)	678.4(14.7)	1013.3(386)	572.4(19.3)	555.1(25.9)	746.7(156.2)
Mg(mg)	279(8.3)	307.8(14.2)	257.6(9.7)	285.2(6.7)	355(128.4)	216.2(6.1)	212.5(7.2)	271.4(52)
P(mg)	1067.3(26.9)	1130.6(28.9)	1021.6(31.6)	1081.3(16.9)	843.5(18.7)	813.9(21.2)	815.7(26.3)	826.3(12.4)
K(mg)	2192.3(52.5)	2534.6(167)	2092.8(66.3)	2301.7(69.5)	1938.6(44.9)	1882.5(47.1)	1834.4(56.8)	1894.6(28.3)
Na(mg)	3816.7(81.8)	4180.7(85.3)	3964.5(108)	3990.9(52.2)	3837(524)	3305.4(75.4)	3154.9(87.6)	3487.1(214)
Cu(mg)	1.5(0)	1.6(0.1)	1.4(0)	1.5(0)	2.6(1.3)	1.2(0.1)	1.3(0.1)	1.8(0.5)
Fe(mg)	20.7(0.8)	21.5(0.8)	17.1(0.9)	20.2(0.5)	17.3(0.6)	15.8(0.7)	14.6(0.6)	16.1(0.4)
Mn(mg)	2.6(0.1)	2.8(0.1)	2.5(0.1)	2.6(0.1)	2.2(0.1)	2.2(0.1)	2.1(0.1)	2.2(0)
Zn(mg)	10.3(0.3)	11.2(0.3)	9.7(0.4)	10.5(0.2)	9.5(1.3)	7.6(0.2)	7.9(0.3)	8.4(0.5)

FFQ Clusters	Boys(n=920)	Girls(n=1025) n(%)	Total
Traditional	323(35.1)	473(46.1)	796(40.9)
Non-Traditional	267(29)	191(18.6)	458(23.5)
Mixed	330(35.9)	361(35.2)	691(35.5)
Macro-Nutrients Cluster			
High	57(6.2)	72(7)	129(6.6)
Moderate	269(29.2)	245(23.9)	514(26.4)
Low	594(64.6)	708(69.1)	1302(66.9)
Vitamins Cluster			
High	68(7.4)	41(4)	109(5.6)
Moderate	296(32.2)	223(21.8)	519(26.7)
Low	556(60.4)	761(74.2)	1317(67.7)
Minerals Cluster			
High	96(10.4)	56(5.5)	152(7.8)
Moderate	295(32.1)	254(24.8)	549(28.2)
Low	529(57.5)	715(69.8)	1244(64)

Table 5: K-Means clusters analysis for FFQ and nutrients intake food consumption.

Table 6: Mean (SE) Food Frequency Intake by the cluster.

Food Groups	Traditional	Non-Traditional	Mixed	F-Test (P<0.001)
Fruits	5.5(1.3)	5.1(1.6)	3.6(1.3)	0.0
Vegetables	5.5(1.3)	4.8(1.6)	3.7(1.4)	0.0
Milk and Milk Products	5.1(1.5)	4.1(2.0)	2.8(1.5)	0.0
Sweets and Chocolate	4.0(1.6)	4.9(1.8)	3.1(1.5)	0.0
Soft Drinks	3.2(1.5)	5.9(1.4)	3.5(1.7)	0.0
Beverages (Juice with Sugar)	4.1(1.6)	5.1(1.7)	2.9(1.4)	0.0
Energy Drinks	1.4(0.8)	4.2(2.2)	1.7(1.3)	0.0

non-traditional cluster show a higher mean intake consumption than other clusters in most of the Nutrients except Calcium, Sodium, Magnesium, and Copper where the mixed cluster reported higher consumptions of calcium, magnesium, sodium, and copper than other clusters.

The consumed grams of food groups

The mean (SE) grams of food groups consumed by the school students in each cluster are presented in table 8. Three clusters were identified for the grams consumed by students: The high cluster was 140 (7.2%) the moderate 556 (28.6%) and the low cluster 1249(64.2%). Girls in the three clusters consumed more beans and legumes, sugars and sweet, poultry and eggs, and fats and oils than boys. In the case of high consumption cluster, girls had a higher average consumption of poultry and eggs, beans and legumes, sugars and sweets, and fats and oils.

In the moderate cluster, girls had a higher consumption of fruits, meat, poultry and eggs, fish and seafood, beans and legumes and fats and oils than boys.

In the low consumption cluster, girls had higher vegetable consumption than boys. Significant differences were observed between food groups dietary patterns and gender. Girls' daily consumption of food groups was associated with significantly higher intake than boys in all food groups except fats and oils, nuts and seeds, and miscellaneous, where no significant differences were observed.

Energy and Nutrient intakes of consumed food groups

The nutrient intakes were divided into three groups: Macronutrients, vitamins, and minerals. The results of Z-score K-Means clusters identified three clusters for each group (High, Moderate and Low). Figure 1 shows the characteristics of macronutrient clusters, the percentage distribution of high, moderate and low clusters is (7.8%, 10.5%, and 81.1%), respectively. Children aggregated into cluster 1 had high Z-Score of energy, protein, and carbohydrate (2.6, 1.6 and 2.9), respectively. Children in cluster 2 scored moderate Z-score in energy, protein, and fat (0.7, 0.7 and 2.3), and had a negative score for carbs (Z-score =-0.4). Children in cluster 3 scored negatively on energy, protein, Fats and carbs z-scores were (-0.4, -0.3, -0.3, -0.2) respectively.

Characteristics of children described in the different clusters by the consumed food group are described in Figure 2. The macronutrient high cluster pattern (Figure 2a) included high fats and oils consumption (56%) of the sample and a significantly higher percentage of girls than boys were observed. In the moderate cluster pattern (Figure 2 b), children consumed a high percentage of grains (98%), there were no significant differences regarding gender. In the low cluster pattern (Figure 2c), children consumed more vegetables, sugar, and beverages (15.9%, 11.7%,

Table 7: Mean (SE) of schoolchildren nutrient intake by FFQ clusters.

Nutrient Intakes	Traditional	Non-Traditional	Mixed	F-Test-P-value
Calories(Kcal)	2354.4(33.3)	2386.5(39.7)	2166.2(29.4)	0
Protein(g)	80.8(1.2)	82.7(1.9)	74.1(1.2)	0
Carbs(g)	332.9(6.2)	335.2(5.7)	308.6(4.5)	0
Fiber(g)	23.9(0.7)	22.5(0.7)	21(0.5)	0
Fat(g)	81.4(1.2)	82.8(1.8)	73.7(1.3)	0
Retinol(mcg)	227.9(27.6)	333(76.7)	230.3(35)	0
VitB1(mg)	0.8(0)	0.8(0)	0.7(0)	0
VitB2(mg)	1.1(0)	1.1(0)	1(0)	0
VitB3(mg)	12.3(0.3)	13.6(0.5)	11.4(0.3)	0
VitB5(mg)	3.6(0.1)	3.8(0.1)	3.2(0.1)	0
VitB6(mg)	1.4(0.1)	1.5(0.1)	1.2(0)	0
VitB9(mcg)	277.3(7.6)	276.5(9.4)	256.9(7.1)	0
VitB12(mcg)	2.6(0.2)	3.4(0.3)	2.9(0.4)	0
VitC(mg)	117.6(4.9)	106.3(6)	95.6(4.4)	0
VitD(IU)	66.8(2.4)	56.7(2.7)	50.3(2.3)	0
Vit(EIU)	4.4(0.1)	4.6(0.2)	4.3(0.1)	0
Ca (mg)	682(15.6)	629.4(19.7)	808.1(23.2)	0.031
Mg(mg)	261.8(7.2)	257.2(7)	310.4(77)	0.005
P (mg)	974.6(17.1)	992.7(24)	884.6(16.2)	0
K(mg)	2222.6(78.7)	2082.6(46.1)	1934.1(35.7)	0
Na(mg)	3729.8(56)	3685.4(74)	3746.8(31.6)	0
Cu(mg)	1.4(0)	1.4(0)	2.1(0.8)	0.017
Fe(mg)	18.9(0.5)	18.1(0.7)	17(0.5)	0
Mn(mg)	2.5(0.1)	2.4(0.1)	2.3(0.1)	0
Zn(mg)	9.3(0.2)	9.7(0.3)	9.4(0.8)	0

and 12%) respectively. Significant differences regarding gender were observed. Figure 3 shows the characteristics of vitamin clusters, the percentage distribution of high, moderate and low clusters is (8.1%, 9.6%, and 82.3%), respectively. Children aggregated into cluster 1 had high Z-Score of Vit B6, B3, and B5 (2.8, 2.7 and 2.1) respectively. Children in cluster 2 scored moderate Z-score in B2, B3, and B5 (2.1, 1.3 and 1.2) and had low score for retinol (Z-score=0.1). Children in cluster 3 scored negatively on vitB6, retinol, B12, B1, B2, B3, and B5 (Z-score =-0.2,-0.07,

Table 8: The Mean (SE) grams intake cluster by food groups and gender.

Food Groups	Boys			Girls			Overall			P-Value
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low	
Vegetable	823.8	366.3	111.5	806.6	360.2	113.1	814.7	363.3	112.4	0.001
	(24.2)	(5.4)	(3.7)	(23.9)	(5.1)	(6.1)	(17)	(3.7)	(3.7)	
Fruits	804.7	344.5	144.4	779.4	345.4	129.3	794.3	345	135.5	0.001
	(29.6)	(7)	(13.8)	(29.3)	(6.3)	(4.1)	(21.1)	(4.7)	(6.1)	
Grains	771.8	391.5	211.7	708.9	354.2	153.1	755.6	372.2	173.4	0.001
	(15)	(4.6)	(29.5)	(19.9)	(4.1)	(3.4)	(12.4)	(3.1)	(10.6)	
Meat	643.9	290.7	75.1	605.4	316.8	72.1	634.3	297	73.5	0.001
	(18.4)	(7.9)	(2.9)	(0)	(21.5)	(2.7)	(16.2)	(8)	(2)	
Poultry and eggs	727.2	311.7	101.2	766.2	322.5	92.4	741.1	315.6	96.6	0.001
	(38.9)	(8.3)	(2.7)	(71.3)	(12.8)	(2.5)	(34.4)	(7)	(1.8)	
Fish and seafood	775	293	114.1	625.3	327	109.7	775	308	112	0.001
	(45)	(13.6)	(5.7)	(0)	(18.4)	(6)	(45)	(11.3)	(4.1)	
Beans and legumes	631.6	303	70.4	889.9	317.7	50.2	803.8	308	60.9	0.001
	(11.2)	(17.4)	(2.4)	(2.4)	(27.2)	(2.2)	(86.1)	(14.6)	(1.7)	
Dairy products	724.8	337.3	92.9	694	320.7	83.7	709.4	329.8	87.7	0.001
	(42.3)	(6.7)	(5.2)	(25.8)	(7.1)	(2.9)	(24.4)	(4.9)	(2.8)	
Sugars & sweets	425.2	278.2	37.8	1264.8	278.1	37.4	1264.8	278.1	37.6	0.001
	(15.7)	(21.5)	(1.4)	(0)	(19)	(1.3)	(27.1)	(14.6)	(1)	
Beverages	848	362	186.8	755.8	350.5	142.9	821.6	356	159.9	0.001
	(20.7)	(6.1)	(26.1)	(20.8)	(5.7)	(3.4)	(16.3)	(4.2)	(10.4)	
Fats & oils	328.4	256.5	47.5	468.1	390.7	35.9	382.2	290	41.6	0.07
	(18.2)	(17.4)	(1.1)	(18.7)	(63.9)	(0.8)	(11.3)	(28.1)	(0.7)	
Nuts & seeds	29.1	18.2	11.6	24.1	15.3	10.4	26.1	23.4	11	0.085
	(19.4)	(0.6)	(0.9)	(0.9)	(0.8)	(0.7)	(0.6)	(0.5)	(0.6)	
Miscellaneous	449.6	317.4	178.4	444.3	348.3	212.9	435.6	352.2	189.7	0.064
	(22.1)	(12)	(9.2)	(14.6)	(11.8)	(6.5)	(14.6)	(16.3)	(18.7)	

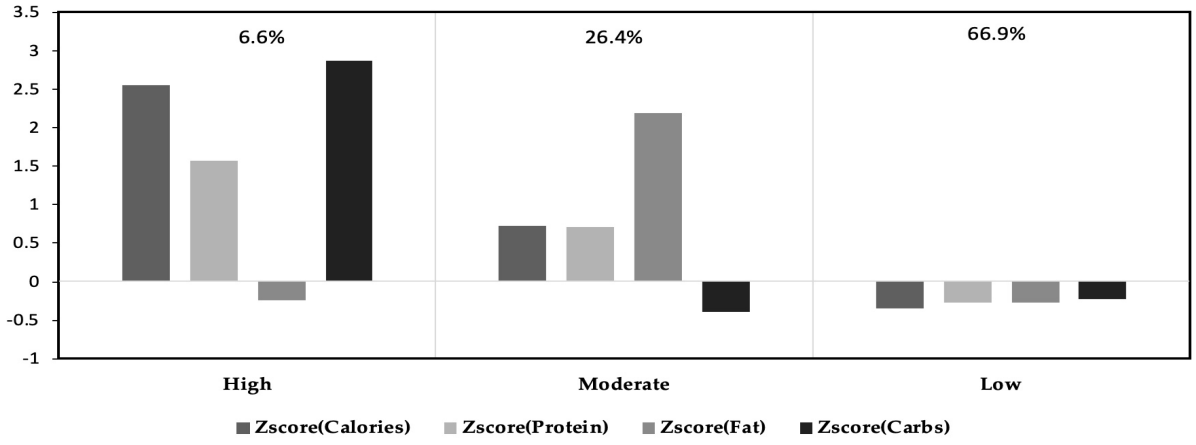

Figure 1: Average Z-score of macronutrient category K-Means clusters.

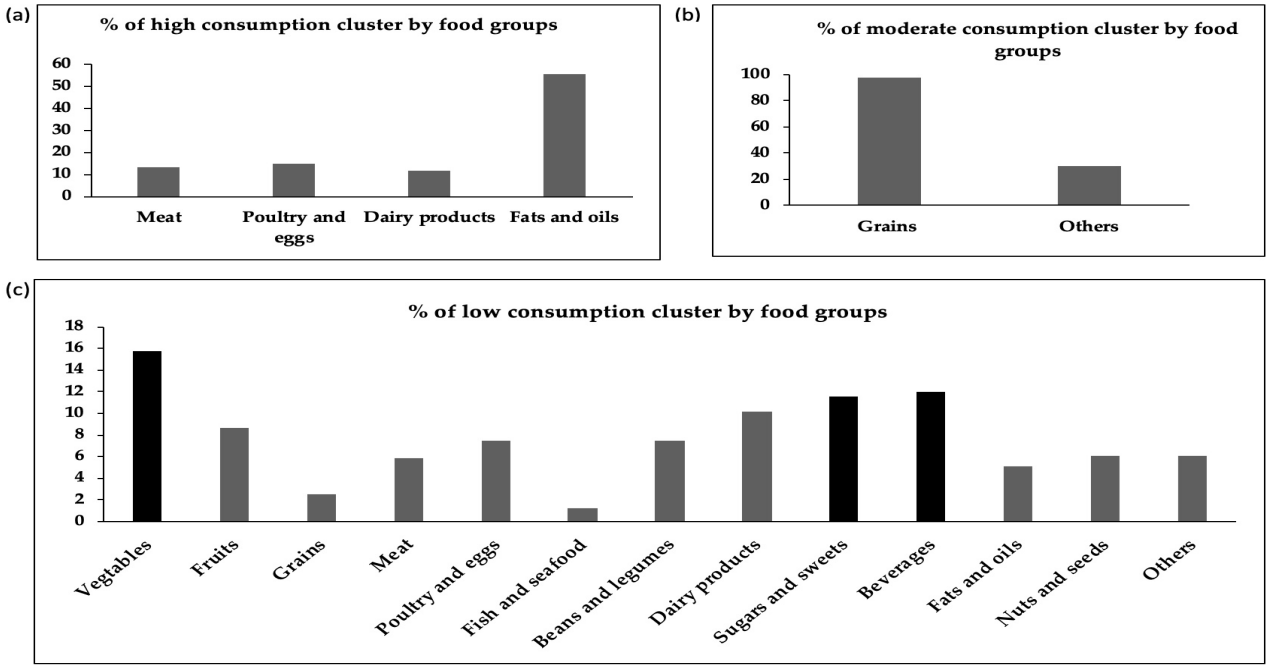

Figure 2: Percentage distribution of food groups consumption by Macronutrient category K-Means clusters.

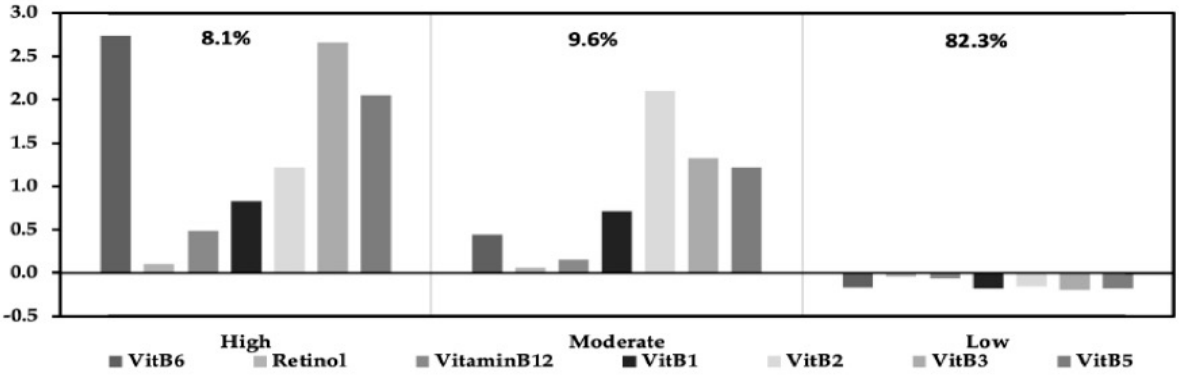

Figure 3: Average Z-Score of vitamin category K-Means clusters.

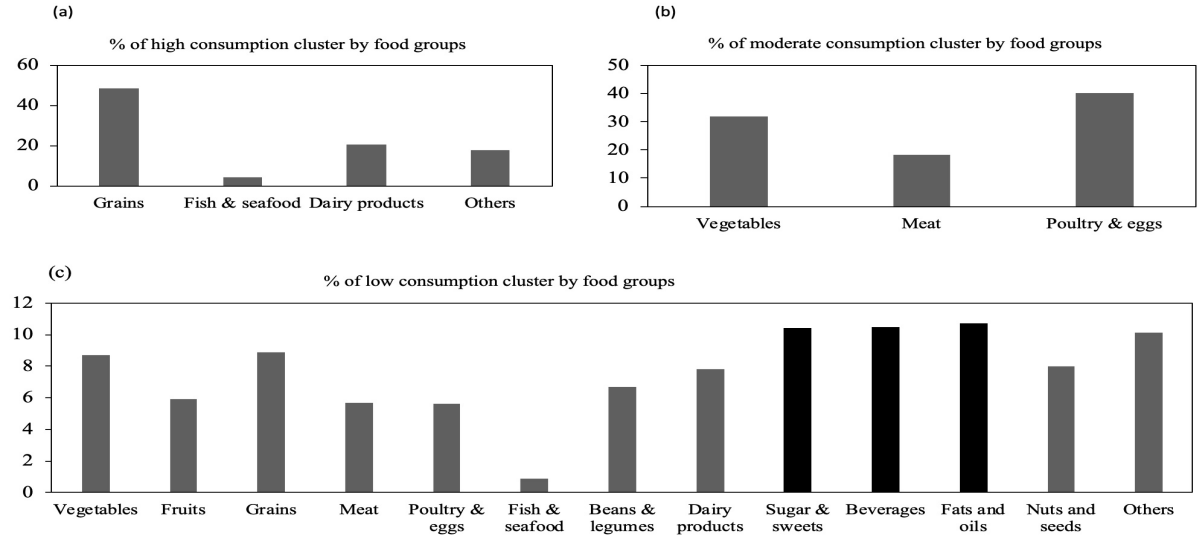

Figure4: Percentage distribution of food groups consumption by Vitamins category K-Means clusters.

-0.1, -0.2, -0.2,-0.3,and -0.2) respectively. Characteristics of children described in the different clusters by the consumed food group are described in figure 4. The vitamin high cluster consumed pattern (Figure 4a) included a high percentage of consumption of grains and dairy products (48% and 20%) of the sample and a significantly higher percentage of girls than boys did. In the moderate cluster consumed pattern (Figure 4b), children consumed high vegetables, meat and poultry and eggs (31%, 18%, and 40%) of the sample and a significantly higher percentage of girls than boys did. In the low cluster consumed pattern (Figure 4c), children consumed more sugar, beverages, fats and oils (10.1%, 10.2%, and 11%) respectively of the sample and a significantly higher percentage of girls than boys did. Figure 5 shows the characteristics of minerals clusters,

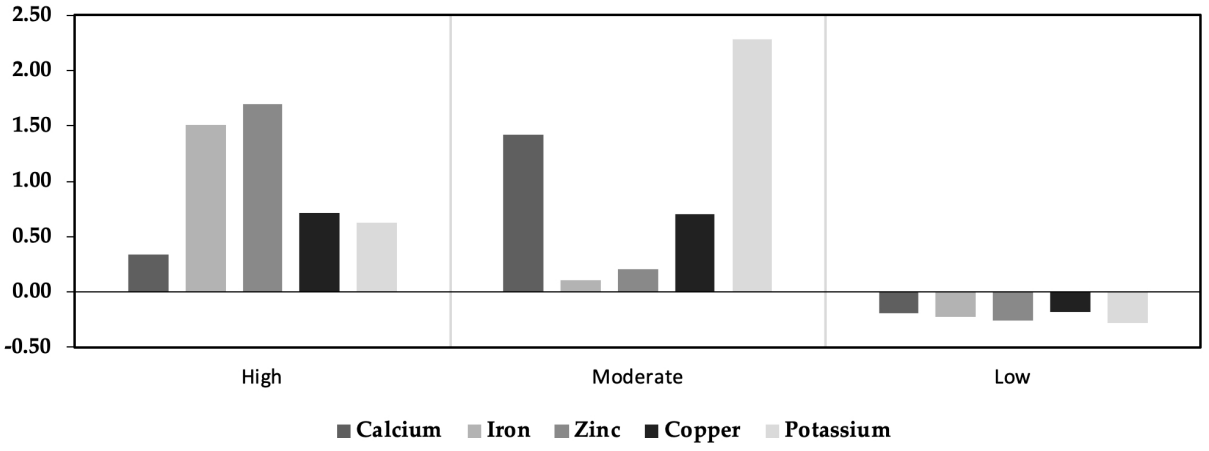

Figure 5: Average Z-Score of Minerals category K-Means Clusters.

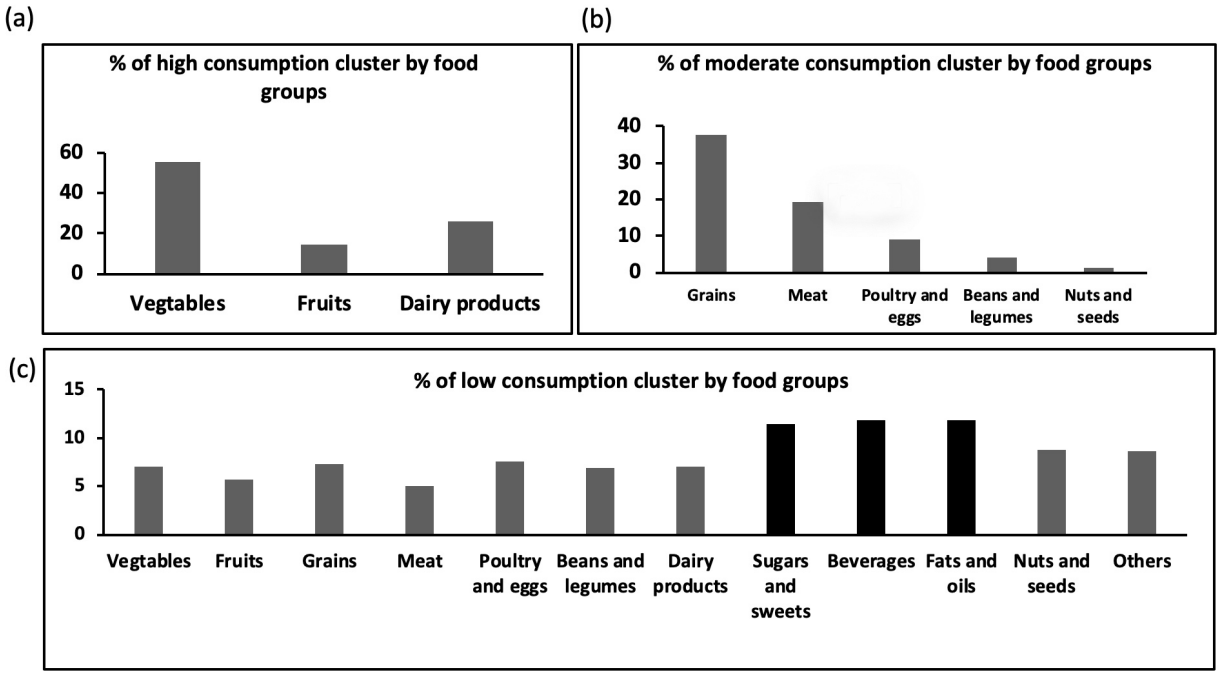

Figure 6: Percentage distribution of food groups consumption by minerals category K-Means clusters.

the percentage distribution of high, moderate, and low clusters is (3.8%, 18.9%, and 77.3%), respectively. Children aggregated into cluster 1 had high Z-Score of calcium, iron, zinc, copper, and potassium (0.3, 1.5, 1.7, 0.7, and 0.6 respectively. Children in cluster 2 scored moderate Z-score in calcium, zinc,copper, and potassium (1.4, 0.21, 0.7, and 2.3). Children in cluster 3 scored negatively on calcium, iron, zinc, copper and potassium (0.2, -0.22, -0.25, -0.18, and -0.28) respectively. Characteristics of children described in the different minerals clusters by the consumed food group are described in figure 6. The minerals high cluster consumed pattern (Figure 6a) included high vegetables, fruits, and dairy products (57%, 15%, and 27%) of the sample and a significantly higher percentage of girls than boys. In the moderate cluster consumed pattern (Figure 6b), children consumed a high percentage of grains and meats (48% and 19%), of the sample and a significantly higher percentage of girls than boys. In the low cluster consumed pattern (Figure 6c), children consumed more sugar, beverages, and fats and oils (11.5%, 11.9%, and 11.9%) respectively of the sample and a significantly higher percentage of girls than boys.

Discussion

The present study involves a national sample of schoolchildren aged 11-16 years-old from West Bank to assess the frequency of food consumption, the energy and nutrient intakes, and the patterns of food groups' consumptions. The study used K-Means cluster analysis to identify the consumption patterns, nutrient intake, and lifestyle differences. This study identified the consumption clusters and adds to the literature information about Palestinian children's food groups' consumption and nutrient intakes patterns, as well as how the clusters linked with lifestyle, physical activities, and demographic variables. Among all students, about 14% were overweight or obese, and more than half of the students corresponded to a moderate level of activity. Boys reported higher activity levels than girls. Furthermore, boys spent more time in leisure time activities than girls. A high portion of students consumed poor healthy foods including take-away, sweet, beverages, and energy drinks. Boys consumed higher unhealthy food than girls.

The results are consistent with findings by other authors reporting food frequency patterns among schoolchildren (Pérez-Rodrigo et al. 2015; Gharib and Rasheed 2011). The food frequency results indicated that students consumed high portions of vegetables, sweets, and soft drinks. Boys consumed higher energy and soft drinks than girls, while girls consumed higher sweets and chocolates than boys. Girls consumed more vegetables and fruits, while boys consumed more milk and milk products. The results of 24-hour recall reported the energy and nutrient intakes among school children. The study has its drawbacks of a one-time 24-hour recall that may not enough to represent the individual usual diet. However, it does represent the average daily consumption of students' groups because of the data analysis unaffected by person variation. The findings related to food frequency clusters are consistent with food consumption patterns in other studies (Desbouys et al. 2019; Williamson et al. 2020).

The mean energy intakes of Palestinian children were higher than RDA standards as well as values reported by USDA (Institute of Medicine 2009). The mean energy intake of children compared by other same-age students is a serious concern (Gharib and Rasheed 2011). High average of energy consumption contributed to high prevalence of overweight and obesity (Faught et al. 2017; Gharib and Rasheed 2011;

James 2008; Farpour-Lambert et al. 2015; Elessi and Albaraqouni 2019; Al et al. 2009). The average protein, carbohydrate, and fat intakes were above the RDA values about USDA standards. The macronutrients consumptions increased with age due to increasing intakes of soft drinks, sweets, chocolates, and energy drinks.

It is a serious concern that around 60% of students consumed at least one soft, or energy drink per day. The increase in the consumption of sugar has been associated with overweight and obesity(Grieger, Scott, and Cobiac 2012). Besides weight problems, sugar consumption is likely to decrease children's HDL cholesterol, increase LDL cholesterol, blood glucose, and insulin concentration factors which are related to Coronary Heart Disease mortality(Gerbens-Leenes, Nonhebel, and Krol 2010; Gharib and Rasheed 2011; Grieger, Scott, and Cobiac 2012). Furthermore, the increase in sugar consumption will cause the nutritional inadequacy of vitamins and minerals(Gharib and Rasheed 2011).

The results obtained in the present study matched previous studies in children and adolescents that used k-Means analysis to identify food consumption patterns, dietary intakes and lifestyle variables(Landsberg et al. 2010; Magee, Caputi, and Iverson 2013; Sanchez et al. 2007; Lioret et al. 2008; Sabbe et al. 2008; Gharib and Rasheed 2011; Grieger, Scott, and Cobiac 2012; Heng and House 2018). Cluster analysis groups students' intakes into mutually exclusive groups based on the similarity in food groups consumed, allowing clusters comparisons. The food frequency k-Means clusters produced three clusters classifying the food consumption patterns. The FFQ clusters in this study are consistent with findings by other studies reporting traditional, non-traditional and mixed consumption patterns that combine healthy and unhealthy food groups and assessed the relationship with physical activities and lifestyle.

Several studies have identified a healthier or traditional food consumption in children, with higher scores of vegetables, fruits, and dairy products(Rathnayaka, Selvanathan, and Selvanathan 2019; Kunin-Batson et al. 2015; Heng and House 2018; Landsberg et al. 2010). Other studies described non-traditional or mixed food consumption as unhealthy consumption patterns with high scores of soft drinks, sweets, and chocolates, and energy drinks(Gharib and Rasheed 2011; Magee, Caputi, and Iverson 2013; Grieger, Scott, and Cobiac 2012; Sanchez et al. 2007). Numerous studies assessed the combination clustering with lifestyle, physical activities, and a healthy diet(Aguilà et al. 2017; Magee, Caputi, and Iverson 2013; Sanchez et al. 2007; Lioret et al. 2008; Landsberg et al. 2010). Leech et al. (Rebecca M. Leech, McNaughton, and Timperio 2014)conducted a systematic review on the clustering of diet, physical activity, and sedentary behavior among children and adolescents aged 9–21 years, his study found that most of children and adolescents had mixed consumption pattern of healthy and unhealthy food. Another study also identified that a higher portion of girls aged 10-12 years old falls in low physical activity (Sanchez et al. 2007).

In our study, Z-scores K-Means clustering was used to identify the energy and nutrient intakes clusters among Palestinian schoolchildren. Three nutrient intakes categories were found, the macronutrient, vitamins, and minerals. Several studies used cluster analysis to identify the relationship between dietary intakes pattern and lifestyle (Jongenelis et al. 2020; Kulik et al. 2019; Pala, Reisch, and Lissner 2019; Shah et al. 2019; Nubani-Husseini et al. 2016).

The study extended other similar studies and identified three clusters (high, moderate and low) consumption patterns (Niermann, Spengler, and Gubbels 2018; Wirfält and Jeffery 1997; Grieger, Scott, and Cobiac 2012; Landsberg et al. 2010; Rebecca

M. Leech, McNaughton, and Timperio 2014; Sabbe et al. 2008). The macronutrient group identified approximately 81% of students with the negative and low z-scores cluster. Students in this cluster consumed more vegetables, sugar, and beverages. The vitamin group identified approximately 82% of students with low and negative scores, students in this cluster consumed more sugar, beverages, fats, and oils and vegetables. The minerals cluster identified approximately 77% of students with low and negative scores, the students consumed more sugar, beverages, and fats and oils.

It is expected that students in these ages consumed higher intake of sugar and soft-drinks and lower healthy nutrient intakes. Interestingly, there was a significant difference in nutrient intakes clusters with gender. Girls have a significant difference in consuming more vegetables in macronutrient groups and more sugar and chocolates in vitamins and minerals groups. The results in this study extended the results of other previous studies using cluster analysis that focused on dietary intakes, lifestyles, and sociodemographic status (R. M. Leech, McNaughton, and Timperio 2014; Gubbels, van Assema, and Kremers 2013; Hosseini et al. 2019; Sanchez et al. 2007; Rebecca M. Leech, McNaughton, and Timperio 2014; Sabbe et al. 2008). These studies have identified that schoolchildren consumed high energy food intakes and more unhealthy food groups, similar to these studies the Palestinian children highly exposed to takeaway food and soft-drinks, chocolates and energy drinks. The widespread of take-away food and sugar and energy drinks increased the students' accessibility to unhealthy food.

Difference between boys and girls in average grams consumption by food group dietary pattern indicated a significant difference by gender distribution, the boys consumed higher grams in vegetables, fruits, grain, meat, dairy products, and beverages, while girls had higher consumption in beans and legumes, fats and oils, and sugars and sweets groups. The food group consumption by gender was reported by other authors(Vasileska and Rechkoska 2012; Desbouys et al. 2019; Gharib and Rasheed 2011; Grieger, Scott, and Cobiac 2012). Gender difference in daily consumption was found, boys consumed higher vegetables, grain, beans and legumes, meat and poultry and eggs. Contradictory results have been reported regarding sugars and sweets, and fats and oils (Gharib and Rasheed 2011), boys consumed higher grams than girls, however, gender significant difference was found(Grieger, Scott, and Cobiac 2012).

The strengths of this study were found in the design of 24-hour food recall data. Food consumption data were analyzed using the Palestinian food recipes database and the Palestinian food composition table developed by ANAHRI. The food consumption classification according to the international food groups categories using energy and grams distribution was the first study among Palestinian schoolchildren. The cluster analysis using food frequency and nutrient intakes allowed us to identify the actual dietary patterns without any predefined criteria and their difference with physical activities, lifestyle and gender provided a comprehensive perspective.

There are some limitations to the present study, including the cross-sectional approach. Therefore, it provides evidence for the association but not causal relationships. Measures of food frequency consumption and physical activity relied on self-reports and were possibly biased, although a careful multistep quality control procedure was implemented under the supervision of the Ministry of the Education team to minimize bias. However, misreporting can influence the potential association with study variables. Cluster analysis is an observed method

of defining similar groups of individuals and is particularly appropriate for identifying groups that could benefit from interventions. A series of particular actions are required when carrying out a cluster analysis, including the selection of food groups, the variables used to determine clusters, especially the nutrient intakes clusters (e.g. grams of consumption, frequency of consumption, vitamins, and minerals), the number of clusters, and the clusters. These actions may not be appropriate in different populations. Thus, the repeatability and generalization of cluster analysis in different populations are limited. However, we performed the same cluster analysis methodology in the study population using the 24-hour face to face interview data, in which three similar clusters found. Using a single day's food intake may also misclassify individuals into a different cluster than what may occur after a longer-term intake. Finally, K-Means analysis is a procedure commonly used to identify dietary patterns and analyze the clustering of lifestyle. However, long term intake may provide more adequate clusters and better to identify patterns and clusters.

Conclusion

Three food consumption patterns were identified, traditional, none-traditional, and mixed, the traditional is close to the Mediterranean diet. Energy and nutrient intakes cluster analysis classified students into three groups with three clusters each. The macronutrient group, vitamins, and minerals. The clusters were identified as high, moderate, and low consumption scores. The lifestyle and physical activity identified two groups of students, unhealthier lifestyle patterns with low physical activity and high consumption of unhealthy foods; and healthier lifestyle patterns with high physical activity and high consumption of healthy foods. The significant differences were found in children into different clusters. Future research using larger samples is needed to further examine how food groups consumption and lifestyle patterns of nutrient intakes track over time and influence on children's health. These cluster analyses are helpful to identify Palestinian children's consumption patterns and act as a baseline for potential intervention strategies.

Declarations

Ethics approval and consent to participate The study received ethics approval from the Health Research Ethics Boards at the Ministry of Education and Al-Quds University. Written informed consent was obtained from all parents and written assent was obtained from children.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to the current use by other Ph.D. students but are available from the corresponding author on reasonable request

Author Contributions

Conceptualization R.Q., Z.A, and H.S; methodology, validation, formal analysis, and writing—review and editing, R.Q., D.A, and Z.A.; review and editing Z.A and H.S.; writing—original draft preparation, R.Q; project administration, R.Q and Z.A.; data curation, H.T, and R.A.Competing interests: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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