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The correlation between major dietary patterns and blood lipid composition among children and Adolescents in Qazvin

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Abstract
Studies have indicated the prevalence of dyslipidemia in childhood and adolescence. It has been proven that eating habits, which are usually formed at early ages of childhood or adolescence, could affect people's health later in life. This study aimed to examine the correlation between major dietary patterns and blood lipid composition in children and Adolescents of Minoodar neighborhood of the city of Qazvin. In this study, 324 participants aged between 10 and 18 were selected. The data on person's food intake were collected through a food frequency questionnaire. Venous blood samples were taken from all cases after a 12-hour fasting. By the use of factor analysis method, three dietary patterns were identified. The results showed that there was no significant difference between blood lipid composition and body mass index in quartile of each dietary pattern. By taking age, gender, body mass index, energy intake, and physical activity as confounders and adjusting these confounding factors, also no significant correlation was found between blood lipid and any of those identified dietary patterns. This study showed no significant association between blood lipid composition and any of three identified dietary patterns.

Keywords: Adolescent, Diet, Factor Analysis, Lipids

Introduction
The disruption of lipid composition and other risk factors for cardiovascular diseases in children and adolescents are related to atherosclerosis and its severity in adulthood [1]. Although a few studies have been conducted to measure the lipid composition and lipid-related disorders in Iranian children and adolescents, all of them have shown the prevalence of dyslipidemia among this group [2-4]. Some studies have emphasized the prevention of this disease primarily in childhood and adolescence, because atherosclerosis process begins in early stages of life [5-6].

Today, a change in food consumption patterns and children and adolescents' tendency to consume fast foods are among factors leading to excessive intake of calories, fats, salt and fewer intake of micronutrients required for this age group, which in addition to increasing obesity, paves the way for cardiovascular diseases [7]. From a dietary perspective, eating too little dairy products, vegetables, fruits, breakfast, and intake of cakes, chocolates, and sweet beverages, which is related to some chronic diseases, has been reported among Moroccan Adolescents [8]. Less physical activity, high Body Mass Index, and bigger waistline are also mostly reported in Adolescents who have unhealthy dietary patterns [9]. Another study among respondents aged from 12 to 24 years old indicated that a dietary pattern that includes fruits and vegetables is related to higher levels of High Density Lipoprotein Cholesterol (HDL-C) as well as lower levels of Low Density Lipoprotein Cholesterol (LDL-C) and Triglyceride (TG) [10]. A study on nutritional knowledge and habits among Adolescents in Tehran showed in spite of having reasonable knowledge about nutrition, only 15% of girls and 25% of boys had acceptable nutritional habits [11]. As different components of diet could affect blood lipid composition, the intake of fat, carbohydrate, vitamins, and minerals is effective in blood lipid. Also, a strong relationship has been observed between different nutrients and total cholesterol, LDL-C, HDL-C, and TG levels [12].

As a result, the researchers have paid more attention to the dietary patterns over the past decade. Conventional studies in nutritional epidemiology are usually focused on the effect of single nutrients or foods, while nutrients are themselves a part of food that a person consumes. The effect of food can be investigated through the person's whole dietary pattern [13]. Most of the surveys conducted on dietary patterns have emphasized the recognition of regional dietary pattern based on gender, race, culture, geography and socio-economic status [14].

Due to the fact that few studies have been carried out about the recognition of dietary patterns [9,15] and rampant lipid disorders among Iranian Adolescents and because eating habits, formed during childhood and adolescence, could influence health and disease pattern in adulthood [7], this study aimed to examine the correlation between major dietary patterns and blood fat composition in children and Adolescents of Minoodar neighborhood.

Method

This cross-sectional study investigated the correlation between nutritional status and the blood lipid composition. It is a part of the first stage of a study on the rampant Metabolic Syndrome in the age range of 10 to 18 at minoodar population research center. Minoodar district is located in northwest of the city of Qazvin, Northwest of Iran, and has a homogenous demographic pattern. So, it is the only area in Qazvin province which hosts the provincial center for demographic studies. The sampling method was according to multistage clustering. The trained health workers interviewed 321 participants aged from 10 to 18 to gather the required data. Sample size was estimated to be 321 by considering confidence interval of 95%, precision of 5%, and the expected dropout rate of 20%.

Food intake on daily, weekly, and monthly basis in the past year were collected through Food Frequency Questionnaires (FFQ) [16]. For calculating the amount of food each person consumed, his/her food consumption at home was taken, turned to grams and the data were exported to Microsoft Excel Program [17]. Boys with energy intakes less than 800 and more than 5,000 kilocalories as well as girls with energy intakes less than 600 and more than 4,500 kilocalories [14] were removed from the study and the data from 301 remained participants were analyzed.

The weight was measured by a Seca digital scale with accuracy of 100 grams when the subject worn light clothing without shoes. Their height was measured in standing position while wearing no shoes [14].

Body Mass Index (BMI) was calculated by dividing weight to the square of height (kg/m^2) and assessed by using gender-specific BMI-for-age percentile cut-offs recommended for children and Adolescents by the Center for Disease Control and Prevention (CDC)[18]. Adolescents with BMI less than fifth percentile were considered underweight, those with BMI between 5th and 85th percentile were considered to have healthy weight, those with

BMI between 85th and 95th percentile were considered overweight and finally, the cases with BMI equal or higher than 95th percentile were categorized as obese.

After receiving parents' consent and 12-hour fasting, a three-milliliter venous blood sample was taken from all cases at a same laboratory. The amounts of Triglycerides, total Cholesterol, LDL-C (Low-Density Lipoprotein Cholesterol) and HDL-C (High-Density Lipoprotein Cholesterol) were measured through enzymatic method of an automatic analyzer and were compared with the criteria recommended for children and Adolescents [19].

For measuring their physical activity, the participants responded to the valid and reliable questionnaire of Physical Activity Questionnaire for older adolescent (PAQ-C) [20] which contains nine questions. A teenager with an average score ranging from 1 to 2.33 was classified in the low physical activity group, between 2.34 and 3.66 had moderate physical activity, and between 3.67 and 5 were considered as cases with high physical activity levels [21].

All statistical analyses were performed using Statistical Package for Social Sciences (SPSS, version 18; Chicago, IL). Data were expressed as mean ± SD or proportions as appropriate. Normality of data was checked using Kolmogrov-Smirnov statistic. Differences in proportions were evaluated using Chi-square between treatment groups. Data was analyzed by independent sample t-test (for normally distributed variables) or Mann–Whitney U (for non-normally distributed variables).

Table 1 *Food groups and factor loading for three main dietary patterns**

Food groups	Food items	Food patterns		
		First	Second	Third
Bread	All kinds of bread	0.403	-------	0.498
Grains	Rice, pasta, barley	-------	-------	0.518
Potato	Boiled, chips, French fries	0.465	-------	-------
Legumes	Lentils, lima, beans, soy beans	0.343	-------	-------
Red meat	Beef, lamb, hamburger	0.436	-------	-------
Poultry	Chicken	0.403	-------	-------
Fish	Canned tuna fish, other fish	0.449	-------	-0.445
Egg	Egg	-----	0.623	------
Organ meat	Liver, kidney, heart	0.450	-------	-------
Fast food	Pizza, sausages, salami	0.321	-0.469	-0.365
Low-fat dairy product	Low-fat milk and yogurt, cheese, yogurt drink	0.353	0.500	-------
Full-fat dairy products	Whole milk, cream, ice cream, full-fat yoghurt and fat cheese, cream	0.458	-------	-------
Vegetables	All kinds of vegetables, leafy vegetables, garlic, onion	0.552	0.391	-------
Fruits	All kinds of fruits, canned fruits, juice, dried fruits	0.593	-------	-------
Nuts and oily seeds	Peanuts, almonds, pistachios, hazelnuts, walnuts, sunflower and pumpkin seeds	0.515	-------	------
Fat	Hydrogenated fat, ghee, butter, mayonnaise	0.440	-------	------
Oil	Olive, canola, corn, sunflower	------	-------	-------
Salt and salty foods	Salty snacks, Pickles	0.593	------	-------
Flavor	Tomato sauces, spices	0.421	------	-------
Sweets	Cookies, cakes, confections	0.476	------	-------
Sugars	Honey, jam, marmalade, chocolates, sugars	0.450	------	0.436
Drink	Cola, industrial fruit juices	0.494	-0.504	-------
Tea & coffee	Tea, coffee	0.337	0.338	-------
Percentage of variance explained		13.90	10.13	8.27

*Values <0.30 were excluded for simplicity.

To identify major dietary patterns based on the 23 food groups (Table 1), we used principal component analysis, and the factors were rotated by orthogonal transformation. The natural interpretation of the factors in conjunction with Eigen-values>1 [22] and the Screen test were used to determine whether a factor should be retained.

Results

Almost half of the participants (154 out of 301) were female and the rest (147 out of 301) were male with mean age of 15.8 years. The population's anthropometric, biochemical, and energy characteristics and macronutrient intake have been shown based on their gender in Table 2.

In comparison with the standard values, the prevalence rate of Hypertriglyceridemia, Hypercholesterolemia, High LDL Cholesterol, and Low HDL Cholesterol in subjects under the study were 7.17, 1.5, 7.3, and 36%, respectively.

Table 2 *Characteristics of participants based on gender*

	Boy n= 147	Girl n=154	Total n=301	p
Age (y)	14.97±2.47*	15.19±2.43	15.08±2.45	0.44**
Body mass index (kg/m²)	19.86±4.05	19.81±3.99	19.83±4.01	0.91
Cholesterol (mg/dl)	151.85±31.89	152.66±26.88	152.26±29.40	0.81
Triglyceride (mg/dl)	95.52±44.78	102.45±69.48	99.06±58.70	0.31
LDL-c (mg/dl)	88.81±21.89	88.74±21.03	88.78±2.42	0.97
HDL-c (mg/dl)	40.75±7.58	42.23±8.36	41.51±8.01	0.11
Total energy (Kcal/d)	2923.48±847.80	2681.72±804.33	2799.79±833.31	0.01
Carbohydrate (g/d)	424.39±128.33	353.03±113.58	398.11±123.51	0.001
Protein (g/d)	96.53±28.41	88.11±29.50	92.22±29.23	0.01
Fat (g/d)	99.70±35.99	99.38±37.93	99.54±36.93	0.94
Physical activity level				
Low level (%)	9.9	21.4	31.3	
Moderate level (%)	22.4	22.1	44.6	0.001
Severe level (%)	16.3	7.8	24.1	

*Data are mean ±SD.
** p-value obtained from independent-sample T-test for quantitative variables and chi-square test for qualitative variables.

67.1 percent of the cases had normal BMI and there was no significant difference in the serum lipid composition (total Cholesterol (p=0.813), Triglyceride (p=0.313), LDL Cholesterol (p=0.978), HDL cholesterol (p=0.114), and fat intake (p=0.94) and BMI (p=0.09)) between boys and girls, though the amount of energy (p=0.012), protein (p=0.012), and carbohydrate intakes (p=0.001) in boys were significantly higher than in girls.

In total, 31.1 percent of Adolescents had low physical activity, 24.1% had moderate physical activity, and only 6.44% had high physical activity. There was also a significant difference in physical activity between girls and boys. That means boys had a higher physical activity than girls (p=0.001).

Using factor analysis method, three dietary patterns with percent variances of 13, 10, and 8.27 were found. Table 1 shows the factor loading and the food items in each pattern. The first dietary pattern included fruits, vegetables, salty foods, high-fat dairy products, potato, spices, lamb and beef, organ meat, chicken and pastries. The second pattern consisted of egg and low-fat dairy products and the third pattern was made of bread, grains, and simple sugars.

Participants' characteristics by quartile of dietary pattern are summarized in Table 3. Blood lipid composition and BMI in each quartile of three dietary patterns were not significantly different. Since age, sex, BMI, energy intake, and physical activity were considered as confounding factors, after adjusting these factors, no relation was observed between blood lipids and each dietary pattern (Table 4).

Table 3 *Characteristics and dietary intake of participants by quartiles of dietary pattern.*

	Quartiles of dietary pattern				
First dietary pattern	Q_1	Q_2	Q_3	Q_4	p**
Body mass index(kg/m²)	20.03±3.37*	20.21±3.90	18.97±3.97	19.99±4.24	0.41
Cholesterol(mg/dl)	146.5±25.53	146.91±23.55	148.65±31.62	155.72±28.21	0.34
Triglyceride (mg/dl)	89.42±35.22	92.29±47.38	93.33±40.25	111.08±104.94	0.41
LDL-c(mg/dl)	83.18±18.44	84.95±15.33	90.32±19.90	92.11±25.31	0.08
HDL-c(mg/dl)	41.14±7.93	40.77±8.84	41.61±10.12	39.33±6.57	0.58
Total energy(Kcal/d)	2485±749.51	2714.03±679.73	2955.91±635.36	3375±743.47	0.001
Second dietary pattern					
Body mass index(kg/m²)	20.56±5.14	20.21±3.46	19.33±3.27	19.33±3.52	0.20
Cholesterol(mg/dl)	151.97±31.79	153.71±25.26	146.73±32.44	144.29±22.59	0.31
Triglyceride (mg/dl)	94.12±41.48	108.45±105.22	93.42±42.64	89.90±36.63	0.47
LDL-c(mg/dl)	85.73±19.60	89.49±19.88	87.75±24.1	87.63±17.04	0.84
HDL-c(mg/dl)	41.06±7.45	41.47±8.08	40.51±9.99	39.71±8.07	0.75
Total energy(Kcal/d)	2341.35±756.46	2694.36±553.82	3075.34±534.30	3447.85±771.55	0.001
Third dietary pattern					
Body mass index(kg/m²)	19.85±3.57	19.19±3.37	19.71±4.46	20.48±4.27	0.45
Cholesterol(mg/dl)	147.68±24.30	153.39±27.71	147.54±34.30	148.02±26.60	0.69
Triglyceride (mg/dl)	89.83±49.51	107.12±101.62	93.93±3.95	96.45±45.40	0.56
LDL-c(mg/dl)	89.83±49.51	89.13±18.90	85.42±22.81	87.67±23.05	0.88
HDL-c(mg/dl)	40.40±6.97	41.39±6.62	41.62±10.38	49.25±9.19	0.50
Total energy(Kcal/d)	2658.02±834.17	2802.70±788.61	2912.59±661.67	3181.85±743.29	0.007

Q Quartiles
*Data are mean±SD
**P-value obtained from Analysis of variance

However, a significant relation between energy intake and three dietary patterns was observed, so calorie intakes were increased in parallel with an increase in the value of dietary patterns (p=0.001), (p=0.001), p=(0.007).
Also, there has been no significant difference between physical activity levels and dietary patterns quartile ((p=0.09), (p=0.75), (p=0.51)).

Discussion

Using factor analysis method and data gathering from Food Frequency Questionnaire (FFQ), we could identify three food patterns that cover 31.32% of the total variance in food intake.
The dietary pattern in the class A is the closest one to a healthy dietary pattern mentioned in other studies. It contains higher amounts of fruits, vegetables, and fish [22-24]. Blood lipid composition and BMI in each quartile of the three patterns were not different. The study found that 44.6 percent of the participants had moderate physical activity, however, no relation was found between the blood lipid composition, dietary pattern, and physical activity.
In general, dietary patterns associated with specific chronic diseases usually begin before the age of puberty and may change to a limited extent after that period. The dietary pattern and lifestyle during childhood and adolescence have significant effects on the prevention of chronic diseases such as obesity, cardiovascular diseases, hypertension, diabetes, and cancers [25].
In this study, the most common form of dyslipidemia is low HDL Cholesterol and high levels of Triglycerides, that is similar to the results of another study by Fesharaki-Nia [2]. Two other studies by Azizi [3] and Delcini [26] have shown that the most common forms of Dyslipidemia among Adolescents are high LDL Cholesterol and total Cholesterol levels, respectively. However no relation between each three patterns and the blood lipid composition was observed even when the confounding factors were removed.
It is believed that lipid disorders are related to the factors such as being overweight,

Table 4 *Multivariate adjusted means of blood fat composition across quartiles of major dietary pattern scores*

	First dietary pattern					Second dietary pattern					Third dietary pattern				
	Q_1	Q_2	Q_3	Q_4	P ð	Q_1	Q_2	Q_3	Q_4	P	Q_1	Q_2	Q_3	Q_4	p
Chol (mg/dl)*															
Model 1**	146.5±22.3	145.04±22.9	148.48±31.9	155.7±31.9	0.19	151.9±31.7	152.8±25.1	146.08±32.9	145.4±21.5	0.56	147.6±24.3	152.7±27.8	147.5±34.3	147.09±25.9	0.9
Model 2***	146.5±22.3	145/04±22.9	148.48±31.9	155.7±31.9	0.19	151.9±31.7	152.8±25.1	146.08±32.9	145.4±21.5	0.49	147.6±24.3	152.7±27.8	147.5±34.3	147.09±25.9	0.9
Model 3****	150.04±22.5	144.96±24.5	150.14±37.7	161.32±31.8	0.08	154.9±32/0	157.64±25.2	147.18±38.2	146.7±22.8	0.46	151.1±26.9	156.1±29.4	147.7±30.0	152.32±25.7	0.78
TG (mg/dl)															
Model 1	89.4±35.2	91.6±48.9	93.3±40.06	111.08±104.09	0.32	94.1±41.4	108.6±108.2	93.6±43.5	89.9±37.0	0.49	89.8±49.5	106.7±104.8	93.9±38.9	96.3±41.5	0.77
Model 2	89.4±35.2	91.6±48.9	93.3±40.06	111.08±104.09	0.40	94.1±41.4	108.6±108.2	93.6±43.5	89.9±37.0	0.42	89.8±49.5	106.7±104.8	93.9±38.9	96.3±41.5	0.78
Model 3	87.9±34.4	93.5±49.4	99.2±40.9	104.01±51.2	0.51	93.9±40.3	105.3±53.5	92.20±43.03	92.09±39.4	0.49	100.1±56.0	99.2±43.06	92.6±32.3	92.6±41.9	0.61
LDLc (mg/dl)															
Model 1	83.1±18.4	83.9±15.4	89.8±19.8	92.1±25.3	0.11	85.7±19.6	89.3±20.2	87.07±24.3	87.2±16.9	0.7	88.4±16.7	88.1±18.1	85.4±22.8	87.4±23.5	0.81
Model 2	83.1±18.4	83.9±15.4	89.8±19.8	92.1±25.3	0.29	85.7±19.6	89.3±20.2	87.07±24.3	87.2±16.9	0.73	88.4±16.7	88.1±18.1	85.4±22.8	87.4±23.5	0.66
Model 3	85.6±15.6	83.4±15.5	88.8±21.1	96.6±23.3	0.1	87.02±19.3	89.7±21/0	90.6±22.8	88.1±17.1	0.76	89.2±17.8	88.7±17.7	86.01±20.1	90.7±22.3	0.78
HDLc (mg/dl)															
Model 1	41.1±7.93	40.18±8.41	41.56±10.23	39.33±6.57	0.28	41.42±7.8	41.2±8.1	41.4±12.2	38.65±8.4	0.97	40.4±6.9	41.24±6.7	41.62±10.3	38.69±8.6	0.33
Model 2	41.1±7.93	40.18±8.41	41.56±10.23	39.33±6.57	0.42	41.06±7.4	40.8±7.5	40.51±10.18	39.65±8.15	0.97	40.4±6.9	41.24±6.7	41.62±10.3	38.69±8.6	0.40

*Data are mean± SD.
Chol (Cholesterol), TG (Triglyceride), LDL-C (Low Density Lipoprotein),HDL-C (High Density Lipoprotein)
**Adjusted for age, sex , and physical activity.
***Adjusted for age, sex, physical activity, and energy intake
****Adjusted for age, sex, physical activity, energy intake, and Body mass index.
Ð p-value obtained from Analysis of Covariance.

family history, serum lipid abnormalities [27], western dietary pattern [28], and high intake of saturated fatty acid [29]. This study found no relation between being overweight and obesity with blood lipid composition. The consumption of saturated fatty acids was also not high compared to the amount of calories intake.

The results of this study in some cases differ from the results of other studies. For example, a survey in USA on adolescents has shown that the consumption of fruits and vegetables is related to higher levels of HDL Cholesterol and low triglycerides while the consumption of pastas, beverages, and fatty foods lead to higher levels of serum triglycerides and low HDL Cholesterol [10]. Kelishadi et al. have indicated that the consumption of meat, egg, dairy products, vegetables, and fruits could reduce the risk of metabolic syndrome [30]. Oddy et al. found that western dietary patterns can increase the risk of metabolic syndrome and its associates such as serum cholesterol levels in females and healthy dietary patterns are associated with the desirable levels of HDL cholesterol in males [31]. According to a study by Shang et al., there is a positive correlation between western dietary pattern with triglycerides, LDL-Cholesterol, obesity, low HDL-Cholesterol, and Glucose levels. As the current study gathered the patients' dietary data over a cycle of 24 hours with the Food Frequency Questionnaire, which is usually used for a period of one year, there is a chance that the resulting model does not reflect all the food patterns [28]. Another research by Bradlee et al. has shown that eating at least one fruit per day could drastically reduce the ratio of LDL-Cholesterol to HDL-Cholesterol. Also, after adjusting the effects of age, socio-economic factors, physical activity, and other confounders, girls with higher consumption of fruits, non-starchy vegetables, and dairy products were 40-50 percent less at the risk of high LDL-Cholesterol than the others. The consumption of red meat as a part of healthy dietary pattern didn't have negative impact on blood lipids and also, triglycerides reduced in a dietary pattern with more whole grains [32]. Some studies, which were conducted on children [33] and adolescence [34], have shown lipid disorder and blood cholesterol are not related to a western dietary pattern including meat and processed meat, egg, refined carbohydrates, hamburger, mayonnaise, chocolates, biscuits and beverages.

So, it seems that the inconsistency between the present study and similar studies is mostly related to the large number of participants associated with the first dietary pattern which is a combination of various food groups and a balanced diet that has protective effects on lipid composition. The consumption of saturated fatty acids, as a factor influencing the lipid composition [29,35], was not high in proportion to the consumed calories. As a result, we can say that fiber intake has affected the levels of blood lipid. Fiber intake was high because of eating fruits, vegetables, nuts and oily seeds, and fibers, through different mechanisms including binding to dietary cholesterol and bile acids, reduced both the absorption of lipids and Lipo-genesis [36]. Blood lipids are affected by other factors such as physical activity. In this survey, most of the participants had physical activity in acceptable ranges. Our study also found no statistically important difference between the levels of physical activity and calorie and macronutrients intakes. This finding was in line with the findings of a study by Zaree [37]. Although by increasing quartile point of dietary pattern, energy, fat, and protein intakes increased in all three models, the amount of carbohydrate intake was only associated with the first and second patterns. In comparison with the standard model, fat, carbohydrate, and cholesterol intake were at the recommended levels and protein intake was lower than the standard values. Energy, protein, carbohydrate, and fat intakes were higher in boys than in girls and there was no significant difference in fat intake between the two groups. In Kelishadi's study, although the amount of energy produced by carbohydrates in all cases were higher than Recommended Dietary Allowances (RDA) and the energy produced through fat intake was within the RDA, the participants' lipid profiles was not desirable [1]. Azizi's survey showed that certain nutrients such as fats, saturated fats, and cholesterol were higher than recommended doses [7]. In this study, a negative significant association was observed between energy and carbohydrate intake and HDL-Cholesterol, while there was no such link with other blood lipids.

It is important to remember that there have been some limitations in this study, such as conducting for a temporary period and the lack of information about parents' blood lipid profiles. The number of samples was not also enough to help us draw a gender-based conclusion.

Conclusion

The current study was the first study to identify dietary patterns in children and Adolescents in Qazvin.

In general, very few surveys have examined the correlation between dietary pattern and blood lipids in that age group. In this study, energy, fat, and carbohydrates intakes were high in all the three main dietary patterns identified through the study. Also, over 44 percent (44.6) of children and Adolescents had moderate physical activities. We found no relation between the dietary patterns, physical activity, and blood lipids. These findings were not as what we expected probably because it was a cross-sectional study conducted for a short period of time. Due to the increase of chronic diseases and nutrition transition to adulthood, future studies with a larger sample size are suggested to determine the correlation between dietary patterns, physical activities, and blood lipid in adolescents in order to perform educational interventions.

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Contribution

Study design: MJ, SHJ

Data collection, analysis: MJ, AJ

Manuscript preparation: FS,SSH, MJ

Conflicts of Interest

The authors declare that they have no competing interests.

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