Original Article

Insulin resistance, body composition, and fat distribution in obese children with nonalcoholic fatty liver disease

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Background and Objectives: The aim of this study was to evaluate the influence of body composition, especially distribution of body fat, and insulin resistance on nonalcoholic fatty liver disease (NAFLD) in obese children. **Methods and Study Design:** One hundred obese children (66 boys, 34 girls) with (n=60) and without NAFLD (n=40) were assessed. Anthropometry, laboratory tests, abdominal ultrasonography, and dual energy x-ray absorption metry (DXA) were evaluated in all subjects. **Results**: Subject age and measurements of liver enzymes, γ-glutamyl transpeptidase (γGT), uric acid, high-density lipoprotein cholesterol, and insulin resistance were significantly different between the non-NAFLD group and NAFLD group. Body fat and trunk fat percentage were significantly different between the two groups (p<0.001 and p=0.003), whereas extremity fat percentage was not (p=0.683). Insulin resistance correlated significantly with body fat and trunk fat percentages, age, liver enzymes, γGT, and uric acid in obese children. Multiple logistic regression analysis indicated that insulin resistance and trunk fat percentage significantly affected the development of NAFLD in obese children. **Conclusions**: Body fat, especially abdominal fat, influences the development of insulin resistance and subsequent NAFLD in obese children. Therefore, body composition measurement using DXA, in conjunction with biochemical tests, may be beneficial in evaluating obese children with NAFLD.

Key Words: obesity, nonalcoholic fatty liver disease, insulin resistance, body composition, child

INTRODUCTION

With the recent increase in the prevalence of pediatric obesity due to a westernized diet and sedentary lifestyle, the prevalence of nonalcoholic fatty liver disease (NAFLD), a hepatic manifestation of the metabolic syndrome in obesity, has been increasing in obese children and adolescents.[1,2] Thus NAFLD, especially nonalcoholic steatohepatitis (NASH), has become a major childhood health-related issue in terms of long-term morbidity and mortality as it can progress to liver cirrhosis, even in children.[3]

Because insulin resistance is a key factor in the pathogenesis of metabolic syndrome in children, previous studies have focused on the relationship between insulin resistance in obese patients and obesity-related complications.[4,5] In addition to the abdominal obesity, hypertension, glucose intolerance or diabetes, and hyperlipidemia or dyslipidemia of metabolic syndrome, NAFLD related to insulin resistance may develop in obese patients.[2,6] However, additional explanations may exist for the pathogenesis of NAFLD beyond insulin resistance because not all obese children with insulin resistance have NAFLD (or NASH) and progress to cirrhosis.

Recently, various techniques of body composition analysis, such as bioimpedance analysis (BIA), dual-energy X-ray absorptiometry (DXA), air displacement plethysmography, and quantitative magnetic resonance have been introduced, leading to increased concern regarding the influence of body composition, especially body fat distribution, on the development of obesity-related complications, including in children and adolescents.[7,8] Among the aforementioned modalities, BIA and DXA have been frequently applied not only to research but also to clinical practice. Although BIA is readily available for clinical purposes, it is less accurate than DXA for analyzing body composition because it may underestimate fat mass (FM) percentage in obese children, requiring prediction equations specific to age or pubertal state.[7,9] Thus, DXA may be a better modality to evaluate body composition in terms of FM and fat-free mass (FFM) or trunk FM.[7,10]

In a previous study of human immunodeficiency virus- and hepatitis C virus-infected adults, the severity of hepatic steatosis on histopathology was associated with an increase of trunk fat in body composition analysis by

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DXA although hepatic fibrosis was not associated with body fat distribution.[11] In another study, abdominal circumference and waist-to-height ratio correlated with trunk fat mass on DXA in obese adults with NAFLD and were significantly different between patients with NAFLD and controls without NAFLD.[12] These results suggest that DXA evaluation of body composition and visceral fat distribution might be beneficial for assessing obese patients with NAFLD. To date, in the pediatric population, few studies have looked at insulin resistance and DXA-determined body composition or fat distribution in relationship to NAFLD in obese children.[13,14] Thus, systematically designed studies in obese children and adolescents are needed because growing children may have different body composition and fat distribution from that in adults.

Therefore, the aim of this study was to evaluate the influence of body composition, especially the distribution of FM, and insulin resistance, along with demographic, anthropometric, and biochemical factors on the development of NAFLD in obese children and adolescents.

MATERIALS AND METHODS

Patients and data extraction

A total of 100 obese children and adolescents who visited Seoul National University Bundang Hospital between April 2012 and April 2014 were assessed. Subjects were divided into two groups according to their NAFLD status: non-NAFLD group (n=40) and NAFLD group (n=60).

Children with underlying organic causes of liver disease or drug history within the prior 3 months were excluded from the study. No patients had a history of alcohol consumption.

This study was approved by the Institutional Review Board (IRB) of Seoul National University Bundang Hospital (IRB. B-1108/133-006).

Anthropometric data

Body weight was measured using a calibrated digital scale to the nearest 0.1 kg, and height was measured to the nearest millimeter in a standing position. Body mass index (BMI) was calculated as body weight (kg) divided by the height squared (m^2). BMI *z*-score was calculated using the least mean square method adjusted for age and gender according to the 2007 Korean National Growth Charts.[15]

Abdominal circumference (AC) was measured to the nearest millimeter using a tapeline at each child's maximum waist girth in a standing position. Abdominal obesity was defined as AC exceeding the 90th percentile for the child's age and gender according to the 2007 Korean National Growth Charts based on the National Cholesterol Education Program–Adult Treatment Panel III criteria for metabolic syndrome.[15]

Blood pressure (BP) was measured at least twice in a resting state, on the right arm, with an electronic device. Hypertension was defined as repeatedly measured systolic BP or diastolic BP exceeding the 90th percentile for the child's age and gender.

Biochemical tests

Serum levels of triglycerides (TG), total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein cholesterol, γ-glutamyl transpeptidase (γGT), uric acid, fasting glucose, and insulin levels were measured after at least a 12-hour fasting period at the first visit.

Hypertriglyceridemia was defined as serum TG level >110 mg/dL, and dyslipidemia was defined as HDL cholesterol <40 mg/dL. Fasting glucose intolerance was defined as fasting blood glucose >100 mg/dL. Insulin resistance was determined by the homeostatic model assessment of insulin resistance (HOMA-IR), which is calculated as [fasting insulin (μU/mL) × fasting glucose (mg/dL)]/405.

Serum levels of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were measured using TBA-200FR NEO (Toshiba Medical Systems Corporation, Tokyo, Japan), and serum AST or ALT levels >40 IU/L were considered abnormal.

DXA

The amount of total mass, FM, FFM, body fat percentage (FM/total mass×100), trunk fat percentage, and extremity fat percentage were measured by whole body DXA scanner (Lunar, General Electric Medical systems, Madison, WI, USA). This quantifies body composition based on body tissue absorption of photons that are emitted at two energy levels, and stratifies body weight into bone mineral, FFM, and FM using software provided by the manufacturer. DXA scanning was applied for 15 minutes in a supine position without any movement in accordance with the manufacturer's recommendations.

Using the DXA data, the FM index [FM except for head area/height $(m)^2$] and the FFM index [lean mass/height $(m)^2$] were additionally calculated.[16]

Diagnosis of NAFLD

The presence of fatty liver in each patient was evaluated by an expert pediatric radiologist using abdominal ultrasonography (USG). The degree of fatty liver on abdominal USG was stratified as mild, moderate, or severe.

The diagnosis of NAFLD was based on serum aminotransferase levels and abdominal USG findings. NASH was defined when serum aminotransferase levels were abnormally elevated in the presence of a fatty liver on abdominal USG.

Statistical analysis

The data are expressed as mean ± standard deviation (SD) for continuous variables. All data were analyzed using the SPSS 18.0 software program (SPSS Inc., Chicago, IL, USA). Student's t-test was used to compare the means of continuous variables between the two groups. Frequency data were compared using the Chi-square test. All *p* values were two-tailed, and $p<0.05$ was considered statistically significant.

Multiple logistic regression analysis with backward selection was performed to evaluate variables that might affect the development of NAFLD in obese children.

RESULTS

Patients characteristics and biochemical data

A total of 100 obese children and adolescents (66 boys, 34 girls; mean age±SD=11.2±3.5 years) were assessed.

Demographic and biochemical data are listed and compared between the non-NAFLD group and NAFLD group in Table 1. Among demographic and laboratory factors, age and serum levels of AST, ALT, γGT, uric acid, HDL-cholesterol, and fasting insulin showed statistically significant differences between the non-NAFLD group and NAFLD group (Table 1). HOMA-IR, indicating insulin resistance, was also significantly different between the two groups (p<0.001; Table 1).

Comparison of body composition factors by DXA between non-NAFLD and NAFLD group

Body composition data measured by DXA in obese children and adolescents are compared between the non-NAFLD group and NAFLD group in Table 2. Among factors related to body composition, body fat percentage between the non-NAFLD group and NAFLD group was significantly different (p<0.001), whereas the FFM to total mass ratio was not (p=0.062) (Table 2). Regarding fat percentage in the trunk and extremities, trunk fat percentage was significantly different between the two groups (p=0.003), whereas extremity fat percentage was not (p=0.683) (Table 2). FM index and FFM index were also significantly different between the two groups (both p<0.001) (Table 2).

Correlation of HOMA-IR with demographic, biochemical data and body composition factors related to NAFLD

Among factors suggesting obesity-related metabolic syndrome or NAFLD, HOMA-IR correlated significantly with age, AST, ALT, γGT, and uric acid (Table 3). HOMA-IR did not correlate with waist-to-height ratio (r=0.109, p=0.305) or BMI z-score (r=0.026, p=0.802) in obese children. Among body composition factors, HOMA-IR correlated significantly with body fat percentage, trunk fat percentage, FM index, and FFM index (Table 3).

Correlation of body fat percentages by DXA with demographic, biochemical data and body composition factors related to NAFLD

Regarding the correlation of body fat percentage, trunk fat percentage, and extremity fat percentage with demographic, biochemical, and body composition data, only extremity fat percentage had a negative correlation with age (r=−0.266, p=0.008) (Table 4). All 3 body fat factors significantly correlated with waist-to-height ratio (r=0.703, p<0.001 for body fat percentage; r=0.608, p<0.001 for trunk fat percentage; r=0.577, p<0.001 for extremity fat percentage) and BMI z-score in obese children (r=0.651, p<0.001; r=0.537, p<0.001; r=0.566, p<0.001, respectively) (Table 4). AST and ALT did not correlate with body composition factors except for the correlation between trunk fat percentage and AST (r=0.249, p=0.014) (Table 4). Uric acid correlated with trunk fat percentage in obese children (r=0.201, p=0.046), whereas the other factors did not (Table 4). HDL-cholesterol correlated with extremity fat percentage (r=0.244, p=0.015), whereas the other factors did not (Table 4).

Table 1. Demographic and biochemical data in non-NAFLD and NAFLD group

Variables	Non-NAFLD (n=40)	NAFLD (n=60)	p value*
Demographic and anthropometric data			
Gender [boys : girls]	21 : 19	45 : 15	0.031
Age (yr)	9.4±3.5	12.4±3.0	<0.001
Waist to height ratio	0.58±0.05	0.58±0.09	0.606
BMI z-score	1.88±0.67	1.83±0.62	0.754
BMI group [OW : OB]	12 : 28	22 : 38	0.525
Biochemical data			
Calcium (mg/dL)	9.6±0.2	9.7±0.4	0.298
Phosphorus (mg/dL)	4.8±0.5	4.8±0.7	0.751
ALP (IU/L)	259±88.3	251±118	0.728
AST (IU/L)	22.5±6.8	50.3±28.5	<0.001
ALT (IU/L)	17.8±6.1	99.5±82.7	<0.001
γGT (IU/L)	16.4±4.9	40.0±57.8	<0.001
Uric acid (mg/dL)	5.1±1.1	6.7±1.6	<0.001
Triglyceride (mg/dL)	109±80.1	126±61.6	0.227
Total cholesterol (mg/dL)	176±46.4	170±27.5	0.483
LDL-cholesterol (mg/dL)	103±42.0	101±25.7	0.684
HDL-cholesterol (mg/dL)	51.4±9.6	45.4±9.6	0.003
hsCRP (mg/dL)	0.58±2.65	0.26±0.47	0.368
Fasting glucose (mg/dL)	93.0±8.8	95.2±8.8	0.213
Fasting insulin (μU/mL)	15.1±6.0	24.8±14.6	<0.001
HOMA-IR	3.5±1.5	5.2±1.9	<0.001

Data are presented as mean±SD

*p value less than 0.05 is regarded as statistically significant.

ALP: alkaline phosphatase; ALT: alanine aminotransferase; AST: aspartate aminotransferase; BMI: body mass index; HDL: high density lipoprotein; HOMA-IR: insulin resistance determined by homeostasis model assessment; hsCRP: highly sensitive C-reactive protein; γGT: γ-glutamyltranspeptidase; LDL: low density lipoprotein; NAFLD: non-alcoholic fatty liver disease; OW: overweight with BMI between 85 and 94 percentile; OB: obesity with BMI ≥95 percentile.

Table 2. Comparison of body composition factors by DXA between non-NAFLD and NAFLD group

Variables	Non-NAFLD (n=40)	NAFLD (n=60)	*p* value*
Body fat percentage (%)	37.5±5.7	40.0±5.7	0.033
Trunk fat percentage (%)	40.1±6.5	43.8±5.9	0.003
Extremity fat percentage (%)	42.0±5.7	42.7±8.7	0.683
Fat mass index	8.8±2.2	10.7±2.6	<0.001
Fat-free mass index	13.6±1.4	15.0±1.9	<0.001

Data are presented as mean±SD
*p value less than 0.05 is regarded as statistically significant.
DXA: dual energy X-ray absorptiometry; NAFLD: non-alcoholic fatty liver disease.

Table 3. Correlation of HOMA-IR with demographic, biochemical data and body composition factors related to NAFLD in obese children

Variables	Correlation coefficient (*r*)	*p* value*
Age	0.495	<0.001
Waist to height ratio	0.109	0.305
BMI *z*-score	0.026	0.802
AST	0.360	<0.001
ALT	0.216	0.039
γGT	0.240	0.021
Uric acid	0.389	<0.001
Body fat percentage	0.341	0.001
Trunk fat percentage	0.393	<0.001
Extremity fat percentage	0.122	0.244
Fat mass index	0.519	<0.001
Fat-free mass index	0.393	<0.001

*p value less than 0.05 is regarded as statistically significant.
ALT: alanine aminotransferase; AST: aspartate aminotransferase; BMI: body mass index; HDL: high density lipoprotein; HOMA-IR: insulin resistance determined by homeostasis model assessment; γGT: γ-glutamyl transpeptidase; NAFLD: non-alcoholic fatty liver disease.

Table 4. Correlation of body fat percentage, trunk fat percentage, or extremity fat percentage by DXA with demographic, biochemical data and body composition factors related to NAFLD in obese children

Variables	Body fat percentage		Trunk fat percentage		Extremity fat percentage	
	r	*p* value*	*r*	*p* value	*r*	*p* value
Age	-0.070	0.488	0.088	0.383	-0.266	0.008
WHR	0.703	<0.001	0.608	<0.001	0.577	<0.001
BMI *z*-score	0.651	<0.001	0.537	<0.001	0.566	<0.001
AST	0.188	0.063	0.249	0.014	0.013	0.902
ALT	0.116	0.255	0.160	0.115	-0.022	0.834
γGT	0.173	0.088	0.198	0.051	0.037	0.717
Uric acid	0.091	0.370	0.201	0.046	-0.059	0.564
HDL-cholesterol	0.116	0.253	0.025	0.805	0.244	0.015

*p value less than 0.05 is regarded as statistically significant.
ALT: alanine aminotransferase; AST: aspartate aminotransferase; BMI: body mass index; DXA: dual energy X-ray absorptiometry; HDL: high density lipoprotein; γGT: γ-glutamyl transpeptidase; NAFLD: non-alcoholic fatty liver disease; *r:* correlation coefficient; WHR: waist to height ratio.

Multiple logistic regression analysis

Multiple logistic regression analysis with backward selection was initially performed by using significant variables such as age, gender, uric acid, γGT, HDL-cholesterol, HOMA-IR, body fat percentage, trunk fat percentage, FM index, and FFM index. The results of logistic regression analysis indicated that γGT and uric acid were significant risk factors for NAFLD in obese children (Table 5). Additionally, multiple logistic regression analysis was performed by adding a BMI *z*-score, which is an important obesity-related factor, in addition to all variables listed above. This analysis revealed HOMA-IR, BMI *z*-score, and trunk fat percentage to be significant risk factors for the development of NAFLD in obese children (Table 6).

DISCUSSION

To our knowledge, the present study is the first to use body composition determined by whole body DXA along with laboratory factors to evaluate obese children with NAFLD.

Among demographic, anthropometric, and laboratory factors related to pediatric obesity, our study revealed that only age and serum levels of liver enzymes, γGT, uric acid, HDL-cholesterol, fasting insulin, and HOMA-IR ere significantly different between obese children with NAFLD and those without NAFLD, suggesting that

Table 5. Multiple logistic regression analysis of factors related to the development of NAFLD in obese children

Variables	Exp(B)	95% CI	*p* value
γGT	1.22	1.10-1.34	0.000
Uric acid	1.94	1.13-3.33	0.016

CI: confidence interval; γGT: γ-glutamyl transpeptidase; NAFLD: non-alcoholic fatty liver disease.

Table 6. Multiple logistic regression analysis of factors possibly related to the development of NAFLD in obese children

Variables	Exp(B)	95% CI	*p* value
HOMA-IR	1.66	1.17-2.35	0.004
BMI *z*-score	0.28	0.10-0.83	0.021
Trunk fat percentage	1.19	1.06-1.35	0.004

BMI: body mass index; CI: confidence interval; HOMA-IR: insulin resistance determined by homeostasis model assessment; NAFLD: non-alcoholic fatty liver disease.

these factors might be important in assessing pediatric NAFLD. Previous studies have also reported that age, serum aminotransferases, γGT, uric acid, and HDL-cholesterol ere noninvasive markers indicative of NAFLD.[17-20] Therefore, it is reasonable to initially assess all obese children with suspected NAFLD using laboratory assays, including hepatic enzymes, lipids, lipoproteins, fasting glucose, and insulin level, as recommended in a recent consensus statement on pediatric NAFLD.[21] Furthermore, when we initially performed multiple logistic regression analysis using all significant variables from our results, γGT and uric acid were the two laboratory variables ultimately reflecting NAFLD in obese children. This suggests the value of γGT and uric acid when interpreting the results of obesity-related biochemical tests in children for whom a diagnosis of NAFLD is being considered.

In our study, HOMA-IR was significantly higher in obese children with NAFLD than in those without NAFLD. In previous studies, HOMA-IR has been suggested as an essential factor in the pathogenesis of obesity-related complications, such as metabolic syndrome and NAFLD.[2,6] Furthermore, multiple regression analysis from our study suggested that HOMA-IR might be a significant risk factor for the development of NAFLD in obese children. Thus, insulin resistance is undoubtedly important with respect to NAFLD in obese children. However, additional factors beyond insulin resistance are still required to explain the predisposition to NAFLD in obese children and adolescents.

In our study, HOMA-IR significantly correlated not only with laboratory markers of NAFLD in obese children, such as AST, ALT, γGT, and uric acid, but also with body composition factors measured by DXA, such as body fat percentage, trunk fat percentage, FM index, and FFM index. Moreover, body fat percentage, trunk fat percentage, and FM index were significantly different between the NAFLD group and non-NAFLD group, whereas extremity fat percentage was not. These results indicate that a systematic approach based on body composition and body fat distribution analysis is needed to understand the pathogenesis of insulin resistance and NAFLD in pediatric obesity.

Previous studies on NAFLD have mostly used simple anthropometric measurements of body components, such as weight, height, BMI, skinfold thickness, AC, and waist-to-height ratio.[22,23] However, in our study, conventional anthropometry was not very helpful in distinguishing the NAFLD group from the non-NAFLD group, and HOMA-IR did not correlate with waist-to-height ratio or BMI *z*-score adjusted for different body size or age and gender. Therefore, we decided to adopt a more advanced method to approach body composition.

Various body composition measurement methods have been developed to date, and two of the most commonly used methods are BIA and DXA, measuring physical properties of impedance and X-ray attenuation, respectively.[24] Both of these methods are readily available as a substitute for conventional anthropometry in the pediatric population.[7] However, BIA estimates body compartments based on assumptions regarding tissue composition and extremity proportions and uses prediction equations that should be specific to the age or pubertal stage of a child to determine FM and FFM; thus, BIA has some limitations in pediatric populations and requires further validation studies.[7] Additionally, BIA tends to underestimate fat mass percentage in obese children, especially in boys.[25] Furthermore, DXA has some advantages over BIA for evaluating pediatric patients because of excellent accuracy and availability in children of all ages; thus, body fat assessment using DXA may become the gold standard to measure FM in obese children.[7,10] Currently, however, only a few studies on NAFLD have applied DXA to body composition measurement in obese populations, and all merely assessed FM, FFM, trunk fat mass, or body fat percentage.[12-14]

In the present study, all body composition factors measured by DXA were taken into consideration. Out of these factors, body fat percentage, trunk fat percentage, and FM index significantly reflected the status of NAFLD, and these factors significantly correlated with HOMA-IR, indicative of insulin resistance. Furthermore, multiple logistic regression analysis in our study revealed that trunk fat percentage, in addition to HOMA-IR, was a significant risk factor for NAFLD in obese children. By contrast, extremity fat percentage had no relationship with insulin resistance or NAFLD in our study. The results from our study suggest that the application of DXA might be useful in obese children with NAFLD, not only for the measurement of FM itself but also for the analysis of fat distribution in terms of trunk fat.

Increase in trunk fat indicates central obesity or abdominal adiposity. According to previous studies, it is probable that abdominal fat, particularly visceral fat, is associated with metabolic syndrome, cardiovascular disease, and NAFLD in obese populations.[13,14] Consequently, precise detection and quantification of visceral, rather than subcutaneous, abdominal fat may be advantageous when assessing obese children for NAFLD. Some adult studies have used abdominal computed tomography (CT) to quantify trunk fat, distinguishing between visceral and subcutaneous fat.[12,26] However, because of the radiation

hazard of CT, this modality is no longer recommended in the pediatric population. Furthermore, the segmentation of abdominal fat into visceral and subcutaneous fat using DXA scanning has now become available and well validated, at least in adults.[10] Because whole body DXA is economical, safe, and readily available with minimal radiation risk, it might be the most promising body composition measurement method for diagnosing NAFLD in obese children in both research and clinical applications.[10]

The present study has some limitations. Data from DXA could not be compared with those from abdominal CT because of the radiation hazard related to CT in pediatric patients. Application of abdominal magnetic resonance imaging (MRI) was also not available in our study because MRI is relatively expensive, largely manual, and time-consuming in measurement and interpretation, requiring heavily utilized clinical equipment.[10] Nevertheless, further studies using both DXA and abdominal MRI may be beneficial in a large group of obese children and adolescents with NAFLD.

In conclusion, insulin resistance is a key factor affecting metabolic syndrome and NAFLD in obese children, and body fat, especially abdominal fat, is associated with insulin resistance in obese children and may influence the development of pediatric NAFLD. Therefore, body composition analysis using DXA in conjunction with biochemical tests, based on the concept of abdominal fat and insulin resistance, may be superior to conventional anthropometric measurements for evaluating obese children with NAFLD.

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AUTHOR DISCLOSURES

There are no conflicts of interest and no financial disclosures regarding this study.

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Original Article

Insulin resistance, body composition, and fat distribution in obese children with nonalcoholic fatty liver disease

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非酒精性脂肪肝肥胖儿童的胰岛素抗性、身体成分和脂肪分布

背景与目的：该研究目的是评价身体成分，尤其是脂肪分布和胰岛素抗性对非酒精性脂肪性肝病（NAFLD）肥胖儿童的影响。**方法与研究设计**：对 100 例肥胖儿童（男 66，女 34）进行评估，其中有 NAFLD 的 60 例，无 NAFLD 的 40 例。所有研究对象均接受人体测量学、实验室检查、腹部超声和双能 X 线吸收法（DXA）的评估。**结果**：NAFLD 组和非 NAFLD 组研究对象年龄、肝酶、γ-谷氨酰转肽酶（γGT）、尿酸、高密度脂蛋白胆固醇和胰岛素抗性之间差异有统计学意义。两组间身体脂肪和躯干脂肪百分比差异有统计学意义（p<0.001 和 p=0.003），而肢体脂肪百分比差异无统计学意义（p=0.683）。肥胖儿童胰岛素抗性与身体和躯干脂肪百分比、年龄、肝酶、γGT 及血尿酸之间有显著相关关系。多因素 logistic 回归分析显示胰岛素抗性和躯干脂肪百分比对肥胖儿童非酒精性脂肪肝的发展有显著影响。**结论**：身体脂肪，尤其是腹部脂肪，影响肥胖儿童胰岛素抗性及其随后非酒精性脂肪肝的发展。因此，使用 DXA 测量身体成分，结合生化检测，有利于评价非酒精性脂肪肝肥胖儿童。

关键词：肥胖、非酒精性脂肪性肝病、胰岛素抗性、身体成分、儿童