TG/HDL-C Ratio Independent of Obesity Associates With Airflow Obstruction in Asthmatic Children

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Research Article

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Abstract

There is conflicting evidence on the association between dyslipidemia and asthma. This study was to evaluate the correlation between dyslipidemia and pulmonary function parameters in asthmatic children.

Asthmatic children (aged 5–18 years old) were measured for fasting serum lipid profiles, including low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C) and C-Reactive protein (CRP). A pulmonary function test was assessed by spirometry.

One hundred-fifty asthmatic children were enrolled with the mean (sd) age 11.82 (3.38) years. Ninety-four children (62.7%) were males, and 70 children (46.7%) had dyslipidemia. Of 70 children with dyslipidemia, 15 children (21.4%) were obese. LDL-C was the most common dyslipidemia (62.85%), followed by TC (55.71%), non-HDL-C (50%), TG (34.28%), and HDL-C (17.14%). The significant correlations between % FEV_1/FVC ratio and the level of serum HDL-C and TC and TG/HDL-C ratio were observed (r=0.215, r=0.831 and r=0.17, p<0.03). There was a significant negative correlation between the level of CRP and HDL-C, and % FEV1/FVC ratio and TG/HDL-C (r =-0.236, p=0.004 and r=-0.170, p=0.038). Children with airflow obstruction (% FEV_1/FVC ratio<90) had significantly higher TG, TG/HDL-C ratio, LDL-C/HDL-C ratio but lower HDL-C. After adjusting with other blood lipids, body weight, BMI z-score, and obesity status, multiple logistic regression model demonstrated that only TG/HDL-C ratio was associated with % FEV_1/FVC ratio<90, OR 2.78; 95% CI 1.5-5.15, p =0.001.

Conclusion: The prevalence of dyslipidemia in children with asthma is high. TG/HDL-C ratio is associated with airflow obstruction in asthmatic children.

Clinical Trial Registration: TCTR20200305005 date of registration 2020-03-04 retrospectively registered

What Is Known

- TG/HDL-C ratio is a strong marker of cardiometabolic risk in children.
- A higher prevalence of asthma has been reported in children with a higher TG/HDL-C ratio.

What is new

- 46.7% of asthmatic children had dyslipidemia but only 21.4% of them were obese.
- Asthmatic children with airflow obstruction had a higher level of TG/HDL-C ratio.

Introduction

The prevalence of dyslipidemia in children has increased in recent years due to the global epidemic of childhood obesity. Among children and adolescents in the United States, approximately 20% of children and adolescents aged 8 to 17 have abnormal lipid values of at least one or more lipid values

[1].Dyslipidemia, defined as abnormal lipid values of total cholesterol (TC) or low-density lipoprotein cholesterol (LDL-C) levels, or high-density lipoprotein cholesterol (HDL-C), or triglycerides (TG), or non-HDL-C. Definition of pediatric dyslipidemia based on the above normative data of; TC ≥ 200 mg/dL, LDL-C ≥ 130 mg/dL, TG ≥ 100 mg/dL for aged 0 – 9 years and ≥ 130 mg/dL for aged 10 – 19 years, or non-HDL-C ≥ 145 mg/dL, or below normative level of HDL-C < 40 mg/dL [2].

There is recently conflicting evidence on the association between dyslipidemia and asthma.[3,4] The prospective cohort study in children born to mothers with a doctor's diagnosis of asthma has demonstrated the increased airway obstruction in children with high LDL-C. Children with high HDL-C had better lung function and less bronchial responsiveness [3]. While a recent epidemiologic study in China found no associations between serum lipid levels and pediatric asthma [4]. Non-HDL-C and the TG/HDL-C ratio are practical addition lipid measures in evaluating dyslipidemia in children [5]. Non-HDL-C and TG/HDL-C ratio were proposed to be robust markers of cardiometabolic risk in children [5,6]. A recent study has shown the higher prevalence of asthma in children with a higher TG/HDL-C ratio [7]. However, no previous study evaluated the association of non-HDL-C and TG/HDL-C ratio and the degree of airflow limitation in asthmatic children before. The current study was to assess the correlation between dyslipidemia and pulmonary function, measured by spirometry in asthmatic children, and find the prevalence of dyslipidemia in pediatric asthma.

Materials And Methods

This cross-sectional study was conducted from January 2019 to December 2019. One hundred and fifty asthmatic children (aged 5 – 18 years old) who regularly followed up at the Pediatric outpatient clinic of Ramathibodi Hospital and having controlled asthma in the past four weeks were enrolled. The diagnosis of asthma and the definition of controlled asthma are based on Global Initiative for Asthma (GINA) [8]. The exclusion criteria were children with other underlying chronic diseases (Diabetes Mellitus, chronic liver diseases, and chronic kidney diseases). Demographic data, atopic history, medication, number of asthma exacerbations before enrollment were recorded. The Pediatric Asthma Control Test (PACT) and the Pediatric Asthma Quality of Life Questionnaire (PAQLQ) were used to assess asthma control. Ethical approval was provided by the Human Rights and Ethics Committee of the Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand (ID: MURA2019/55). Written informed consent and informed written assent for children aged seven years or older were obtained for all participants and their parents. The current study was registered at the Thai Clinical Trials Registry (No. TCTR20200305005).

Anthropometric measurements, including height and weight, were measured. Body mass index (BMI) and BMI z-score were calculated. Obesity children have defined as BMI z-score > 2.00 standard deviations (SD) according to the World Health Organization (WHO) *Report of the Commission on Ending Childhood Obesity* [2].

Blood samples were collected from the subjects after fasting for at least 8 hours. Serum lipid profiles (TC, LDL-C, TG, and HDL-C) and C- Reactive protein (CRP) were measured. Aeroallergen sensitization was evaluated by skin prick test to aeroallergen. Spirometry was performed.

Pulmonary function test assessments

Spirometer, pre-and post-bronchodilator with 400 mcg of salbutamol inhalation were evaluated. The percentage of bronchodilator response (%Δ) was calculated from the absolute difference value obtained before and after salbutamol inhalation, then divided by the absolute values before salbutamol, and the result was multiplied by 100. The spirometry was performed using Spiromaster PC-10; Chest M.I., Co Ltd, Tokyo, Japan. Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), $\%FEV_1$/FVC ratio, and forced expiratory flow at 25-75% of FVC (FEF_{25-75}) were measured.

Statistical analysis

Statistical analysis was performed using SPSS software, version 18. Differences between groups were examined using Chi-square test, student *t*-test, Mann-Whitney Test, one-way ANOVA, or Kruskal-Wallis test. Correlation analyses were performed using Pearson correlation. Logistic regression analysis was performed to investigate the relationship between the blood lipids and the risk of having airflow obstruction defined as $\%FEV_1$/FVC ratio <90 based on GINA guideline [8].

Results

One hundred-fifty asthmatic children were enrolled with the mean (SD) age of 11.82 (3.38) years. Ninety-four children (62.7%) were males, 110 children (73.3%) were allergic asthma, and 147 (98.7%) children had allergic rhinitis. Only 23 children (15.3%) were obese. The mean (SD) PACT and score PAQLQ were 23.48 (2.51), 6.55 (0.44), respectively. Seventy children (46.7%) met the criteria for dyslipidemia. Of 70 children with dyslipidemia, 15 children (21.4%) were obese, 44 children (62.85%) had high LDL-C, 39 children (55.71%) had high TC, 35 children (50%) had high non-HDL-C, 24 children (34.28%) had high TG, and 12 children (17.14%) had low HDL-C. The baseline characteristic of the enrolled children was demonstrated in Table 1.

Correlations of serum cholesterol, triglyceride, LDL, HDL, and spirometry

There were no significant correlations between TG, LDL-C, non-HDL-C, and CRP with spirometry parameters. However, significant correlations between HDL-C, TC and TG/HDL-C ration with $\%FEV_1$/FVC ratio were observed (r=0.215, p=0.008, r=0.183, p=0.025, and r=-0.17, p=0.038, respectively) (Figure 1A-C).

Correlations between CRP and Lipid Profile

A Pearson correlation analysis was performed to analyze the correlation between CRP and lipid profile. HDL-C was significantly negative correlated with CRP value (r = -0.236, p = 0.004) (Figure 1D).

However, there were no significant correlations between the level of CRP and other lipid profiles.

Comparison of spirometry between dyslipidemia and non-dyslipidemia children

There were no significant differences in the baseline characteristics between children with or without dyslipidemia (Table 2). There were no significant differences in spirometry parameters between subjects with dyslipidemia and those with normal lipid profiles (Table 2).

Comparison of spirometry parameters between obese and non-obese children

Obese children had significantly higher FVC % predicted, FEV_1% predicted but lower % FEV_1/FVC. Obese children also had significantly more %D of FEV_1 and FVC. Obese children also had a significantly higher CRP level than those having a normal weight. No significant differences in ACT/PACT and PAQLQ scores were observed. Interestingly, only the TG level was significantly different between obese asthmatic children and non-obese asthmatic children (Table 3).

Subgroup analysis comparison in lung function parameters between children with or without dyslipidemia and obesity or non-obesity

Comparison among children with obesity and dyslipidemia, obesity and non-dyslipidemia, dyslipidemia and non-obesity, and non-dyslipidemia and non-obesity demonstrated that FVC % predicted and FVC %D were significant differences among groups. The obesity with dyslipidemia and non-dyslipidemia groups had a significantly higher value of FVC %predicted and FEV_1%predicted than those of the non-obesity group. There were no significant differences in FOT parameters among these four groups. Further analysis of TG/HDL-C ratio abnormality(TG/HDL-C > 2.5) and obesity in children demonstrated that FVC % predicted, FVC %D, % FEV_1/FVC were significant differences among groups. Children who had abnormal TG/HDL-C ratio and non-obesity had the lowest % FEV_1/FVC (Table 4).

Comparison of lipid profiles between children with airflow obstruction and without airflow obstruction

Baseline characteristics and blood lipids of children who had airflow obstruction (% FEV_1/FVC ratio < 90) and children with no airflow obstruction (% FEV_1/FVC ratio $\geq$ 90) were compared. Children who had airflow obstruction had significantly higher TG, TG/HDL-C, LDL-C/HDL-C but lower HDL-C. However, children with airflow obstruction had significantly higher body weight, BMI, BMI z-score, and more obesity than those with no airflow obstruction (Table 5). Multiple logistic regression analysis demonstrated only TG/HDL-C ratio was associated with % FEV_1/FVC ratio < 90, odd ratio 2.78; 95% confident interval (CI) 1.5-5.15, p =0.001. The model was adjusted for age, body weight, height, BMI, obesity status, and blood lipid parameters.

Discussion

We have demonstrated the association of TG/HDL-C ratio and airflow obstruction in asthmatic children as defined by the FEV_1/FVC ratio < 90. In contrast, no similar association was shown with other blood lipids. A recent crossectional study in Korean adolescents has shown the greater prevalence of asthma in children who had a high TG/HDL-C ratio.[7] A study in adults demonstrated that elevated serum TG and low HDL-C were associated with self-reported wheezing after adiposity adjustment [9]. A recent study in children showed the association of a high HDL level and the improvement of specific airway resistance and decreased bronchial responsiveness [3]. A study in adults with asthma demonstrated the association of HDL and FEV_1 % predicted [10]. A recent meta-analysis has also shown the association of low HDL and pediatric asthma compared with the non-asthma group [11].

We found that obese asthmatic children had a greater FVC %predicted & FEV_1 %predicted and had a lower % FEV_1/FVC. The increase in FEV_1 and FVC in obese children may explain by the airway dysanapsis, the incongruence between the growth of the lung tissue and airway caliber [12]. Obesity has a significant effect on lung function in children.[13] However, we found that the obesity group had a greater FVC %Δ and FEV_1 %Δ value than the non-obesity group, which represents more bronchodilator reversibility of airflow obstruction in obese asthmatic children.

Apart from higher TG/HDL-C ratio, asthmatic children who had evidence of airflow obstruction (% FEV_1/FVC ratio < 90) were more obese and higher LDL/HDL-C ratio than those who had no airflow obstruction (% FEV_1/FVC ratio > 90). However, multiple logistic regression model adjusted with age, body weight, BMI, obesity status, blood lipids found only TG/HDL-C ratio was significantly associated with having airflow obstruction (% FEV_1/FVC ratio < 90) [OR 2.78; 95% CI 1.5-5.15, p =0.001. This result would suggest that the TG/HDL-C ratio, irrespective of obesity, seems to have an association with having airflow obstruction (% FEV_1/FVC ratio < 90) in asthmatic children. High TG and low HDL-C may have a role in systemic inflammation in asthmatic patients. A study in adults demonstrated the negative correlation of HDL-C, and positive correlation of TG with blood eosinophils, a marker of inflammation in asthmatic patients [14]. We also found that children who had abnormal HDL also had a significantly higher CRP level, the systemic inflammatory marker. In contrast, children who had abnormal LDL, cholesterol, or triglyceride did not have a higher CRP level. An in-vitro study of Th-cell and monocyte subsets has shown that HDL was inversely associated with monocyte activation and Th1 polarization in obese asthmatic children [15]. Additionally, dysfunctional HDL could modulate T cells through inhibiting T reg and promoting proinflammatory Th1 and Th17 cell production [16]. As a result, children with a high TG/HDL-C ratio may have chronic inflammation resulting in more airflow obstruction, as demonstrated in lower FEV_1/FVC. Intervention to lower TG and increase HDL-C may lessen the systemic inflammation and result in improved lung functions. However, further controlled study with more sample size is needed to strengthen our findings.

The prevalence of dyslipidemia in the current study is much higher (46%) than in the previous report in Thai children (11.8%) [17]. Interestingly, 55 out of 70 dyslipidemia of our enrolled children (78.57%) were not obese. Only 23 children (18.11%) among 150 children met the criteria for the diagnosis

of obesity. We have found that children who had airflow obstruction (% FEV_1/FVC < 90) had higher TG, TG/HDL, LDL-C/HDL-C ratio, lower HDL-C, and more obese. However, after the multiple logistic regression analysis, we found that only TG/HDL was associated with % FEV_1/FVC < 90. This result would suggest that dyslipidemia, especially TG/HDL-C ratio and obesity, impacts the pulmonary function test on the different mechanism.

Our study has limitations in that we did not have a control group who are non-asthmatic and non-dyslipidemia. Nevertheless, a recent study in Korean adolescents demonstrated a higher TG/HDL-C ratio in asthma than non-asthma [7]. Besides, only 5% of our enrolled children had obesity but having normal lipid profiles. The study sample size in the current study may not be large enough to differentiate the effect of obesity and dyslipidemia on pulmonary functions parameter in asthmatic children.

Conclusions

The prevalence of dyslipidemia in asthmatic children is higher than in general children. The majority of dyslipidemia asthmatic children are not obese. Abnormal TG/HDL-C but not other blood lipids are associated with airflow obstruction (%FEV_1/FVC <90) irrespectively from obesity. Intervention for improving the level of TG/HDL-C ratio may benefit lung function parameters in asthmatic children.

Abbreviations

Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), forced expiratory flow at 25-75% of FVC (FEF_{25-75}).Pediatric Asthma Control Test (PACT), Pediatric Asthma Quality of Life Questionnaire (PAQLQ), C- Reactive protein (CRP),high-density lipoprotein cholesterol (HDL)

high low-density lipoprotein cholesterol (LDL-C)

Declarations

Acknowledgment

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Availability of data and material (data transparency): : Yes the linked will be provided

Code availability (software application or custom code): NA

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WM draft the manuscript. WM edited the final manuscript. All authors read and approved the final manuscript.

Ethics approval: Ethical approval was provided by the Human Rights and Ethics Committee of the Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand (ID: MURA2019/55) (include appropriate approvals or waivers)

Consent to participate :Written informed consent and informed written assent for children aged seven years or older were obtained for all participants and their parents

Consent for publication: Written informed consent and informed written assent for children aged seven years or older were obtained for all participants and their parents

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Tables

Table 1: Baseline characteristics of the participants

Patient features	N = 150
Age (years)	11.82 (3.38)
Gender: Male	94 (62.7)
Female	56 (37.3)
BW (kg)	47.43 (19.57)
Height (cm)	149.85 (134, 162.5)
BMI (kg/m2)	19.15 (16.2, 24.1)
BMI Z-Score	0.35 (-0.8, 1.57)
Obesity	23 (15.3)
History of Atopic disease	
· Allergic rhinitis	148 (98.7)
· Atopic dermatitis	10 (6.7)
· Food allergy	16 (10.7)
Family history of allergic disease	
Parents	45 (30)
Sibling	32 (21.3)
Atopic Asthma	110 (73.3)
Dyslipidemia	70 (46.67)
· High TC	39 (26)
· High LDL-C	44 (29.3)
· High Non-HDL-C	35 (23.3)
· High TG	24 (16)
· Low HDL-C	12 (8)
CRP (mg/dL)	0.65 (0.23,1.83)
PACT* (score)	23.48 (2.51)
PAQLQ** (score)	6.55 (0.44)

Data present as mean (SD), median (IQR) or n (%) PACT*: Pediatric Asthma Control Test, PAQLQ**: Pediatric Asthma quality of life questionnaire

Table 2: Comparison between asthmatic children with dyslipidemia and non-dyslipidemia group

Parameters	Dyslipidemia N = 70	Non-dyslipidemia N = 80	P-value
Age (year)	11.48 (3.34)	12.11 (3.40)	0.778
Body weight (kg)	47.74 (21.23)	47.15 (18.12)	0.058
Height (cm)	147 (132,162)	153 (137, 163)	0.572
BMI (kg/m^2)	20.75 (16.12, 24.44)	18.7 (16.2, 23.3)	0.130
BMI Z-Score	0.46 (-0.7, 1.74)	0.25 (-0.93, 1.35)	0.160
Obesity	15 (21.4%)	8 (10%)	0.069
Atopic asthma	47 (67.1%)	63 (78.8%)	0.139
PACT (score)	24 (22, 25)	24 (22, 25)	0.779
PAQLQ (score)	6.6 (6.42, 6.83)	6.7 (6.48, 6.85)	0.791
CRP (mg/dL)	1.02 (0.30, 2.19)	0.44 (0.20, 1.48)	0.104
Spirometry values			
· FVC %Predicted	91.7 (85.6, 101.4)	90.9 (83.5, 98.9)	0.453
· FVC %Δ	1.5 (-0.5, 2.8)	0.7 (-1.3, 3.5)	0.409
· FEV_1 %Predicted	86.9 (78.7,95.3)	83.7 (78.5, 92.2)	0.480
· FEV_1%Δ	5 (2.8, 7.4)	4.4 (2.1, 8.2)	0.568
· FEV_1/FVC	86.92 (84.54, 89.59)	87.16 (81.69, 91.15)	0.652
· FEV1/FVC %Δ	3.4 (1.4, 6.3)	3.3 (1.4, 5.7)	0.685
· $FEF_{25-75\%}$ % Predicted	82.5 (70.4, 92.9)	80.3 (68.3, 100.3)	0.973
· $FEF_{25-75\%}$ %Δ	19.1 (11.4, 28.7)	15.9 (8.9, 25.8)	0.268

Table 3: Comparison between obese and non-obese asthmatic children

Parameters	Obese N = 23	Non-obese N = 127	P-value
Age (years)	11.17 (3.66)	11.93 (3.32)	0.32
Height (cm.)	147.59 (16.69)	148.71(17.09)	0.77
PACT (score)	24 (22, 25)	24 (21, 25)	0.779
PAQLQ (score)	6.52 (0.42)	6.55(0.44)	0.791
CRP (mg/dL)	1.92(0.99,4.82)	0.42 (0.22, 1.56)	<0.001
Lipid Profiles			
• TC (mg/dL)	178.69(33.22)	182.13(30.47)	0.624
• LDL-C (mg/dL)	116.04(37.09)	113.41(29.11)	0.703
• Non-HDL-C (mg/dL)	125.30 (37.92)	124.33(27.62)	0.76
• TG (mg/dL)	116.17(61.13)	79.41(31.45)	<0.001
• HDL-C (mg/dL)	52.39 (24.97)	57.80 (12.07)	0.107
• TG/HDL-C	2.58 (1.83)	1.46 (0.73)	<0.001
• LDL-C/HDL-C	2.53 (1.15)	2.05 (0.69)	0.008
Spirometry parameters			
• FVC %Predicted	97.7 (91.3, 103.0)	89.7(83.3, 98.9)	0.006*
• FVC %Δ	3.5(1.4, 4.7)	0.7 (-1.3, 2.6)	<0.001*
• FEV_1 %Predicted	90.3 (83.3,93.8)	83.7 (77.5, 92.2)	0.037*
• FEV_1%Δ	7.5 (3.8, 10.3)	4.4 (2.1, 7.4)	0.008*
• FEV_1/FVC	85.9 (79.5, 87.2)	87.5 (82.35, 91.03)	0.024*
• FEV1/FVC %Δ	2.5 (1.1, 6.0)	3.3 (1.4, 6.1)	0.62

• $FEF_{25-75\%}$ % Predicted	83.8 (69.9, 93.0)	80.7 (68.5, 96.4)	0.86
• $FEF_{25-75\%}$ %Δ	17.7 (10.0, 31.6)	18 (10.3, 27.1)	0.739

Data present as median (IQR) or mean (sd). % Δ represents the percentage of bronchodilator response

Table 4: Subgroup analysis to obesity for lung function parameter in dyslipidemia and non-dyslipidemia group

Parameter Spirometry values	Dyslipidemia Obesity N = 15	Dyslipidemia Non-obesity N = 55	Non-dyslipidemia Obesity N = 8	Non-Dyslipidemia Non-obesity N = 72	P-value
FVC %Predicted	97.7 (90.4, 101.4)*	89.8 (84.1, 101.1)	98.1 (92.55, 112.45) *	89.4 (82.8, 98.8)	**0.042**
FVC %Δ	2.8 (2, 4.4)	0.9 (-1.55, 2.65)	4.25 (0.55, 5.35)"	0.7 (-1.3, 2.5)	**0.006**
FEV_1 %Predicted	87.5 (82.7, 92.5)	86.65 (77.05, 97.05)	93 (88.1, 101.25) *	83.2 (77.9, 90.1)	0.053
FEV_1%Δ	7.5 (4.3, 10.3) *	4.2 (2.1, 6.7)	7.85 (2, 10.2)	4.4 (2.1,8)	0.055
FEV_1/FVC%	84.62 (79.49, 86.92) "	88.08 (84.36, 90.44)	86.86 (81.54, 90.45)	87.02 (81.68, 91.15)	0.057
Parameter **Spirometry values**	**Abnormal TG/HDL-C[a]** **Obesity** **N = 8**	**Abnormal TG/HDL-C[a]** **Non-obesity** **N = 12**	**Normal TG/HDL-C** **Obesity** **N = 15**	**Normal TG/HDL-C** **Non-obesity** **N = 115**	**P-value**
FVC %Predicted	94.7 (87.4, 101.4)	96.15 (87.55, 105.97)	98.1 (92.4, 106.2))[&]	88.4 (83.0, 98.8)	**0.008**
FVC %Δ	3.15 (2.32, 5.45)[&,#]	-0.25 (-2.25, 2.35)	3.8 (0.0, 4.7)[&,#]	0.9 (-1.30, 2.7)	**0.003**
FEV_1 %Predicted	87.2 (83.7, 91.05)	88.60 (80.57, 98.10)	92.2 (82.7, 95.30)	83.5 (77.2, 92.2)	0.125
FEV_1%Δ	6.25 (4.47, 8.17)	4.20 (1.95, 9.07	9.5 (2.5, 10.60)	4.4 (2.1,7.2)	0.063
%FEV_1/FVC	85.11 (80.11, 86.66)	84.11 (80.46, 86.21))[&]	86.52 (77.16, 87.62)	88.15 (83.39, 91.32)	**0.005**

Data presents as median (IQR), %Δ represents the percentage of bronchodilator response. [a]Abnormal TG/HDL-C ratio defined as the ratio > 2.5

P-value of less than 0.05 was considered statistically significant.

*: Significant difference compared with non-dyslipidemia non-obesity group

": Significant difference compared with dyslipidemia non-obesity group

& Significant difference compared with normal TG/HDL-C non-obesity

Significant difference compared with abnormal TG/HDL-C non-obesity

Table 5: Comparison between children with airflow obstruction (%FEV1/FVC < 90) and no airflow obstruction (%FEV1/FVC ≥ 90)

Patient features	% FEV1/FVC< 90 **N = 108**	%FEV1/FVC≥ 90 **N = 42**	**P-value**
Age (year)	11.89 (3.41)	11.64 (3.31)	0.69
Body weight (kg)	49.91 (20.77)	41.04 (14.39)	0.012
Height (cm)	149.46 (16.99)	146.17 (16.91)	0.286
BMI (kg/m^2)	21.48 (5.67)	18.61 (3.74)	0.003
BMI Z-Score	0.61 (-0.5, 1.73)	-0.23 (-1.01, 0.76)	0.005
Obesity	21 (19.6)	2 (4.7)	0.023
Atopic asthma	78 (72.9.1)	32 (74.4)	1.00
PACT (score)	23.19 (2.60)	24.21 (2.11)	0.025
PAQLQ (score)	6.49 (0.47)	6.69 (0.32)	0.012
Lipid profile			
TC (mg/dL)	181.37 (30.73)	182.21 (31.41)	0.88
LDL-C (mg/dL)	115.08 (30.82)	110.54 (29.19)	0.41
Non-HDL-C (mg/dL)	126.15 (30.22)	120.71 (26.70)	0.31
TG (mg/dL)	89.81 (42.99)	72.78 (25.50)	0.017
HDL-C (mg/dL)	55.21 (15.64)	61.50 (11.37)	0.019
TG/HDL-C	1.79 (1.17)	1.21 (0.44)	0.002
LDL-C/HDL-C	2.23 (0.84)	1.85 (0.57)	0.008
CRP (mg/dL)	0.85 (0.23, 2.0)	0.39 (0.23, 1.45)	0.134

Data present as mean (SD), median (IQR), or n (%)